CUK-H06723-190 : RP320

NATURE

A Weekly Journal of Science

Vol. 186, No. 4729 SATURDAY, JUNE 18, 1960 2s. 6d.

190

190

The AEI Nuclear Magnetic Resonance Spectrometer type RS2 is an advanced equipment designed to combine the highest resolution with extreme flexibility in use. *Here are its outstanding features :*

HIGH RESOLUTION Resolution of 1 part in 10^8, i.e. a line width at half-height of 0.4 c/s at 40 Mc/s ; 0.6 c/s at 60 Mc/s etc.

ELECTROMAGNET Field continuously variable from 1,000 to 17,000 gauss. Low power dissipation and special thermal insulation ease problems of drift.

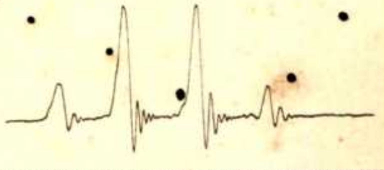
MAGNET GAP The standard gap is 1½ in. but this can readily be altered to values of ¾ in., 1 in., 1¼ in., 2 in., 2½ in., or 3 in. without changing the pole shoes. Space between coils gives easy access for probe.

R.F. SIGNAL Choice of eleven frequencies from 2.5 to 60 Mc/s combined with continuously variable magnetic field gives widest possible coverage.

PROBE Simple interchangeable inserts for variation of frequency, sample size and temperature.

Other Features: Built-in A.F. oscillator for chemical shift calibration, 10 in., and 2 in., recorders with integral design of controls to facilitate operation.

This trace shows the proton resonance spectrum of CHO group of acetaldehyde at 60 Mc/s. The separation between the peaks is 2.85 c/s and the average line width (at half-height) is 0.6 c/s approximately.



The AEI range of scientific equipment includes apparatus for ELECTRON MICROSCOPY, MASS SPECTROMETRY, RADIOGRAPHY, CRYSTALLOGRAPHY, MATERIALS IRRADIATION, HIGH VACUUM ENGINEERING, X-RAY MICRO-ANALYSIS.

Let us look into YOUR *problem.*

AEI

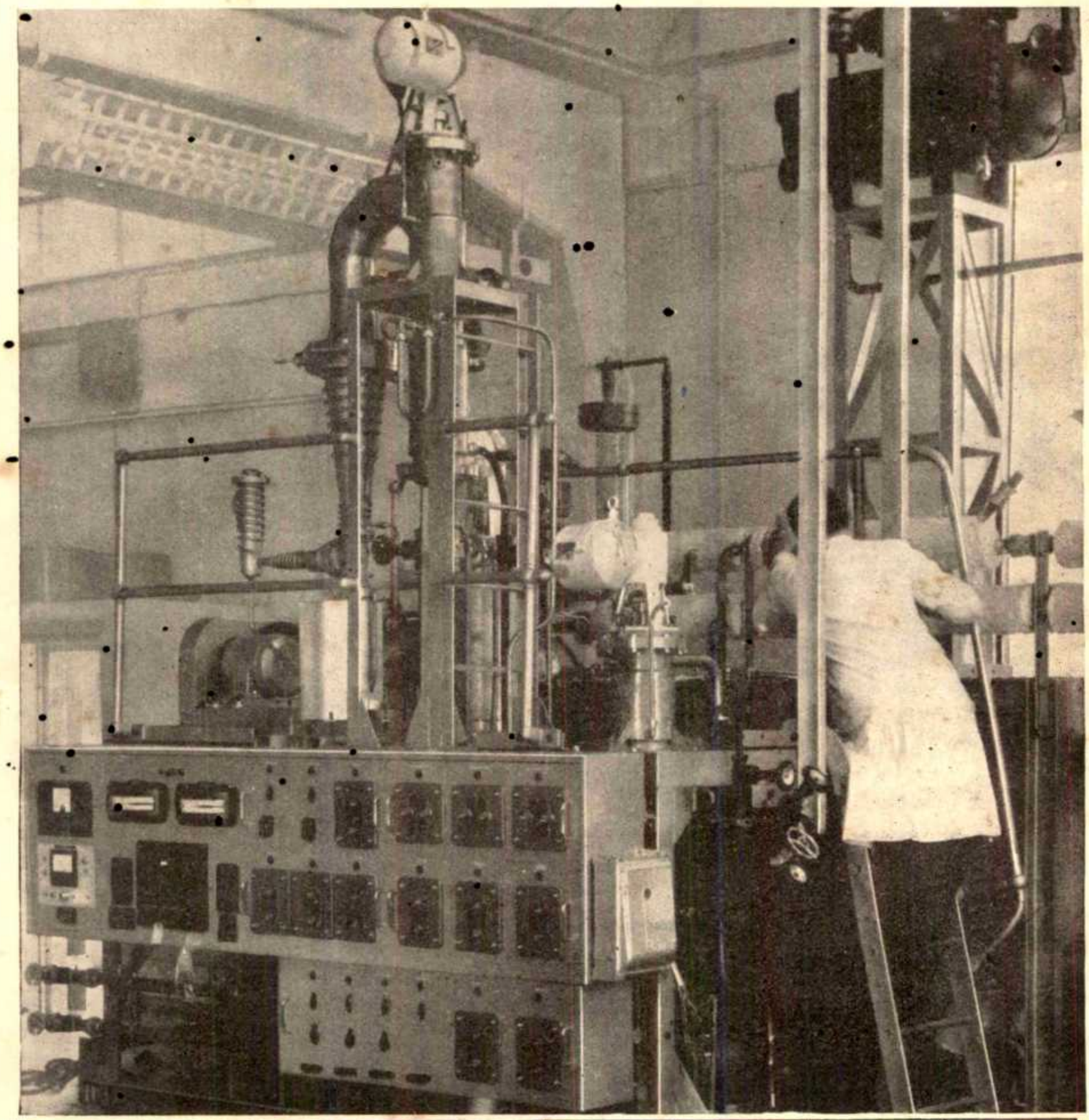
Instrumentation Division
Scientific Apparatus and X-Ray Department
Associated Electrical Industries Limited
TRAFFORD PARK, MANCHESTER 17

N/R 906

MOLECULAR DISTILLATION

- Suitable for materials with molecular weights up to 1200.
- Adaptable for distillation from the micron range up to 100 torr and above.
- Fully instrumented for pilot and production duties.
- Feed rates from 50–200 lbs. per hour. (Depending on material).

SIMPLE MOLECULAR DISTILLATION
Epoxy resins, plasticisers, glycerine and any material with molecular weights up to 1200.
STRIPPING
Sterols, vitamins A or E from liver oils, etc., non-condensable impurities, residual alcohols from esterification products, residual free acids from synthetic resins and plasticisers.
CONCENTRATION
Extracts and solutions
DEODORISING
Vegetable oils and plasticisers
SEPARATION
Polyglycols, complex mineral oils and mono-glycerides.



EDWARDS HIGH VACUUM LTD | MANOR ROYAL | CRAWLEY | SUSSEX | Crawley 1500

NATURE

A WEEKLY JOURNAL OF SCIENCE

> "To the solid ground
> Of nature trusts the Mind that builds for aye"—WORDSWORTH

(not received No 4719 and 4721)

Volume 186

APRIL 2, 1960, to JUNE 25, 1960

CHEMICAL LABORATORY
Date 8. 12. 60.
SCIENCE COLLEGE

LONDON
MACMILLAN AND CO., LTD.
NEW YORK: ST. MARTIN'S PRESS, INC.

DATES and PAGINATION of WEEKLY ISSUES

Serial No.		*Date of issue*		*Pagination*
4718	...	April	2	1–106
4719	...	,,	9	107–184
4720	...	,,	16	185–264
4721	...	,,	23	265–340
4722	...	,,	30	341–418
4723	...	May	7	419–500
4724	...	,,	14	501–576
4725	...	,,	21	577–662
4726	...	,,	28	663–742
4727	...	June	4	743–828
4728	...	,,	11	829–914
4729	...	,,	18	915–996
4730	...	,,	25	997–1076

RP320

Wanting No 4719 and 4721 not received.

NATURE

No. 4718 SATURDAY, APRIL 2, 1960 Vol. 186

CONTENTS

Page

DEVELOPMENT OF NUCLEAR ENERGY IN BRITAIN . . . 1

SUPERFICIAL CHEMISTRY AND SOLID IMPERFECTIONS. By Prof. F. C. Tompkins, F.R.S. . . . 3
CHROMOSOMES IN PRIMARY NEOPLASTIC GROWTH. By Dr. K. Bayreuther . . . 6
THE LIVERPOOL GEOLOGICAL SOCIETY, 1859–1959. By R. G. C. Bathurst . . . 9
NEW FELLOWS OF THE ROYAL SOCIETY . . . 11

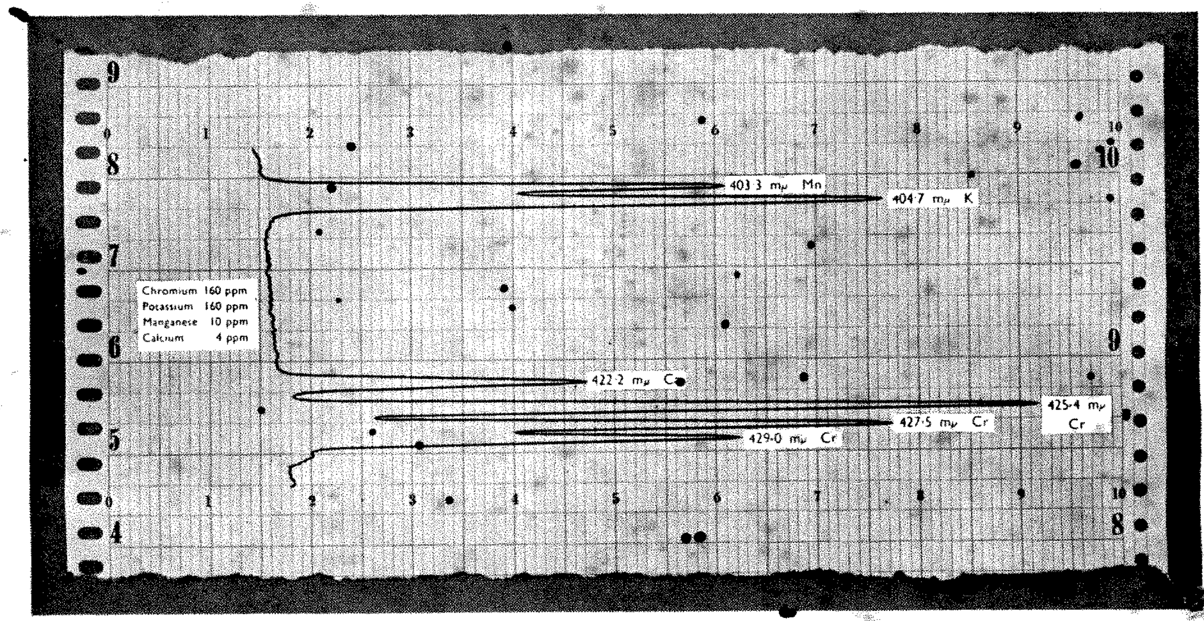
NEWS AND VIEWS . . . 12

HOW MANY MORE NEW JOURNALS? By Dr. D. Richter . . . 18
HUMAN GROWTH. By Dr. J. M. Tanner . . . 19
THE ROCKEFELLER FOUNDATION . . . 20
INTERNATIONAL CONTROL OF NARCOTIC DRUGS . . . 21
MARRIAGE-RATE OF AMERICAN COLLEGE GRADUATES . . . 22
PLANT POPULATION AND CROP YIELD. By R. Holliday . . . 22
THE RESPIRATORY DEAD SPACE OF THE GIRAFFE. By Prof. Eugene D. Robin, Dr. Joseph M. Corson and Prof. Gustave J. Dammin . . . 24
PROTON MAGNETIC RESONANCE IN A SERIES OF DIMETHYL SILOXANE POLYMERS. A SPECIFIC LONG-CHAIN EFFECT? By Dr. J. G. Powles and A. Hartland . . . 26

REVIEW SUPPLEMENT:

MEDICINE IN SHAKESPEARE'S WRITINGS. By Sir Russell Brock . . . 35
THE ROYAL COLLEGE OF SURGEONS OF ENGLAND. By Prof. Charles Singer . . . 35
EARLY SCIENCE IN CHINA. By Prof. W. M. Smart . . . 36
HERBERT SPENCERISM. By Dr. John Tucker . . . 37
HUMAN RITES. By Dr. Kenneth Walker . . . 37
AFRICAN CULTURES. By G. W. B. Huntingford . . . 38
SELF-REGULATION FOR CHILDREN. By Prof. M. D. Vernon . . . 38
MOTIVATION. By Prof. J. Drever . . . 39
MEMORY AND LEARNING: A NEUROLOGIST'S POINT OF VIEW. By Dr. Gilbert Hall . . . 39
[illegible] YEARS OF LEARNING THEORY. By Prof. [illegible]. R. L. Hall . . . 40
SOCIAL SCIENCE, CRIMINOLOGY AND PSYCHIATRY. By Prof. E. Stengel . . . 41
A DIVERSITY OF TRENDS IN MEDICINE. By Prof. L. J. Witts, C.B.E. . . . 42
THE EYE AND VISION. By R. C. Davenport . . . 42
EARLY ETHOLOGY. By Dr. R. A. Hinde . . . 43
A NINETEENTH-CENTURY BOTANIST. By Sir Edward Salisbury, C.B.E., F.R.S. . . . 44
MASTER OF MICROBIOLOGY. By Prof. B. C. J. G. Knight . . . 44
DIAGNOSIS OF HUMAN GROWTH. By Dr. K. M. Hawkins . . . 45
RED, ROE AND FALLOW. By R. S. R. Fitter . . . 45
THE ARADIDAE. By R. G. Fennah . . . 46
PARASITES, IMAGINARY AND REAL. By Dr. Ben Dawes . . . 46
PROGRESS IN PLANT PATHOLOGY. By W. C. Moore, C.B.E. . . . 47
MYCORRHIZA. By Dr. J. Warren Wilson . . . 48
THE BANANA. By Prof. C. W. Wardlaw . . . 48
TROPICAL ANIMAL HUSBANDRY. By Sir John Hammond, C.B.E., F.R.S. . . . 49
ORGANIZATION, CONTROL AND SYNTHESIS IN MICRO-ORGANISMS. By Dr. B. A. Newton . . . 49
BIOCHEMICAL DATA. By Dr. K. S. Dodgson . . . 50
GENERAL BIOCHEMISTRY. By Prof. F. G. Young, F.R.S. . . . 51
ANTIGENS, TRANSPLANTATION AND TOLERANCE. By Dr. D. M. V. Parrott . . . 51
GENERAL PHYSIOLOGY. By Prof. A. St. G. Huggett, F.R.S. . . . 52
ANALYTICAL CHEMISTRY OF POLYMERS. By Prof. C. E. H. Bawn, C.B.E., F.R.S. . . . 52
THE ORGANIC CHEMISTRY OF SULPHUR. By Dr. F. G. Mann, F.R.S. . . . 53
LIGHT-INITIATED ORGANIC SYNTHESIS. By Prof. R. N. Haszeldine . . . 53
CHEMICAL NOMENCLATURE. By Prof. H. J. Barber . . . 54
ELECTRONIC STRUCTURE OF MOLECULES. By Prof. C. A. Coulson, F.R.S. . . . 54
CHEMICAL THERMODYNAMICS. By Prof. A. R. Ubbelohde, F.R.S. . . . 55
A STRUCTURAL TOOL FOR THE CHEMIST. By Prof. E. R. Andrew . . . 55
THEORY AND PRACTICE OF SEDIMENTATION. By Dr. K. V. Shooter . . . 56
CHEMICAL ANALYSES OF ROCKS. By Prof. K. C. Dunham, F.R.S. . . . 56
GEOLOGICAL WAYS AND BY-WAYS. By Dr. J. V. Harrison . . . 57
GLOSSARY OF GEOLOGICAL TERMS. By Dr. V. A. Eyles . . . 57
LOW-ENERGY NUCLEAR PHYSICS. By Dr. E. Bretscher . . . 58
ROCKET PROPELLANTS. By Dr. W. B. Littler, C.B. . . . 58
AN EASY GUIDE TO RADIO ASTRONOMY. By Dr. J. S. Hey . . . 59
PROBLEMS OF SPACE FLIGHT. By D. G. King-Hele . . . 59
PLANETARY DYNAMICS. By Dr. R. H. Garstang . . . 60
STEVIN'S MATHEMATICAL WORKS. By Dr. J. F. Scott . . . 60
GÖDEL'S THEOREM. By F. I. G. Rawlins, C.B.E. . . . 61
ORGANIZATION AND METHODS. By E. S. Hiscocks . . . 62
SHORT REVIEWS . . . 63

Progress with Flame Photometry



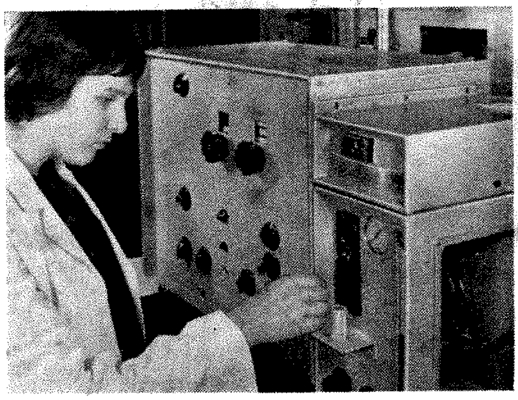
The highest standards of performance combined with speed, convenience and reliability place the Unicam SP.900 Flame Spectrophotometer in a class of its own as an analytical tool. Used as a direct-reading galvanometer instrument the SP.900 achieves new levels of ease and speed. External recorder indication adds further to the advantages of this outstanding instrument.

Elements in solution are quickly and precisely determined by the SP.900 in both trace quantities and at high concentration levels. The spectrum above illustrates the power of the SP.900 to resolve characteristic emission lines produced by different elements at narrowly separated wavelengths. Studies of complex solutions have shown that both chemical and flame interferences are reduced to a minimum and frequently can be eliminated using simple techniques.

Our Technical Sales Department will be pleased to receive details of your analytical problems and to suggest possible applications of the SP.900 Flame Spectrophotometer.

Above: Detection of four elements in one solution.

Below: The SP.900 Flame Spectrophotometer combines speed and simplicity of operation with accuracy and reliability.



A new leaflet describing the SP.900 is in preparation. Please write for a copy.

UNICAM

SP.900 FLAME SPECTROPHOTOMETER

UNICAM INSTRUMENTS LTD., ARBURY WORKS, CAMBRIDGE
U192 REV

LETTERS TO THE EDITORS

Page

PHYSICS

Action of Graphite as a Lubricant.—W. Bollmann and J. Spreadborough 29
Effect of Cathode Surface Roughness and Oxidation on Arc Movement.—Dr. T. J. Lewis and Dr. P. E. Secker 30
Bulk Conductivity in Organic Crystals.—Dr. H. Kallmann and Dr. M. Pope 31

CRYSTALLOGRAPHY

Growth of Single Crystals of Copper.—Rev. D. S. Kemsley 33

GEOPHYSICS

Motion of Geomagnetic Field Lines.—C. J. Loughnan 33

GEOCHEMISTRY

High-pressure Phase Transformations in Laboratory Mechanical Mixers and Mortars.—Frank Dachille and Prof. Rustum Roy 34
Strontium-90 in the 'Mixed Layer' of the Atlantic Ocean.—Dr. Vaughan T. Bowen and Prof. Thomas T. Sugihara 71

CHEMISTRY

Gas Content of Graphites.—Dr. J. P. Redmond and Dr. P. L. Walker, jun. 72
Optical Properties of the $\alpha\omega$-Dimethanesulphonoxyalkanes.—Dr. A. C. Bishop and Dr. R. D. Marshall 74
Requirements for Stereospecificity in Hydrolysis by Chymotrypsin: Diethyl β-Acetamidoglutarate.—Prof. Saul G. Cohen and Ezra Khedouri 75
Structure of the Viscous Phase of Liquid Sulphur.—Dr. E. McLaughlin 76

BIOCHEMISTRY

Bradykinin Activity of some Synthetic Peptides with only Slight Structural Resemblance to Natural Bradykinin.—Dr. G. L. Tritsch and Prof. D. W. Woolley 76
Synthesis of Contractile Proteins in the X-Irradiated Embryo.—Dr. Yoshito Ogawa 77
Production of Shikimic Acid by *Penicillium griseofulvum* Dierckx.—Prof. Paul Simonart and Anselme Wiaux 78
Measurement of Transaminases in Serum.—Dr. H. Yatzidis 79
Conjugation of 3 : 4-Benzpyrenols in Mouse Skin.—Dr. K. H. Harper and G. Calcutt 80
Heterogeneity of Tumour Ribonucleic Acid and the Effect of 'Degranol' on it.—F. Antoni, E. J. Hidvégi and K. Lapis 81

ANIMAL PHYSIOLOGY

Effects of 1,4-Dihydrazinophthalazine on the Catechol Amines.—M. Bygdeman and L. Stjärne 82
Diurnal Temperature Variation in the Rhesus Monkey under Normal and Experimental Conditions.—Dr. Lloyd B. Erikson 83
Body-Weight and Liver —SH Levels of Mice.—Dr. G. Calcutt 84
Essential Fatty Acids of Normal and Atherosclerotic Aortas from Chickens receiving Differently Saturated Fats for Three Years.—Prof. H. Fisher and A. S. Feigenbaum 85

Page

HÆMATOLOGY

Elevation of Serum Haptoglobin in Rabbits in Response to Experimental Inflammation.—R. K. Murray and G. E. Connell 86
Effect of Manganese Edetate on Blood Formation in Rats.—T. J. Sullivan 87
Rivanol in the Preparation of Plasminogen (Profibrinolysin).—Dr. M. Steinbuch and Dr. S. Niewiarowski 87

PLANT PHYSIOLOGY

Specific Interaction of Native Protein and Inorganic Salts.—Folke Rønnike 88
2,6-Dichlorobenzonitrile: a New Herbicide.—Dr. H. Koopman and J. Daams 89
Volvox Colonies and Snail 'Cytase'.—Dr. B. C. Sharman 90

RADIOBIOLOGY

Significance of Adrenals for Increased Oxygen Consumption in Rats during Irradiation.—Dr. A. Vacek 90
Hazard of Tritium as a Deoxyribonucleic Acid Label in Man.—R. Oliver and Dr. L. G. Lajtha 91

BIOLOGY

Age Determination in the Harbour Seal, *Phoca vitulina* L.—A. W. Mansfield and H. D. Fisher 92
Anomalies in the Microscopic Structure of Some Wools.—T. D. Brown and W. J. Onions 93
Unusual Web Pattern made by an Unfertilized Female of the Spider *Uloborus walckenaerius* Latreille.—Dr. Rasza Szlep 94
Perfect Stage of *Microsporum gypseum*.—Dr. D. M. Griffin 94
Occurrence of the Slipper Limpet, *Crepidula fornicata* L., in Ireland.—D. C. Arnold 95
A Mesozoic Microflora from South Africa.—A. R. H. Martin 95
Cell Wall Formation in Spores of the Fungus *Allomyces*.—J. M. Aronson and Prof. R. D. Preston, F.R.S. 95

ENTOMOLOGY

Mechanisms of Resistance of the Adult Housefly (*Musca domestica*) to 'Cyclodiene' Insecticides.—Dr. G. T. Brooks 96
Effect of Sub-Zero Temperatures on Diapause Eggs of *Acheta commodus* (Walk.).—T. W. Hogan 98
Nervous Control of Movements in the Foregut of *Schistocerca gregaria* Forsk.—Dr. K. U. Clarke and H. Grenville 98
Environmental Determination of Sex in a Parthenogenetic Parasite.—F. Wilson and L. T. Woolcock 99
Selection for High-Order Resistance to 'Dieldrin' in *Lucilia cuprina* Wied.—G. J. Shanahan 100

BACTERIOLOGY

Enhancement of Staphylococcal Virulence for Mice by Intraperitoneal Cortisone Acetate, Cholesterol and Lecithin.—Dr. Daniel Amsterdam and Dr. S. Stanley Schneierson 101
Isolation of a Phagocytosis-inhibiting Substance from Culture Filtrates of an Encapsulated *Staphylococcus aureus*.—Dr. Stephen I. Morse 102

MISCELLANY

Arrow Symbol in Biology.—Dr. A. E. Needham 103
A Simple Method for obtaining Perforated Supporting Membranes for Electron Microscopy.—V. Drahoš and A. Delong 104

★ READY MID-APRIL ★

Principles of Semiconductor Device Operation

A. K. JONSCHER, PH.D.

Research Laboratories of The General Electric Co. Ltd., Wembley

This book should fill a notable gap in semiconductor literature. It sets out to deal systematically with the broad subject of injection, transport and decay of excess carriers in semiconductors. It presents the complete account of transport laws for excess carriers, a complete theory of junction diodes including current flow at high and very high densities, as well as the theory of carrier transport in inhomogeneous media. Transistor topics are discussed from the same point of view and the operation of certain new devices is presented. 30*s.* *net*

★ 2ND PRINTING OF 2ND EDITION ★

Andrade

AN APPROACH TO MODERN PHYSICS

NEW SCIENTIST: 'This is a book which can be read with pleasure and profit not only by any layman and any scientist, but also by professional physicists . . . there is hardly any important development of modern physics (pure or applied) which has not been woven into the fabric of this book.'
Illustrated 27*s.* 6*d.*

Physics & Electronics in Physical Medicine

A. NIGHTINGALE
M.A., PH.D., F.INST.P.

Senior Lecturer, St. Thomas's Hospital Medical School

This textbook has been written to meet the needs of medical students, physicians, neurologists, physiotherapists and specialists in physical medicine, especially for physiotherapists starting their training for the Preliminary Examination of the Chartered Society and for postgraduate students reading for the Diploma in Physical Medicine of the Royal College of Physicians and Surgeons. 30*s.*

Drawings of British Plants

STELLA ROSS-CRAIG, F.L.S.

BRITISH MEDICAL JOURNAL: 'This is one of those rare works that deserve the name of masterpiece.' Parts I–XIII now available. Part XIV ready summer 1960. Prospectus on application.

G. Bell & Sons, Ltd., 6 Portugal St., London, W.C.2

BELL

GRIFFIN
Established in 1820

PASCALINE DAUDEL
Chargée de Recherches at the Radium Institute, Paris

RADIOACTIVE TRACERS
IN CHEMISTRY AND INDUSTRY

Text augmented and revised by the Author

Translated by
ULLI EISNER, Ph.D., D.I.C.

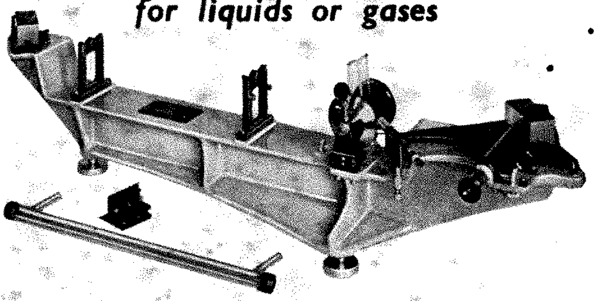
This English version of Mme. Daudel's monograph—specially revised and enlarged for publication in this country—meets the need for an introductory text dealing with the chemical and industrial uses of radioactive tracers, as distinct from the biological. Aspects of the subject discussed include the preparation of radio-indicators, their use in investigating the mechanism of chemical reactions, and their special advantages in chemical analysis on a micro scale. Electrochemical and metallurgical applications, as well as control devices for industrial processes, are also considered.

212 pages. Very full bibliographies. With 30 diagrams, 9 tables, and 3 plates. 36s. net.

CHARLES GRIFFIN & COMPANY LIMITED
42 DRURY LANE WC2
LONDON

PRECISION BS INSTRUMENTS

Jamin Refractometer
for liquids or gases



Average accuracy in measurement of refractive index is approximately 0·000001 for gases and 0·000002 for liquids.
The elimination of all spring adjustment to the mirrors results in great stability and freedom from vibration. Worm wheel gearing actuates the compensator. Tubes up to 50 cm. length can be used.

Bellingham & Stanley Ltd.
DEPT. N, 71 HORNSEY RISE, LONDON, N.19
PHONE: ARCHWAY 2270
Sole distributors in U.K. for Schott Monochromatic Interference Filters

Water Analysis

Water analysis is one of many problems to which the Unicam SP.900 Flame Spectrophotometer offers a powerful new approach. Effluents, boiler feeds, textile treatment, brewing and foodstuffs, dyeing—in these and many other uses of water it is necessary to know the concentration levels of a large number of inorganic elements. It is frequently found that the quickest, most sensitive method of determination is the flame spectrophotometer.

If your problem is water analysis—or any other difficulty in inorganic analysis—write now to learn how the SP.900 Flame Spectrophotometer brings new precision, new ease and speed, new levels of accuracy to existing problems and provides the answer to many new ones.

UNICAM

SP.900 FLAME SPECTROPHOTOMETER

UNICAM INSTRUMENTS LIMITED · ARBURY WORKS · CAMBRIDGE

U197

NATURE

No. 4720 SATURDAY, APRIL 16, 1960 Vol. 186

CONTENTS

Page

A Staff College for Technical Teachers 185

Rocket Propulsion. By J. E. P. Dunning 186
Neutron Physics. By Dr. P. A. Egelstaff 187
Insect Photography. By H. Oldroyd 187
Meyrick's Microlepidoptera. By R. G. Fennah 188
Problems of Human Fertility. By Dr. Kenneth Walker 188
Textile Engineering. By Prof. C. S. Whewell 189
Bonds between Rubber and Metal. By Dr. W. C. Wake 189

The Royal Society's Expedition to Halley Bay during the International Geophysical Year. By Sir Graham Sutton, C.B.E., F.R.S. . 191
The Teaching of Veterinary Anatomy as a Branch of Biology. By Dr. R. A. Green 192
Ribonucleic Acids and the Synthesis of Cellular Proteins. By Prof. J. Brachet 194
The Agadir Earthquake of February 29. By Ernest Tillotson . . . 199

Obituaries:
Dr. W. F. P. McLintock, C.B. By Prof. C. F. Davidson, O.B.E. . 200
Prof. S. A. Mitchell. By Prof. F. J. M. Stratton, O.B.E., F.R.S. . 200
Dr. George A. Edwards 201

News and Views 201

The Carnegie Institution of Washington 207
Status and Development of the Teaching of Chemistry. By Prof. T. S. Wheeler 208
Water Pollution by Trade Effluents 210
Iridium–Platinum Alloys 211
Development of Learning in the Rhesus Monkey 211
Scientific Research in Antarctica 212
Visual Pigment of the Horseshoe Crab, *Limulus polyphemus*. By Dr. Ruth Hubbard and Prof. George Wald 212
Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in Animal Cells and its Bearings on Cancer. By Prof. A. Sibatani, K. Yamana, K. Kimura and T. Takahashi 215
Chlorophyll Content of Gibberellin-treated Wheat Seedlings. By Prof. Frederick T. Wolf and Dr. Alan H. Haber 217
Protein Components from Turnip Yellow Mosaic Virus. By Dr. J. M. Kaper 219
Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-Methyl*iso*thiazole): a New Antibacterial Sulphonamide. By A. Adams, W. A. Freeman, A. Holland, D. Hossack, J. Inglis, Miss J. Parkinson, H. W. Reading, K. Rivett, R. Slack, R. Sutherland and R. Wien 221

(Continued overleaf)

8. 12. 60.

INDEX

Pure Chemistry Library.
SCIENCE COLLEGE.
92, Upper Circular Road.
CALCUTTA.

AARONSON, Dr S., and Lessie, T. : Nonulosaminic Acid (Sialic Acid) in Protists, 719
Abbott, Prof. B. C., and Baskin R. J. : Determination of Small Rapid Volume Changes in a Muscle during Activity, 1055
Abel, Pamela, and others : Reactivation of Poxviruses by a Non-Genetic Mechanism, 992
Ability (Plaque-forming), of Urea- or Phenol-treated T_2 Coli-Phage Preparations (Dr. P. H. Hofschneider), 330
Abnormalities (Chromosome), in Man (Dr. C O. Carter), 683
Abnormalities (Foliar), including Repeated Branching and Root Formation, induced by Kinetin in Attached Leaves of *Marsilea* (Dr A. Allsopp and Aliqa Szweykowska), 813
ABO Blood Groups (Dr. A. E. Mourant, Ada C. Kopeć and Kazimiera Domaniewska-Sobczak), *review* by Dr. F. Stratton, 581
'Abominable Snowman'. A Reconstruction of the Foot of the (W. Tschernezky), 496
Abraham, Dr. E. P. : Appointed reader in chemical pathology at the University of Oxford, 767
Abrahams, Harold M. (edited by) : Britain's National Parks, *review*, 70
Abrupt and Delayed Effects of Insulin on the Distribution Space of Glucose in the Dog (Dr. G. Hetenyi, jun., and Prof. G. A. Wrenshall), 808
Abscising Fruits (Adhering and), of Peach treated with N-1-Naphthyl Phthalamic Acid : A Comparison of (Prof. Loyd E. Powell and Charlotte Pratt), 814
Absence of Catecholamines in Cardioactive Acetone Extracts of Ox Spleen (Dr. L. B. Cobbin and Prof. R. H. Thorp), 473
Abson, W. : Nuclear Electronics, *review*, 583
Absorption (Solar Cap), of Cosmic Noise. A Relation between Solar Radio Emission and (Dr M. R. Kundu and Prof. F. T. Haddock), 610
Absorption Spectra of Diatomic Radicals containing Boron or Silicon (Dr. B. A. Thrush), 1044
Absorption Spectroscopy (Atomic) : Determination of Calcium in Blood Serum by (J. B. Willis), 249
Abstract Algebra : A Concrete Approach to (Prof W. W. Sawyer), *review*, 69, 440
Abstracting Scientific Information, 358
Abundances of the Rare-Earth Elements, Lanthanum to Lutetium, in Chondritic Meteorites (Dr. R. A. Schmitt, A. W. Mosen, C. S. Suffredini, J. E. Lasch, Dr. R. A. Sharp and D. A Olehy), 863
Academic Research and Development : United States Expenditure on, 1016
Academy of Sciences of the U.S.S.R. : To publish a collection of Reference Books on Mineralogy, 203
  Bibliographical Index of Literature in Russian Language for 1958, 359
  Magneto-Ionosphere Disturbances, 359
Accelerated Motion in the Theory of Relativity : Analysis of (Robert T. Jones), 790
Accidental Mortality of Guppies exposed to Elevated Temperature : Sex Difference in (Prof. John A. Freeman), 491
Accidents (Road) : Proneness of Drivers to (Dr R. J. Smeed), 273
Accidents (Traffic), and Driver Characteristics (Sauli Hakkinen), 273
Accumulation of Substrate by Isolated Rat Diaphragm—a Possible Mechanism for the Anti-Inflammatory Action of Corticosteroids (Prof. Ira G. Wool), 728
β-Acetamidoglutarate (Diethyl) : Requirements for Stereospecificity in Hydrolysis by Chymotrypsin—A (Prof Saul G Cohen and Ezra Khedouri), 75
Acetate (Cortisone), Cholesterol and Lecithin : Enhancement of Staphylococcal Virulence for Mice by Intraperitoneal (Dr. Daniel Amsterdam and Dr. S. Stanley Schneierson), 101
Acetobacter aceti : Pigment-producing Strains of (J G. Carr and J. L. Shimwell), 331
Acetone Extracts (Cardioactive), of Ox Spleen · Absence of Catecholamines in (Dr. L. B. Cobbin and Prof R. H. Thorp), 473
6-O-Acetyl-α-Glucose : Synthesis of (Y. Z. Frohwein and Prof. J. Leibowitz), 153
Acetylation of 4-Quinazolone (R. Mirza), 716
Acetylcholine in Rat Diaphragm : Release of (K. Krnjević and J. F Mitchell), 241
Acetylcholine in the Rat's Brain : Effect of Methylpentynol on (Giancarlo Pepeu and Prof. Nicholas J. Giarman), 638
Acetylcholine Administration : Intracellular Potentials in Rat Atria during and after Vagal Stimulation or (P. A. Bierstaker, J. Th. F. Boeles and L. N. Bouman), 637
Acetylene (Methyl) : Decomposition of (F. Fitzgerald), 386
Acheson, Dr. Roy : Human Growth (Effects of Malnutrition and Illness on Growth), 20
Acheta commodus (Walk.) : Effect of Sub-Zero Temperatures on Diapause Eggs of (T. W. Hogan), 98
Achievement of Man-powered Flight (Financial grants from the Royal Aeronautical Society Man Powered Aircraft Group, for promising projects designed to further the), 1020
Acid-soluble Nucleoside 5'-Monophosphates : Heterogeneous Labelling of, during Short *in vivo* Incubation with Phosphate-^{32}P (Dr. T. D. Price, K. K. Tsuboi, H A Hinds and P. B. Hudson), 158
Acidic Dissociation Constant of Alcoholic Hydroxyls of Oxycarboxylic Acids—Mandelic Acid (Dr. M. T. Beck and M. Halmos), 388
Ackee Toxin, a Riboflavin Antimetabolite? (H. C. Fox and D. S. Miller), 561
Acoustic Radiation Impedance of Rigid Pistons in an Array : Measurements of the Total (J. S. M Rusby), 144
Acoustic Tiles for Noise Control, 602
Actinomycins and their Importance in the Treatment of Tumours in Animals and Man (New York Academy of Sciences Conference on), 771
Action of a Bacterial Dextranase on Branched Dextrans (R. W. Bailey, Dr. D. H. Hutson and Dr. H. Weigel), 553
Action of Graphite as a Lubricant (W. Bollmann and J. Spreadborough), 29
Action of the Heart : Korotkov's Sounds— (Wing-Comdr. J. E. Malcolm), 723
Action of Ionizing Radiations on Water : Primary Processes in the—Formation and Reactivity of Self-trapped Electrons ('Polarons'), (Prof. Joseph Weiss), 751
Action (Anti-Inflammatory), of Corticosteroids : Accumulation of Substrate by Isolated Rat Diaphragm—a Possible Mechanism for the (Prof. Ira G. Wool), 728
Action (Antipyretic), of *l*-Phenyl-3,5-pyrazolidinedione (Salah A. Tawab, Prof. Ahmed Mustafa and Mohamed Kira), 165
Action (Milk-ejecting), of Ergot (Prof. Ranjit Roy Chandhury and Mandakini B. Dikshit), 722
Action (Peroxidase) : Enhancement of, by Polysaccharides (Dr. B. Z. Siegel and Dr. S. M. Siegel), 391
Action (Synergetic), of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia (Dr. E Fischer, J. L. J Szabó and M. Stamburgo), 893
Action Potentials in Active Tissue with Delayed Potassium Permeability (Dr. E. P. George), 889
Action Potentials (Extracellular Unit), from the Central Nervous System : 'Weightless' Micro-electrodes for Recording (Prof. B. Delisle Burns and Dr. J. G. Robson), 246
Active Nitrogen : Reaction of, with Polyethylene (Dr. J. L. Weininger), 546
Active Steroids (Hormonally) : A New Class of (Dr. E. H. Reerink, H. F. L. Scholer, P. Westerhof, A. Querido, A. A. H. Kassenaar, E. Diczfalusy and K. C. Tillinger), 168
Active Tissue : Action Potentials in, with Delayed Potassium Permeability (Dr E. P. George), 889
Active Transport of γ-Aminobutyric Acid in Brain Cortex Slices, with special reference to Phosphorus-32 Turnover in Phospholipids in Cytoplasmic Particulates (Yasuzo Tsukada, Yutaka Nagata and Shusuke Hirano), 474
Activities (Geomagnetic) : Correlation of Occurrence of Whistlers with (Atsushi Kimpara), 230
Activity : Determination of Small Rapid Volume Changes in a Muscle during (Prof B. C. Abbott and R J Baskin), 1055
Activity of Muscle Receptors in the Kitten (Dr. Sten Skoglund), 478
Activity in relation to *p*H of Myosin-5'-Nucleotidase (Darcy Gilmour), 295
Activity (Antibacterial), of Surface-Active Compounds : Methods for the Evaluation of the (Society for Applied Bacteriology and the Microbiology Group of the Society of Chemical Industry Symposium on), 131, *erratum*, 206
Activity (Biological), of Pregnant Mare Serum Gonadotropin : Effect of *p*H on (Bengt H. Persson and Stig E. J. Melander), 163
Activity (Bradykinin), of some Synthetic Peptides with only Slight Structural Resemblance to Natural Bradykinin (Dr. G. L. Tritsch and Prof. D. W. Woolley), 76
Activity (Cardiac), in Quantitative Tissue Culture Effect of Supernatant Potassium-Level on (Prof. A. W. B. Cunningham, K. Kleutch and W. Herbst), 241
Activity (Dipeptidase), of Brain (L. Lahut Uzman, Marilynn K. Rumley and Stanley van den Noort), 559
Activity (Higher Nervous) *Pavlov Journal of* (translated from the Russian), 935
Activity (5-Hydroxytryptophan Decarboxylase) : Development of, in Rat Kidney (Dr. Irene Huang, Sheila Tannenbaum and Dr David Yi-Yung Hsia), 717
Activity (Metabolic) · Neurokeratin Network of the Peripheral Nerve Fibre Myelin Sheath as a Centre of (Dr H. B. Tewari and Prof. Geoffrey H. Bourne), 645
Activity (Phagocytic), of the Reticulo-Endothelial System : Duration of Stimulation of, after Cessation of Treatment with Diethylstilboestrol (C C. Ware and Prof T. Nicol), 974
Activity (Pyrophosphatase), in Reticulocytes : Gluathione Stability and—Direct Evidence for the Importance of Glutathione for the Enzyme Status in Intact Cells (Prof. S. Rapoport and D. Scheuch), 967

INDEX

Acton, Dr. Forman S., and others : Improvement of the Intravenous Glucose Tolerance Test, 808
Actuaries, Institute of : Election of Officers for 1960-61, 127
Acute Whole-Body Dose of X-Rays : Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in Rats receiving an (Prof. J. Maisin, P. Dumont and A. Dunjic), 487
Adams, A., and others : Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methyl*iso*thiazole), a New Antibacterial Sulphonamide, 221
Adams, A. M., and others . A Technique for Sampling Oxide Layers and Brittle Materials for Microdiffraction, 147
Adams, J. B. : Appointed interim director-general of the European Organization for Nuclear Research (CERN), 523
  Identification of Isomeric Chondroitin Sulphates, 555
  Obituary of Prof. C. J. Bakker, 761
Addiction-producing Drugs : Tenth Report of the Committee on (World Health Organization, Technical Report Series No. 188), 1018
Addink, Dr. N. W. H. : Subnormal Level of Carbonic Anhydrase in Blood of Carcinoma Patients ?, 253
Addison, Dr. Cyril Clifford : Appointed professor of inorganic chemistry in the University of Nottingham, 767 ; work of, 767
Addition Compounds between Copper Complexes and Organic Bases (R. C. Traill), 631
Adenine Dinocleotide (Nicotinic Acid) : Excretion of Nicotinic Acid and, by Biotin-deficient Yeast (Dr. Anthony H. Rose), 139
Adenine Nucleotides and Thyroxine (Succinate,) . Swelling of Fresh and Aged Liver Mitochondria as affected by (Dr. P. Emmelot, C. J Bos, P. J. Brombacher and I. H. M. Reyers), 556
Adenosine-5'-phosphate : Crystal Structure of (J. Kraut and L. H. Jensen), 798
Adenosine Triphosphate : Effect of Electrical Stimulation on a Muscle Fibre Model in the Presence of (Prof. Masahiro Fujino, Tatsuaki Matsushima, Tomizo Muroya, Hideyo Yabu, Saburo Yamaguchi and Masaki Takahashi), 318
Adenosine Triphosphate in Bacterial Photosynthesis : Equivalence of Light and (Dr. M. Losada, Dr. A. V. Trebst, S. Ogata and Prof Daniel I. Arnon), 753
Adenosine Triphosphate (^{32}P-) Exchange Reaction in Rat Liver Mitochondria : Effects of Fatty Acids on the (K. Ahmed and Dr. P. G Scholefield), 1046
Adenosine Triphosphate and Glycogen in the Liver : Changes in the Levels of, caused by Protein Administration (Dr. Catherine M. Clark, Dr. G. A J. Goodlad, Dr. J Chisholm and Dr. H. N. Munro), 719
Adenovirus Materials (Non-infectious) : Antigenic Structure of (Dr. H. G. Pereira), 571
Adhering and Abscising Fruits of Peach treated with N-1-Naphthyl Phthalamic Acid : A Comparison of (Prof. Loyd E. Powell and Charlotte Pratt), 814
Adipose Tissue : Coenzyme A Content of (Marilyn M. Thompson and Prof. Jean Mayer), 640
Adkins, Dr. C. J. Awarded first prize (Home Awards) of the Darton Prizes of the Royal Meteorological Society, 440
Adlard, E. R., and Hill, D W. : Analysis of Anaesthetic Mixtures by Gas Chromatography, 1045
Administration . Scientists and (T. H. Hawkins), 446
Administration of β-Amino*iso*butyric Acid to the Mouse : Urinary Excretion of a Ninhydrin-positive Compound, probably a Peptide, after (Dr James B. Gilbert and Dr. Yuoh Ku), 160
Administration of Tritiated Water : Saliva–Serum Ratios of Tritium after the (Dr. A. J. Coppen and Dr. J. L. Gibbons), 724
Administration (Acetylcholine) . Intracellular Potentials in Rat Atria during and after Vagal Stimulation or (P. A. Biersteker, J. Th. F. Boeles and L. N. Bouman), 637
Administration (Lysozyme and Egg-White) : Increase in 'Alkaline' Ribonuclease of Rat Kidney Cortex after (Dr. T. Maack, Dr. R. Brentani and Dr. M. Rabinovitch), 158
Administration (Protein) . Changes in the Levels of Adenosine Triphosphate and Glycogen in the Liver caused by (Dr. Catherine M. Clark, Dr. G. A. J. Goodlad, Dr. J Chisholm and Dr. H. N. Munro), 719
Adrenalin : Membrane Potential Changes associated with Stimulation of Smooth Muscle by (G. Burnstock), 727
Adrenals : Significance of, for Increased Oxygen Consumption in Rats during Irradiation (Dr. A. Vacek), 90
Adsorption in Double Layers involving Solid Metals Determination of (Dr. Erik A. Blomgren and Dr. John O'M. Bockris), 305
Adsorption of Helium on Carbons—Influence on Measurement of Density (Dr. F. A P. Maggs, P. H. Schwabe and J. H Williams), 956
Adsorption (Carboxylic Acid), to Steel · Effect of Moisture on (M. E. Schrader and J L. Kalinsky), 710
Adsorption (*T1* and λ Phage), on Protoplast-like Bodies of *Escherichia coli* (Dr. P. H. Hofschneider), 568
Adult *Amoeba lescherae* : Recovery of, from Dried Cultures (Monica Taylor), 329
Adult Education, National Institute of : Residential Short Courses, 685
Adult Housefly (*Musca domestica*) : Mechanisms of Resistance of the, to 'Cyclodiene' Insecticides (Dr G T. Brooks), 96
Adult Male and Nymph Development Stages of *Triatoma infestans* : Non-Identity of Triosephosphate Dehydrogenase of (Prof. M. Agosin, A. Neghme and N Scaramelli), 1052
Adult Rat : Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the (S. L Liu), 475
Adult Rat inoculated after Birth with Rous Sarcoma Tissue : Presence of Chicken Tumour Virus in the Sarcoma of the (Dr Jan Svoboda), 980
Advanced Technology, Birmingham College of : Appointment of K. L. Stretch as vice-principal, 12
Advancement of New States : Science in the (Weizmann Institute of Science International Conference on), 604
Advances in Aeronautical Sciences—Proceedings of the First International Congress on the Aeronautical Sciences, Madrid 1958 (edited by Th. von Kármán, A. M. Ballantyne, R. R. Dexter, H. Blenk, H. L. Dryden and M. Roy), *review* by Prof A. R. Collar, 665
Advances in Agronomy (edited by A. G. Norman), Vols. 10 and 11, *review* by G. V. Dyke, 1000
Advances in Coconut Research in India : Recent (Indian Central Coconut Committee Conference on), 860
Advances in Ophthalmology : Vol. 13, Documenta Ophthalmologica (edited by G. von Bahr, G B. Bietti, J. ten Doesschate, H. Fischer von Bunau, J. Francois, H. Goldman, H. K Muller, Jean Nordmann, A. J. Schaeffer and Arnold Sorsby), *review* by R. C. Davenport, 42
Advances in Plant Physiology, *review* by Prof. W. Stiles, 747
Advances in Veterinary Surgery, *review* by G. N. Gould, 667
Advisory Committee on Poisonous Substances in Agriculture and Food Storage : Appointment of Sir Charles Dodds as chairman, 934
Advisory Council (Northern), on Further Education : Training of Technical Teachers, 281
  Report for 1958-59, 281
Advisory Group for Aeronautical Research and Development (NATO) : AGARDograph No. 31, Explosions, Detonations, Flammability and Ignition, Part 1 (Prof. S. S. Penner) ; Part 2 (B. P. Mullins), *review* by Dr. H F. Coward, 666
  Meeting on Ionospheric Research, 685
  Discussion on Boundary Layer Research, 1022
Advisory Water Committee (Central) : Final Report of the Trade Effluents Sub-Committee (Ministry of Housing and Local Government), 210
Ady, Peter (edited by) : Inventory of Economic Studies concerning Africa South of the Sahara—an Annotated Reading List of Books, Articles and Official Publications (Commission for Technical Co-operation in Africa South of the Sahara, CSA/CCTA Publication No 30, Joint Project No. 4), 202
Aerial Contamination of Agricultural Land : An Assessment of the Quantities of Fission Products likely to be found in Milk in the Event of (Dr. R. J. Garner), 1063
Aerial Photogrammetry (École Nationale des Sciences Géographiques Theoretical and Technical Course on), 127
Aeronautical Research and Development, Advisory Group for (NATO) : AGARDograph No. 31, Explosions, Detonations, Flammability and Ignition, Part 1 (Prof S. S. Penner) , Part 2 (B. P. Mullins), *review* by Dr. H F Coward), 666
  Meeting on Ionospheric Research, 685
  Discussion on Boundary Layer Research, 1022
Aeronautical Sciences : Advances in—Proceedings of the First International Congress on the Aeronautical Sciences, Madrid 1958 (edited by Th von Kármán, A. M. Ballantyne, R. R. Dexter, H. Blenk, H. L. Dryden and M. Roy), *review* by Prof. A. R. Collar, 665
  Aspects of, *review* by Prof. A. R Collar, 665
Aeronautical Sciences, Institute of (United States Air Force Office of Scientific Research and the) : Second Annual Astronautics Symposium—Vistas in Astronautics, Vol. 2 (edited by Morton Alperin and Hollingsworth F. Gregory), *review* by D. G King-Hele, 59
Aeronautical Society (Royal) : Honorary Fellowships conferred on Prof. W J Duncan and Sir George Edwards, 685
  Financial grants from the Man Powered Aircraft Group for promising projects designed to further the achievement of man-powered flight, 1020
Aeronautics, College of : Appointment of J. R Ellis as professor of automobile engineering and first director of the Advanced School of Automobile Engineering at Cranfield, 762
Aether and Matter (Larmor's) : A Forerunner of Twentieth Century Physics—a Re-view of (Lancelot Law Whyte), 1010
Aetiology of Infective Diseases (Prof. Reginald Lovell), *review* by Dr. G. Lapage, 581
Affairs (World) · Present Problems in (Le Play Society Conference on), 606
Affinities of the New Olduvai Australopithecine (Dr. J. T. Robinson), 456 ; (Dr. L. S B. Leakey), 458
Africa Nature Conservation in, 935
Africa South of the Sahara : Inventory of Economic Studies concerning—an Annotated Reading List of Books, Articles and Official Publications (edited by Peter Ady), (Commission for Technical Co-operation in Africa South of the Sahara, CSA/CCTA Publication No. 30, Joint Project No. 4), 202
Africa South of the Sahara, Scientific Council for . Publication No. 37, Tenth Meeting of the Science Council, Kampala (1959), 502
Africa (East) : Agricultural Insects of (compiled by R. H. Le Pelley), *review* by Dr Kenneth Mellanby, 65
Africa (East) High Commission . East African Agriculture and Forestry Research Organization—Record of Research for 1958, 133
Africa (South) : A Mesozoic Microflora from (A. R H. Martin), 95
  True's Beaked Whale from the South-East Coast of (F H. Talbot), 406
Africa (South), Royal Society of : Election of Officers and Council for 1960, 766
Africa (West) . Blindness in (Prof. F. C. Rodger), *review* by R. C. Davenport, 64
  Variation in *Phytophthora palmivora* (Butl.) Butl on *Theobroma cacao* L. in (P. D Turner), 495
African Cultures, *review* by G. W. B. Huntingford, 38
  Continuity and Change in (edited by William R. Bascon and Melville J. Herskovits), *review* by G. W. B. Huntingford, 38
African (Central) Savannahs, *review* by J. P. M. Brenan, 505
African (East) Agriculture and Forestry (Dr. E. C. Humphries), 133
African (East) Agriculture and Forestry Research Organization : Record of Research for 1958 (East Africa High Commission), 133
African (South) Council for Scientific and Industrial Research : Register of Current Scientific Research at South African Universities, 1959 (edited by D. Ryle Masson), 854
African (South) Universities Register of Current Scientific Research at, 1959 (edited by D Ryle Masson), (South African Council for Scientific and Industrial Research), 854
African (West) Flowers A Handbook of (Harold N. Saunders), *review* by J. P. M. Brenan, 65
Africans (East) : Glucose-6-Phosphate Dehydrogenase Deficiency in Red Blood Cells of (Dr. A. C. Allison), 531
l'Afrique Centrale : Les Savanes de (Roger Sillans), *review* by J. P. M. Brenan, 505
Agadir Earthquake of February 29 (Ernest Tillotson), 199
Agar Cells (Lipophilic) · Diffusion of Proteins through (Dr. Ch. Wunderly), 885
Agar-Gel Electrophoresis · Variations in Electrophoretic Position of Haptoglobin Mixtures in (Dr Jan Hirschfeld), 894

INDEX

Agar-Gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_2-Globulin Region of Norman Human Sera (Dr. Jan Hirschfeld), 321
Agar-Gel (Starch–) Electrophoresis of Tuberculoproteins from Heated Culture Filtrates (T P. Dekker), 392
AGARDograph No. 31, Explosions, Detonations, Flammability and Ignition, Part 1 (Prof S. S Penner) ; Part 2 (B. P. Mullins), (NATO Advisory Group for Aeronautical Research and Development), *review* by Dr H. F. Coward, 666
Agassiz Medal of the United States National Academy of Sciences awarded to Dr. Anton Frederick Bruun, 686
Age of Emplacement of Granites (Dr. W Compston, Dr. P M. Jeffery and G. H. Riley), 702
Age of the Father : Dependence of the Sex Ratio at Birth on the (Dr. Leo Szilard), 649 ; (Dr A. Comfort), 1065
Age (Body-Weight and), in relation to the Metabolic-Rate of the Young Pig (Dr L. E. Mount and J G. Rowell), 1054
Age (Physiological), for Female *Glossina morsitans* : Determination of (D S. Saunders), 651
Age Changes in Performance : Construct 'Reactive Inhibition' in the Interpretation of (Dr S Griew and Dr. R. Lynn), 182
Age Determination in the Harbour Seal, *Phoca vitulina* L. (A. W Mansfield and H D. Fisher), 92
Age Difference in Nicotinamide Mononucleotide Synthesis by Human Erythrocytes (Dr. Vlastimil Habermann and Sona Habermannová), 389
Aged Liver Mitochondria (Fresh and) : Swelling of, as affected by Succinate, Adenine Nucleotides and Thyroxine (Dr. P. Emmelot, C. J. Bos, P. J. Brombacher and I. H. M. Reyers), 556
Ageing : Research Programmes in (United States Department of Health), 852
Ageing Neurons of some Teleosts : Cytoplasmic Inclusions of the (Prof. A. Stolk), 332
Ageing and Research, 852
Ager, Dr. D V Appointed to the University of London readership in geology at the Imperial College of Science and Technology, 522
Ages (Exposure), for Iron Meteorites (Oliver A. Schaeffer and David E. Fisher), 1040
Aggregating Proteins in the Ultracentrifuge : Concentration-Dependent Sedimentation of (Dr. G. A Gilbert), 882
Agosin, Prof M , and others : Non-Identity of Triosephosphate Dehydrogenase of Adult Male and Nymph Development Stages of *Triatoma Infestans*, 1052
Agricultural Botany, National Institute of : Thirty-ninth Report (1958), 287
Agricultural Bureaux (Commonwealth) : Plants Recorded as Resistant to Root-Knot Nematodes (*Meloidogyne* spp), (Mary T. Franklin and D. J. Hooper), 684
Agricultural Engineers, Institution of Bursaries and a Scholarship, 284
Agricultural Insects of East Africa (compiled by R H. Le Pelley), *review* by Dr. Kenneth Mellanby, 65
Agricultural Land : An Assessment of the Quantities of Fission Products likely to be found in Milk in the Event of Aerial Contamination of (Dr. R. J. Garner), 1063
Agricultural Materials in the United Kingdom, 1958-59 : Strontium-90 in Milk and (Agricultural Research Council), 852
Agricultural Meteorology (Royal Meteorological Society Symposium on), 604
Agricultural Research Council : Studentships and Fellowships, 126
  A new Weed Research Organization, 436
  Appointment of Dr. E. K. Woodford as director of the Weed Research Organization, 436
  Report No. 2, Strontium-90 in Milk and Agricultural Materials in the United Kingdom, 1958-59, 852
Agricultural Research Council and the Medical Research Council : Joint Committee on Feeding Antibiotics to Farm Animals, 280
Agricultural Sciences in the Rockefeller Foundation, 681
Agricultural Society of England (Royal) Research Medal awarded to Prof. R. L Wain, 685
Agricultural Society of India : Election of Officers, 937
Agricultural, Animal Health and Forestry Research (Colonial), Committee for : Report for 1958-59, 501
Agriculture : Increase of Settlement Size and Population since the Inception of (Dr. Max Pettersson), 870
Agriculture (Tropical) : Nitrogen in (Australian Commonwealth Scientific and Industrial Research Organization Symposium on), 941
Agriculture, Fisheries and Food, Ministry of : Appointment of an Advisory Committee on the experimental and research work of the Infestation Control Laboratory, 361
Agriculture, Fisheries and Food, Ministry of, and others : Postgraduate Training Grants in Fishery Research, 360
Agriculture and Food Storage, Advisory Committee on Poisonous Substances in : Appointment of Sir Charles Dodds as chairman, 934
Agriculture and Forestry : East African (Dr. E. C Humphries), 133
Agronomy : Advances in (edited by A. G. Norman), Vols 10 and 11, *review* by G. V Dyke, 1000
  What is ?, *review* by G V Dyke, 1000
Ahmed, K., and Scholefield, Dr. P. G : Effects of Fatty Acids on the ^{32}P-Adenosine Triphosphate Exchange Reaction in Rat Liver Mitochondria, 1046
Aikat, B. K , and others : Foetal Haemoglobin in the Monkey, 977
Air : Mortality and Viability of Insect Migrants High in the (L. R. Taylor), 410
Air Density (Upper-Atmosphere), at the Height of 180-212 km. derived from the Orbit of *Sputnik III* Profile of (Z. V Bochníček), 460
Air Force (United States), and others : Conference on Coherence Properties of Electromagnetic Radiation, 127
Air Force Office of Scientific Research (United States), and Institute of Aeronautical Sciences : Second Annual Astronautics Symposium—Vistas in Astronautics, Vol 2 (edited by Morton Alperin and Hollingsworth F. Gregory), *review* by D G King-Hele, 59
Air Pressure : New Record Low Sea-Level (C. L. Jordan), 283
Aircraft Establishment (Royal) Promotion of D G A Rendel to Deputy Chief Scientific Officer and appointment as head of the Mechanical Engineering Department, 12
Aircraft Establishment (Royal), and Semiconductors, Ltd. : The *Corsair*, a Digital Differential Analyser, 201
Aircraft Research Models : 'Araldite' in, 360
Aircraft and Guided Missiles : Use of Miniature Gyroscopes in (W. R. Simons), 522
Aktiverte Essigsaure (Dr. Karl Decker), *review* by Prof. D. C. Harrison, 66
Alberta : *Anchiceratops* from the Oldman Formation of (Wann Langston), 522
Albumin (Bovine Serum) : Iodination of Specific Sites on (Dr. David Pressman and Dr. Gerald Radzimski), 1049
Albumin, Lecithin and Cephalin : Interaction between (Dr. Eric Ponder and Ruth V. Ponder), 235
Alcohol (Isoprenoid) Dolichol, a Naturally Occurring (J F. Pennock, F W Hemming and Prof R. A Morton), 470
Alcoholic Hydroxyls of Oxycarboxylic Acids : Acidic Dissociation Constant of— Mandelic Acid (Dr. M. T. Beck and M. Halmos), 388
Alcoholic Plant Extracts : An Ion-Exchange Resin Method for the Fractionation of (Dr. Dalton Wang), 326
Aldehyde (Vitamin A^1), in Hen's Eggs (Dr. P. A. Plack), 234
Aldehydes : Behaviour of some, on a Sulphonated Polystyrene Resin (Dr. S. A. Barker, K. Murray and Prof M. Stacey), 469
Aldrich, Dr. B. I , and Newman, E. L : Visco-Elastic Systems (Couette Viscometer designed for Testing Syrup), 943
Alexander, Prof. A. E. : Elected a Fellow of the Australian Academy of Science, 519
Algae (Calcareous) in a Sediment Core from the Mindanao Trough : Fragments of (H Horn af Rantzien), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No 7), 609
Algae and Aplanospores (Unicellular) : Living and Fossil (D. M. Churchill), 493
Algal Cytochrome, *Porphyra tenera*–Cytochrome 553 : Crystallization of an (Dr Sakae Katoh), 138
Algebra (Abstract) : A Concrete Approach to (Prof W. W. Sawyer), *review*, 69, 440
Ali, Prof M A. Influence of Environment on the Distribution and Form of Sponges, 177
Aliphatic Hydrocarbons : Radiation Labelling with Carbon-14 of (Fulvio Cacace and Angelo Guarino), 632
Alivisatos, Prof S. G. A. : Mechanism of the Gastric Secretion of Hydrogen Ions, 368
Alivisatos, Prof S. G. A , and others : Non-Enzymic Reactions of Indoles with Coenzyme I, 718
Alkaline Conversion of 4-Hydroxyphenylpyruvic Acid to 4-Hydroxybenzaldehyde (Dr C. H. Doy), 529
Alkaline Oxidation of Cellulose : Catalytic Effects in the (Dr. W. A. Bell), 963
Alkaline Phosphatase in the Meninges and in Meningiomas (Dr. W. J. Pepler), 979
'Alkaline' Ribonuclease of Rat Kidney Cortex : Increase in, after Lysozyme and Egg-White Administration (Dr. T. Maack, Dr. R. Brentani and Dr M Rabinovitch), 158
Alkaloids (Pyrrolizidine) : Detection of N-Oxides of the (A. T. Dann), 1051
Alkanoate Solutions (Cupric) : Nature of (Dr. D. P. Graddon), 715
Alkylating Reagents : Non-Protein Sulphydryl Group in the Original Strain and Sub-line of the Ascites Tumour resistant to (Iwao Hirono), 1059
Alkylation of Coal by Benzyl Chloride–Aluminium Chloride (M. S. Iyengar, D. D Banerjee and D K. Banerjee), 387
All-Union Mineralogical Society (East Siberian Division) : *Zapiski Vostochno-Sibirskogo Otdeleniya Vsesoyuznogo Mineralogicheskogo Obshchestva*, Vol. 1, No 1, 683
Allele (New), in the Kidd Blood Group System : Evidence for a, in Indians of Northern Mato Grosso, Brazil (Dr. Richard T. Silver, Jame M. Haber and Dr Aaron Kellner), 481
Allen, Prof. C. W. : The Sun and its Influence, *review*, 69
Allen, Prof. G. C. : British Industries and their Organization, fourth edition, *review* by R. Brightman, 70
Allen, Prof J F : A Supplement to 'Helium', *review*, 835
Allibone, Dr T E. : Nuclear Theory and its Utilization, *review*, 917
Allison, Dr. A. C. : Glucose-6-Phosphate Dehydrogenase Deficiency in Red Blood Cells of East Africans, 531
Allner, K (Macpherson, Dr I A , and) *L* Forms of Bacteria as Contaminants in Tissue Culture, 992
Allomyces (Fungus) : Cell Wall Formation in Spores of the (J. M Aronson and Prof. R D. Preston), 95
Allotropic Transformations in Plutonium (J D. Hill), 304
Alloy (Silver–Cadmium) : Thin Films of (K Bahadur and P. V. Sastry), 467
Alloys based on the Aluminium–Zinc–Magnesium System : A Trace Element Effect in (I J. Polmear), 303
Alloys (Iridium–Platinum) : Constitution and Properties of the (Dr A. S Darling), 211
Allsopp, Dr. A , and Szweykowska, Alicja : Foliar Abnormalities, including Repeated Branching and Root Formation, Induced by Kinetin in Attached Leaves of *Marsilea*, 813
Alper, Dr. Tikvah, and others : The Sigmoid Survival Curve in Radiobiology, 1062
Alperin, Morton, and Gregory, Hollingsworth F (edited by) : Vistas in Astronautics, Vol 2 (Second Annual Astronautics Symposium sponsored by the United States Air Force Office of Scientific Research and the Institute of Aeronautical Sciences), *review* by D. G King-Hele, 59
α-L-Fucosidase Mammalian (Dr. G A Levvy), 472
α-Ketogluratate and Succinate Oxidation in E-Deficient Liver Homogenates : Maintenance of, by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine (Dr. Laurence M Corwin and Dr. Klaus Schwartz), 1048
α-Lead Azide Radiation-induced Changes in (G. Todd and E. Parry), 543
α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine : Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by (Dr Laurence M Corwin and Dr Klaus Schwartz), 1048
α_2-Globulin Region of Normal Human Sera : Agar-gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an Indoxylacetate Splitting Component in the (Dr. Jan Hirschfeld), 321

αω-Dimethanesulphonoxyalkanes : Optical Properties of the (Dr. A. C. Bishop and Dr. R. D. Marshall), 74
α- and β-Chains of Globins : Separation of the, by means of Starch-gel Electrophoresis (C. J. Muller), 643
Altschule, Dr. Mark D., and others : Effects of Injection of Bovine Pineal Extract on the Nuclei of Rat Pineal Parenchymal Cells, 393
Aluminium Chloride (Benzyl Chloride—) : Alkylation of Coal by (M. S. Iyengar, D. D. Banerjee and D. K. Banerjee), 387
Aluminium Single Crystals : First Stage of Work Hardening in (N. A. McKinnon), 148
Aluminium–Zinc–Magnesium System : A Trace Element Effect in Alloys based on the (I. J. Polmear), 303
Alyavdin, V. F. : Mineralogy in the U.S.S.R., 853
Ambrose, Dr. D. : Gas Chromatography, 943
Ambs, William J. (Kruger, Jerome, and) : Reaction between Copper and Solid Oxygen condensed at Very Low Temperatures from a Gas Discharge, 794
Ambulatory and Domiciliary Medical Care : Role of Hospitals in—Second Report of the Expert Committee on Organization of Medical Care (United Nations, World Health Organization, Technical Report Series No. 176), 202
Amenities and Development in Britain, 265
America (Latin-) : Scientific Institutions and Scientists in (Unesco, Centro de Cooperacian Cientifica para America Latina), Vol. I, Paraguay ; Vol 2, Chile, 203
American Chemical Society : Scientific Russian without Tears (Prof. J. W. Perry), 359
American College Graduates : Marriage-Rate of, 22
American Cyanamid Company : Lederle Medical Student Research Fellowships, 283
American Geographical Society : Grant of 2,500 dollars from the Asia Foundation, to aid Asian libraries and Asian scholars temporarily in the United States, 126
American Industry : Science and Engineering in—Report of a 1956 Survey (United States National Science Foundation), 763
American Journal of Science : Publication of a 'Festschrift' in appreciation of the work of Dr. W. H. Bradley, chief geologist of the United States Geological Survey during 1944-59, 934
American Philosophical Society : Proceedings, Vol. 103, No. 4, A Blood Parasite from the California Yellow-legged Frog (Donald L. Lehmann), 765
  Yearbook for 1959, 850
American Phytopathological Society : Plant Pathology, Problems and Progress, 1908-1958 (edited by C. S. Holton, G W. Fischer, R W Fulton, Helen Hart and S. E. A. McCallan), *review* by W. C. Moore, 47
American Species of the Genus *Psaronius* : The Morphology and Anatomy of (Jeanne Morgan), *review* by Prof. John Walton, 190
Amide Nitrogen Content of Ovomucoid (Dr. R. D Marshall and Prof. A. Neuberger), 311
Amines (Catechol) : Effects of 1,4-Dihydrazinophthalazine on the (M. Bygdeman and L. Stjärne), 82
Amines (Catechol), Dihydroxyphenylalanine and 5-Hydroxyindoles : Vanadium Catalysis of the Oxidation of (Dr. G. M. Martin, E. P. Benditt and N. Eriksen), 884
Amini, E. : Appointed lecturer in mechanical engineering at the University of Birmingham, 522, 767
Amino-Acid Composition of Proteins from Surface Tissue of the Tongue (Dr. C. J. Barnes and Dr L. N. Ferguson), 617
Amino-Acids : Antioxidative Effect of (Dr. Reinhard Marcuse), 886
  Localization of, for Histochemical Estimation (Helen M Notovny and Robert G. Owens), 1057
3-Amino-1,2,4-triazole : Effect of, on the Experimental Production of Liver Cancer (Munemitsu Hoshino), 174
γ-Aminobutyric Acid in Brain Cortex Slices : Active Transport of, with special reference to Phosphorus-32 Turnover in Phospholipids in Cytoplasmic Particulates (Yasuzo Tsukada, Yutaka Nagata and Shusuke Hirano), 474
S-β-Aminoethyl*iso*thiouronium Bromide Hydrobromide : Effect of, on X-Ray Damage to Guinea Pig Skin (Dr. J. B. Walter and Prof. D. Slome), 177
β-Amino*iso*butyric Acid : Urinary Excretion of Ninhydrin-positive Compound, probably a Peptide, after Administration of, to the Mouse (Dr. James B Gilbert and Dr. Yuoh Ku), 160
Aminopyrine Analgesia (Morphine, Dihydrocodeine and) : Synergetic Actions of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on (Dr. E. Fischer, J. L. J Szabó and M. Stamburgo), 893
Ammal, Dr. E. K. Janaki : Retirement from the directorship of the Central Botanical Laboratory, Allahabad, 519 ; work of, 519
Ammocoetes : Sex Ratio of (M. W. Hardisty), 988
Ammonia adsorbed on Silica–Alumina Catalysts : Infra-Red Spectra of (D. E. Nicholson), 630
Ammonia Plant (New), to be built at Severnside (Imperial Chemical Industries, Ltd.), 202
Amnion (Human) : Ultra-Structure of, and its Possible Relation to the Circulation of Amniotic Fluid (Dr. Gordon L. Bourne and Dr. Dennis Lacy), 952
Amniotic Fluid : Ultra-Structure of Human Amnion and its Possible Relation to the Circulation of (Dr. Gordon L. Bourne and Dr. Dennis Lacy), 952
Amoeba lescherae (Adult) : Recovery of, from Dried Cultures (Monica Taylor), 329
Amoebidium Parasiticum (Trichomycete) : Pure Culture of the (Dr. Howard C. Whister), 732
Amphibians : Control of Colour Change in (C. Barker Jørgensen and Lis Olesen Larsen), 641
Amphibians and Reptiles : Poisonous (Prof. Floyd Boys and Prof Hobart M. Smith), *review* by A. G. C. Grandison, 269
Amphoteric Metals : Photo-stimulated Emission of Exo-electrons from the Surface Layer of, reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide (J. Wawrzyniak and Dr B Sujak), 467
Amplification (Parametric) : Experiments in the Field of (B Bollée and G. de Vries), 1019
Amsterdam, Dr. Daniel, and Schneierson, Dr. S. Stanley : Enhancement of Staphylococcal Virulence for Mice by Intraperitoneal Cortisone Acetate, Cholesterol and Lecithin, 101
Anacystis nidulans : A Methyl Cytidine from the Ribonucleic Acid of (Dr. B. B. Biswas and J. Myers), 238
Anaemia (Sickle-Cell), in Nigerian Children (R. G. Hendrickse), 1027
Anaerobes (Obligate) : Specific Inhibition of (Dr. Herbert N. Prince), 816
Anaesthetic Mixtures : Analysis of, by Gas Chromatography (E. R. Adlard and D W. Hill), 1045
Analgesia (Morphine, Dihydrocodeine and Aminopyrine) : Synergetic Action of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on (Dr. E. Fischer, J L. J Szabó and M. Stamburgo), 893
Analogues (Base) : Reversions induced by, in *Salmonella typhimurium* (Rivka Rudner and Elias Balbinder), 180
Analogy to the Kirkendall Effect in the Gas Phase (L. Miller and P. C. Carman), 549
Analyse de Variance et Plans d'Expérience (Prof. Daniel Dugué et Prof. Maurice Girault), *review* by Dr. D. J. Finney, 68
Analyser : The *Corsair*, a Digital Differential (Royal Aircraft Establishment and Semiconductors, Ltd), 201
Analyses (Chemical), of Rocks, *review* by Prof. K. C. Dunham, 56
Analysis : Microquantitative Infra-Red—Application to Gas Chromatographic Fractions (J E. Stewart, R. O. Brace, T. Johns and W. F. Ulrich), 628
Analysis of Accelerated Motion in the Theory of Relativity (Robert T. Jones), 790
Analysis of Anaesthetic Mixtures by Gas Chromatography (E. R. Adlard and D. W. Hill), 1045
Analysis of the Paragenesis of Minerals : Physiochemical Basis of the (D S. Korzhinskii), translated from the Russian, *review* by Dr. Bernard E. Leake, 745
Analysis (Qualitative), of Volatile Mercaptan Mixtures : A Rapid Method for (John F. Carson, William J Weston and Jack W. Ralls), 801
Analysis (Sterol), by Gas Chromatography (R. K. Beerthuis and J. H. Recourt), 373
Analysis (Trace), by X-Ray Fluorescence using Ion Exchange Resins (J. N. van Niekerk and J. F de Wet), 380
Analytical Chemistry of Polymers (edited by Gordon M Kline), Part I, Analysis of Monomers and Polymeric Materials–Plastics, Resins, Rubbers, Fibres, *review* by Prof. C. E. H Bawn, 52
Anaphylactic Release of Histamine from Chopped Guinea Pig Lung : Inhibition of the, by Chymotrypsin Substrates and Inhibitors (Dr. K. F. Austen and Dr. W E. Brocklehurst), 866
Anatomy of American Species of the Genus *Psaronius* : The Morphology and (Jeanne Morgan), *review* by Prof John Walton, 190
Anatomy (Human) : The Teaching of Veterinary Anatomy as a Branch of Biology—its Relationships to (Dr. R A. Green), 192
Anatomy (Veterinary), as a Branch of Biology : The Teaching of—its Relationships to Human Anatomy (Dr. R. A Green), 192
Anchicerotops from the Oldman Formation of Alberta (Wann Langston), 522
Anderer, F. A., and others : Primary Structure of the Protein of Tobacco Mosaic Virus, 922
Anderson, Harry G : Food Habits of Migratory Ducks, 17
Anderson, Prof H L. : Elected a member of the United States National Academy of Sciences, 773
Anderson, Dr. W , and others : Detection of Recently Produced Fission Products in the Atmosphere, 223
  Radioactive Fallout during 1959, 925
Andrade, Prof. E. N. da C : Growth of Single Crystals of Copper, 540
Andrew, C. S. : Nitrogen in Tropical Agriculture (Growth of Legumes in Acid Soils), 941
Andrew, Prof E. A : A Structural Tool for the Chemist, *review*, 55
Andrews, Dr Roy Chapman : *Obituary* by Dr. W. E. Swinton, 594
Andronikashvili, E. L. (Lifshits, E. M., and) : A Supplement to 'Helium', (translated from the Russian), *review* by Prof J. F. Allen, 835
Anglia (East) : Investigating Glacial and Interglacial Geology in (Dr. R. G. West), 771
Anglian (East) Butterflies : Some (S. Beaufoy), 771
Anglian (East) Mammals (Lord Cranbrook), 770
Angyal, Dr. S J. : Appointed to the chair of organic chemistry in the University of New South Wales, 357 ; work of, 357
Anhydrase (Carbonic) : Subnormal Level of, in Blood of Carcinoma Patients ? (Dr N W H. Addink), 253
Animal (a Cold- and a Warm-Blooded) : Influence of Temperature upon Blood Coagulation in (Dr. H. B. Anstall and Dr. R. G. Huntsman), 726
Animal Cells : Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in, and its Bearings on Cancer (Prof A. Sibatani, K. Yamana, K. Kimura and T. Takahashi), 215
Animal Experiments : Combined Application of Hydrogen Peroxide and Ionizing Rays in (E Fleischmann, H. Werkgartner and K. Karrer), 324
Animal Health Yearbook 1959 (Food and Agriculture Organization of the United Nations), 281
Animal Husbandry : Tropical, *review* by Sir John Hammond, 49
Animal Husbandry in the Tropics An Introduction to (G Williamson and Dr. W. J A. Payne), *review* by Sir John Hammond, 49
Animal Reproduction : Ford Research Fellowships in (Zoological Society of London), 519
Animal Tissues : Effects of Non-Ionic Surfactants upon (Helen Goldhammer and W R McManus), 317
Animals : Precipitating Antibody in Trypanosomiasis of Cattle and other (A. R. Gray), 1058
Animals Move : How (Sir James Gray), *review* by Dr. N. B. Marshall, 921
Animals (Farm) : Feeding Antibiotics to (Agricultural Research Council and the Medical Research Council Joint Committee on), 280
Animals (Freshwater Invertebrate) : A Guide to (Dr. T. T. Macan), *review* by Dr J P Harding, 345
Animals (Laboratory), in the Standardization of Drugs : The Use of (Research Defence Society, Pamphlet No. 10), 438
Animals (Pond) . Suffolk Ponds and (J. E. Marston), 771
Animals and Man Actinomycins and their Importance in the Treatment of Tumours in (New York Academy of Sciences Conference on), 771
Anion Exchanger : Fractionation of Heparin on an (Dr. J. P. Green), 472
Anisotropy of Susceptibility and the Natural Remanent Magnetization of some Welsh Slates (M. D. Fuller), 791
Annealing : Magnetic, 439
Annelid (Enchytraeid) : Monoxenic Cultivation of an (Dr. Ellsworth C. Dougherty and Bjørn Solberg), 1067

INDEX

Annual: The Veterinary, 1959 (edited by W A Pool), review by G N. Gould, 667
Annual Review of Microbiology (edited by Charles E. Clifton, Sidney Raffel and Mortimer P Starr), Vol. 13, review by Dr. B. A. Newton, 49
Annual Review of Plant Physiology (edited by Leonard Machlis, in association with John G Torrey), Vol. 10, review by Prof W Stiles, 747
Anomalies in the Microscopic Structure of some Wools (T. D. Brown and W. J. Onions), 93
Anopheles pharoensis Theobald Normal Susceptibility Levels of, to DDT and Dieldrin (Dr. F. Kuhlow), 410
Anstall, Dr. H. B , and Huntsman, Dr. R. G Influence of Temperature upon Blood Coagulation in a Cold- and a Warm-blooded Animal, 726
Antarctic Atmosphere : Temperature Changes in the (Dr. H. Wexler), 445
Antarctic Expedition : The New Zealand (Sir Edmund Hillary), 526
Antarctica : Lower Tertiary Microfossils from McMurdo Sound (Dr. Lucy M. Cranwell (Mrs Watson Smith), Dr. H J. Harrington and I G. Speden), 700
 Scientific Research in, 212
Antecedents of Man (Prof Sir Wilfrid E Le Gros Clark), review by Dr. G G Simpson, 665
Anthelmintic Efficiency of Tetrachlorodifluoroethane against *Fasciola hepatica* in Sheep (J. C Boray and I G Pearson), 252
Anthropological Institute (Royal) : Occasional Publication No. 13, The ABO Blood Groups (Dr A E Mourant, Ada C Kopeć and Kazimiera Domaniewska-Sobczak), review by Dr. F. Stratton, 581
Anthropology Contributions to (National Museum of Canada, Bulletin No. 162), 1017
Antibacterial Activity of Surface-Active Compounds : Methods for the Evaluation of the (Society for Applied Bacteriology and the Microbiology Group of the Society of Chemical Industry Symposium on), 131, *erratum*, 206
Antibacterial Sulphonamide Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methyl*iso*thiazole), a New (A. Adams, W. A. Freeman, A. Holland, D. Hossack, J. Inglis, J Parkinson, H W. Reading, K. Rivett, R Slack, R Sutherland and R Wren), 221
Antibiotics : Feeding, to Farm Animals (Agricultural Research Council and the Medical Research Council Joint Committee on), 280
Antibody : An Rh, Specific for V and R's (Dr Ruth Sanger, Jean Noades, Patricia Tippett, Dr R R. Race, J. A. Jack and Dr. C. A. Cunningham), 171
Antibody (Precipitating), in Trypanosomiasis of Cattle and other Animals (A R. Gray), 1058
Antibody and Complement : Effect of, on Volume Control in an Ascites Tumour Cell (Dr H Green and Dr. F Silverblatt), 646
Antigen M (Human Blood-Group) M_1, a Subdivision of the (J. A. Jack, Patricia Tippett, Jean Noades, Dr Ruth Sanger and Dr. R R Race), 642
Antigen 15 (Somatic), as a Precursor of Antigen 34 in *Salmonella* (Hisao Uetake and Shin Hagiwara), 261
Antigen 34 in *Salmonella* : Somatic Antigen 15 as a Precursor of (Hisao Uetake and Shin Hagiwara), 261
Antigen-Induced Damage to Isolated Sensitized Mast Cells (Dr. I Mota and W. Dias da Silva), 245
Antigenic Structure of Non-Infectious Adenovirus Materials (Dr. H G. Pereira), 571
Antigens, Transplantation and Tolerance, *review* by Dr. D M. V. Parrott, 51
Antigens (Immobilization), of *Paramecium aurelia* : Genetical and Biochemical Studies of the (J. O Bishop and Dr. G. H Beale), 734
Antigens (*Salmonella*) : The a-z-z_{38} Group of (Leonard Schrire), 569
Antiglobin Serum (Rabbit) : Observations on Globin, Haemoglobin and Haptoglobin using a (D S Rowe and J. F. Soothill), 975
Antiglobulin Reaction : Role of C'_4 in the (G C. Jenkins, Margaret J. Polley and Dr. P L. Mollison), 482
Anti-Inflammatory Action of Corticosteroids : Accumulation of Substrate by Isolated Rat Diaphragm—a Possible Mechanism for the (Prof. Ira G. Wool), 728
Anti-Locust Research Centre : Report of the Director for 1958-59, 501
Antimalarial Properties of some Guanidine Derivatives (Y. Ch. Chin, Y Y. Wu, B. Skowrońska-Serafin, Prof T Urbański and J. Venulet), 170
Antimetabolite (Riboflavin) Ackee Toxin, a (H C Fox and D S Miller), 561
Antioxidative Effect of Amino-Acids (Dr. Reinhard Marcuse), 886
Antipyretic Action of *l*-Phenyl-3,5-pyrazolidinedione (Salah A. Tawab, Prof Ahmed Mustafa and Mohamed Kira), 165
Antithromboplastin in Human Serum and Plasma (Dr. T. G. Scott, Dr. C. Symons and R L. Markham), 248
Antoni, F , and others : Heterogeneity of Tumour Ribonucleic Acid and the Effect of 'Degranol' on it, 81
Antonini, E (Rossi-Fanelli, Prof A , and) : Oxygen Equilibrium of Haemoglobin from *Thunnus thynnus*, 895
Antonini, E., and others : Oxygen Equilibrium of Myoglobin from *Thunnus thynnus*, 896
Antony, J Recent Advances in Coconut Research in India, 862
Aortas (Normal and Atherosclerotic), from Chickens receiving Differently Saturated Fats for Three Years : Essential Fatty Acids of (Prof. H. Fisher and A S Feigenbaum), 85
Aortic, Serum, Connective Tissue and Osseous Chemistry in Lathyritic Rats (Dr. R. A. Grant, M Hathorn and Prof Theodore Gillman), 164
Aortitis (Chronic), in the California Sea-lion, *Zalophus californianus* (Dr. Arthur L Kelly and Dr David Jensen), 731
Aoyagi, Masaya, and others : A Micro Gas Chromatograph, 309
Apidium and *Oreopithecus* (Dr. Elwyn L Simons), 824
Aplanospores (Unicellular Algae and) Living and Fossil (D M. Churchill), 493
Aplysia depilans L. : Yolk Formation in Oocytes of *Patella coerulea* L. and, as observed in the Electron Microscope (A. Bolognani), 490
Apoferritin : X-Ray Diffraction Study of Denatured Ferritin and (Vladimir Kleinwachter), 313
Apoje, Nigeria : Grooved Rocks at (William Fagg), 205
Apparatus for Panning in Ciné Micrography (Dr. W. H. Hughes and Dr. P. N. Cardew), 258
Apparent Double Crossing-Over in a Short Genetic Interval in *Drosophila melanogaster* (Prof M M Green), 990
Apparent Radio Radiation at 11-m Wave-Length from Venus (Dr J. D. Kraus), 462
Apple : Changes in Structure of a Periclinal Chromosomal Chimera of, following X-Irradiation (Charlotte Pratt), 255
Apple Fruits (Tomato and) : Ethylene Production by (D. F Meigh, K. H Norris, C C Craft and M Lieberman), 902
Applegate, Howard G. : Freezing-Point Depressions of Hoagland's 'Carbowax' Systems, 232
Appleton, A A : Industrial Chemistry of the Lower Olefines (Production and Utilization of Butadiene), 285
Application to Body-centred Cubic Lithium An Energy Band Interpolation Scheme, with (J. F. Cornwell and Dr E. P Wohlfarth), 379
Application to the Feulgen Reaction : A New Technique for Studying the Quantitative Aspects of Cytochemical Reactions and its (P. van Duijn and J. -P Persijn), 805
Application to Gas Chromatographic Fractions : Microquantitative Infra-Red Analysis— (J E. Stewart, R. O Brace, T. Johns and W. F. Ulrich), 628
Application of Pyramidone to Detection of Nitrous Acid (Dr Wiktor Wawrzyczek), 883
Application to the Resolution of Human Haemoglobin Variants A New Electrophoretic Medium and its (Dr. E. R Huehns and Dr A. O. Jakubovic), 729
Application (Combined), of Hydrogen Peroxide and Ionizing Rays in Animal Experiments (E Fleischmann, H Werkgartner and K Karrer), 324
Applications to Controlled Thermonuclear Reactions : Bibliography on Plasma Physics and Magnetohydrodynamics and their (J. D Ramer), 522
Applications of the Electron Microscope : Techniques and (Cornell University Summer Laboratory Course in), 127
Applications in Medicine and the Biological Sciences Elementary Statistics with (Prof Frederick E Croxton), *review* by R. M Cormack, 746
Applications of Nuclear Science for Peaceful Purposes : Recent Developments in the (CENTO Institute of Nuclear Science Symposium on), 685
Applications to Organic Chemistry : Nuclear Magnetic Resonance— (Prof. J D. Roberts), *review* by Prof E R Andrew, 55
Applications de la Thermodynamique Chimique Bases Fondamentales et (Prof Maurice Dodé), Tome 1, Les Principes, les Systèmes ideaux Gazeux, et avec Phases Condensées pures, *review* by Prof A. R Ubbelohde, 55
Applications (Spectroscopic), of Photographic Emulsion Mosaics (Prof R. W. Nicholls), 715
Applied Arts and Sciences, Museum of (Sydney) : Annual Report for 1958, 683
Applied Bacteriology, Society for Annual Meeting and Summer Conference, 523
Applied Bacteriology, Society for, and the Microbiology Group of the Society of Chemical Industry : Symposium on Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds, 131, *erratum*, 206
Applied Biologists, Association of, and the British Mycological Society Symposium on the Nature and Exploitation of Crop Plant Resistance to Disease, 857
Applied Hydrodynamics (H. R. Vallentine), *review* by E. P. Sutton, 669
Applied Radiation Chemistry, *review* by Prof. F. S. Dainton, 344
Applied Research (Fundamental and) : The Balance of, 341
Appointments in Industry and Commerce, 682
Apprenticeship Training in Britain, 436
Approach (A Biochemical), to Pathology (M. J R Dawkins and Dr K R. Rees), *review* by Dr. R. W. R. Baker, 921
Approach (A Concrete), to Abstract Algebra (Prof. W. W. Sawyer), *review*, 69, 440
Approach (Russian), to Mineral Paragenesis, *review* by Dr Bernard E Leake, 745
Aptitude (Arts/Science) A Differential Test of (L Hudson), 413
Aquatic (Sub-) Medicine (Club Alpin Sous-Marin International Colloquium on), 440
Äquatorialen Atlantiks Ein Beitrag zum Problem der Tiefseesande im westlichen Teil des (F W Focher), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Sediment Cores from the North Atlantic Ocean, No. 5), 609
Aqueous Solution (Dilute) : Chemical Effects of Ionizing Radiation on Deoxyribonucleic Acid in (G Hems), 710
Aqueous Solutions : Use of Nitrous Oxide to discriminate between the Forms of Hydrogen Atoms (H and H_2^+) produced by γ-Irradiation of (Prof F. S. Dainton and Dr. D. B. Peterson), 878
Aqueous Solutions under Ionizing Radiation : Significance of the 'Equivalent Redox Potential' in (Dr. G. H. Cartledge), 370
Aqueous Solutions of Potassium Iodide irradiated with Ultra-violet Light : Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in (Prof F S. Dainton and S. A. Sills), 879
Aquivalenter Grundlage : Petrochemische Berechnungsmethoden auf (Prof Conrad Burri), *review* by Prof K C Dunham, 56
Aradidae : The, *review* by R G. Fennah, 46
Aradidae (*Hemiptera-Heteroptera*) : Classification of the (Prof Robert L. Usinger and Ryuichi Matsuda), *review* by R G Fennah, 46
'Araldite' in Aircraft Research Models, 360
Arber, Dr Agnes : *Obituary* by Dr H. Hamshaw Thomas, 847
Arc Movement : Effect of Cathode Surface Roughness and Oxidation on (Dr. T. J Lewis and Dr. P. E. Secker), 30
Archaeology Scientific Techniques in Art and (Dr A. E. Werner), 674
Archaeology in Suffolk (N. Smedley), 770
Architecture : Psychiatric Services and (A. Baker, R Llewelyn Davies and P Sivadon), (United Nations, World Health Organization, Public Health Papers No 1), 936
Are Macromolecules required for Growth of Single Isolated Mammalian Cells ? (Ralph B Gwatkin), 984
Arid Zone Problems (Unesco Symposium on), 284
Armstrong, J McD. and others A New Type of Autoxidation Reaction—Flavin Dissociation and Inactivation of Cytochrome b_5 by Oxygen, 1033
Armstrong, L. D. : Visco-Elastic Systems (Experimental Evidence on the Great Increase in Creep of Wood when changes in Moisture Content take place while the Material is Loaded), 943

Armstrong, Dr. W. D. (Singer, Dr. Leon, and). Removal of Strontium from Milk, 484
Army (United States) (Office of Ordnance Research), and Brown University: Conference on the Mechanisms of Peroxide Reactions, 127
Arnold, D. C.: Occurrence of the Slipper Limpet, *Crepidula fornicata* L., in Ireland, 95
Arnold, Wilfred N, and others: (+) S-Methyl-L-Cysteine Sulphoxide, an Inhibitor of Aspartic Acid Utilization in *Leuconostoc mesenteroides*, 1051
Arnon, Prof. Daniel I., and others: Equivalence of Light and Adenosine Triphosphate in Bacterial Photosynthesis, 753
Aromatic Compounds · Effect of Solvent Polarizability on the Ultra-violet Spectral Shifts of (Dr. F. A. Bovey and S S. Yanari), 1042
Aronson, J. M., and Preston, Prof. R. D. · Cell Wall Formation in Spores of the Fungus *Allomyces*, 95
Array: Measurements of the Total Acoustic Radiation Impedance of Rigid Pistons in an (J S. M Rusby), 144
Arrow Symbol in Biology (Dr A E. Needham), 103
Arsenic: The Radiochemistry of (Harold C. Beard), 602
Art: Scientific Methods in the Care of Works of (F. I G. Rawlins), 437
Art and Archaeology. Scientific Techniques in (Dr. A. E. Werner), 674
Arter, E., and others: Use of Ionizing Radiation in Spot Tests for Nitrogenous Compounds, 383
Artificial Earth Satellite: Secular and Periodic Motions of the Node of an (Prof Leon Blitzer), 874; (D. G. King-Hele), 875
Artificial Insemination in Cattle, *review* by Sir John Hammond, 667
Artificial Satellites · Electron Density Measurements in the Upper Ionosphere using the Faraday Rotation of Radio Signals from (Dr. D. McL A. Wilson), 623
  Figures of Equilibrium of Celestial Bodies, with Emphasis on Problems of Motion of (Prof Zdenek Kopal), *review* by D. G King-Hele, 747
Arts, Royal Society of · Report on the Industrial Arts Bursaries Competition for 1959, 684
Arts/Science Aptitude A Differential Test of (L Hudson), 413
Arts and Sciences (Applied), Museum of (Sydney): Annual Report for 1958, 683
Arya, Dr V. P.: Awarded a Ciba Fellowship for 1960-61, 684
Ascites Tumour resistant to Alkylating Reagents: Non-Protein Sulphydryl Group in the Original Strain and Sub-line of the (Iwao Hirono), 1059
Ascites Tumour Cell · Effect of Antibody and Complement on Volume Control in an (Dr H. Green and Dr F. Silverblatt), 646
Ascites Tumour Cells (Ehrlich): Calcium Binding in Homogenates of (R. Schofield and D. Thomason), 656
Ascites Tumours. Viability and Tetrazolium Salt in (Dr. Gustav Dallner), 176
Ascorbic Acid in the Locus Coeruleus of the Mammalian Brain · Histochemical Demonstration of (Dr Nobuo Shimizu, Tomokazu Matsunami and Satoko Onishi), 479
Ashby, Sir Eric · *Obituary* of Prof. E. J. Kraus, 516
Ashby, Dr. W. Ross: The Brain as Regulator, 413
Ashcroft, G. W., and Sharman, D. F.: 5-Hydroxyindoles in Human Cerebrospinal Fluids, 1050
Ashton, G. C.. Thread Protein and β-Globulin Polymorphism in the Serum Proteins of Pigs, 991
Ashwell, Dr. Gilbert (Cynkin, Dr. Morris A., and) · Estimation of 3-Deoxy Sugars by means of the Malonaldehyde–Thiobarbituric Acid Reaction, 155
Asia (South-East): The Development of Science in (Unesco South-East Asia Science Co-operation Office and the Indonesian Council of Sciences Discussion on), 859
Asia Foundation: Grant of 2,500 dollars to the American Geographical Society, to aid Asian libraries and Asian scholars temporarily in the United States, 126
Aspartic Acid Utilization in *Leuconostoc mesenteroides*: (+) S-Methyl-L-Cysteine Sulphoxide, an Inhibitor of (Wilfred N. Arnold, Clayton J. Morris and John F. Thompson), 1051
Aspects of Aeronautical Sciences, *review* by Prof. A R. Collar, 665
Aspects of the Organic Chemistry of Sulphur (Prof Frederick Challenger), *review* by Dr F G. Mann, 53
Aspects of Orogens (J V. Harrison), 689
Aspects (Fundamental), of Reactor Shielding (Dr Herbert Goldstein), *review* by Dr. T. E. Allibone, 917
Aspects (Physical and Structural), of Non-destructive Testing of Metals (Non-destructive Testing Group of the Institute of Physics and the Société Française de Métallurgie Conference on), 284
Aspects (Preventive), in the Teaching of Pathology (World Health Organization, Technical Report Series No. 175), 602
Aspects (Quantitative), of Cytochemical Reactions: A New Technique for Studying the, and its Application to the Feulgen Reaction (P van Duijn and J.-P. Persijn), 805
Aspects (Social) · Intraspecific Differentiation—Biological and (Dr. Max Pettersson), 431
Aspergillus nidulans High Frequency of Spontaneous and Induced Somatic Segregation in (Dr Etta Kafer), 619
  'Sage', a Colour Modifier in (B J. Kilbey), 906
Assessment of the Quantities of Fission Products likely to be found in Milk in the Event of Aerial Contamination of Agricultural Land (Dr R. J. Garner), 1063
Assistance from the United Kingdom for Overseas Development (White Paper on), 501
Assistants. Laboratory Technicians and (Ministry of Labour and National Service, Choice of Careers Series No. 94), 682
Association between Capsulation and Phage Sensitivity in *Erwinia amylovora* (Eve Billing), 819
Association between Dental Caries and certain Soil Conditions in New Zealand (T. G. Ludwig, W B Healy and Capt F L. Losee), 695
Association des Ingénieurs Electriciens (sortis de l'Institut Électrotechnique Montefiore) · International Information Day about Nuclear Energy, 440
Astin, Dr. A. V.: Elected a member of the United States National Academy of Sciences, 773
Astronautical Congress · International (Swedish Interplanetary Society), 523
Astronautics: Vistas in (edited by Morton Alperin and Hollingsworth F. Gregory), Vol. 2 (Second Annual Astronautics Symposium sponsored by the United States Air Force Office of Scientific Research and the Institute of Aeronautical Sciences), *review* by D G King-Hele, 59
Astronomical Photography at the Telescope (Thomas Rackham), *review* by D. H. P. Jones, 190
Astronomical Union, International: Symposium No. 6, Electromagnetic Phenomena in Cosmical Physics (Stockholm 1956), (edited by B. Lehnert), *review* by Dr R. H. Garstang, 67
Astronomy, a Textbook for University and College Students (Dr. Robert H Baker), seventh edition, *review* by D. H P. Jones, 69
Astronomy in Australia—Stellar Interferometer of the School of Physics, University of Sydney, 270
Astronomy (Physics and): From Nucleus to Universe—a Course of Selected Lectures in (University of Sydney, 1960), (edited by Prof. S. T. Butler and Prof. H Messel), *review* by G. R. Noakes, 748
Astronomy (Radio): An Easy Guide to, *review* by Dr J S. Hey, 59
Asunmaa, Saara K. · Silver-activated Nitrocellulose as Recording Material for X-Ray Microscopy, 1036
Asymmetry in a Water-boatman (*Krizousa-corixa femorata*): Inheritance of (Dr. Walter Peters), 737
Ataxia in Hens poisoned by Tri*para*ethylphenyl Phosphate (Ann Silver), 766
Athay, R. Grant: Rocket and Satellite Observations of the Solar Ultraviolet Spectrum, 1036
Atherosclerotic Aortas (Normal and), from Chickens receiving Differently Saturated Fats for Three Years: Essential Fatty Acids of (Prof. H Fisher and A. S Feigenbaum), 85
Atkin, N. B (Pearson, Dr A. E. G., and): Changes in the Deoxyribonucleic Acid Content of Mouse Sarcoma 37 Cells following Serial Irradiation, 647
Atkins, Prof. K R: Liquid Helium, *review* by Dr. J. G Valatin, 345
Atlantic Ocean: Strontium-90 in the 'Mixed Layer' of the (Dr. Vaughan T. Bowen and Prof Thomas T. Sugihara), 71
Atlantic Ocean (North). Sediment Cores from the (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Nos 4-5), 609
Atlantiks (aquatorialen): Ein Beitrag zum Problem der Tiefseesande im westlichen Teil des (F W. Locher), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Sediment Cores from the North Atlantic Ocean, No 5), 609
Atmosphere Detection of Recently Produced Fission Products in the (Dr. W. Anderson, Dr. R. E Bentley, L. K. Burton and Dr. C. A Greatorex), 223
  Radioactivity of the, due to Distant Nuclear Test Explosions (D H Peirson, R. N. Crooks and E. M. R. Fisher), 224
Atmosphere (Antarctic): Temperature Changes in the (Dr. H. Wexler), 445
Atmosphere (Upper) · Density of the, and its Dependence on the Sun, as revealed by Satellite Orbits (D. G. King-Hele and D. M. C. Walker), 928
Atmosphere (Upper-) Air Density at the Height of 180-212 km. derived from the Orbit of *Sputnik III*: Profile of (Z. V. Bochníček), 460
Atmospheric Radio Noise · Observations of (G R. A. Ellis), 229
Atmospheric Tracer · Use of Long-lived Natural Radioactivity as an (W M Burton and N G. Stewart), 584
Atomfysik (Teoretisk), Nordisk Institut for (Copenhagen): Årsberetning (1957-58), 850
Atomic Absorption Spectroscopy: Determination of Calcium in Blood Serum by (J. B Willis), 249
Atomic Clock: Preliminary Flight Tests of an, in Preparation of Long-range Clock Synchronization Experiments (Friedrich H. Reder and Gernot M R. Winkler), 592
Atomic Energy: The Peaceful Uses of (Proceedings of the Second United Nations International Conference on, held in Geneva, 1958), Vol. 2, Survey of Raw Material Resources, *review* by Prof. C F. Davidson, 921
  World List of Institutions concerned with (International Atomic Energy Agency), 361
Atomic Energy Agency (International): Appointment of Prof. C Salvetti as director of the Division of Research and Laboratories, 17
  International Directory of Radioisotopes, Vol. I, Unprocessed and Processed Radioisotope Preparations and Special Radiation Sources: Vol. 2, Compounds of Carbon-14, Hydrogen-3, Iodine-131, Phosphorus-32 and Sulphur-35, 282
  Scientific Conference (Use of Radioisotopes in the Physical Sciences and Industry), 284
  General Publication No. 3, World List of Institutions concerned with Atomic Energy, 361
  Appointment of Dr Gerald B Cook as chief chemist, 854
  Assistance Programme, 855
Atomic Energy Authority (United Kingdom), (Production Group and Development and Engineering Group): Fifth Report from the Select Committee on Estimates, Session 1958-59, I
Atomic Energy Commission (Australian): Conference on the Technological Use of Radiation, 126
Atomic Energy Commission (Danish) · International Summer Course on Plasma Physics, 938
Atomic Energy Research Establishment · Appointment of B S. Smith as head of the Isotope Research Division, 933
  Appointment of N. G Stewart as head of the Health Physics Division, 933
Atomic Physics in Norway, 850
Atomic Terminology, a Dictionary of Nuclear Science, Engineering and Technology in Four Languages (English–German–French–Italian), (compiled by Dr Lore Lettenmeyer), *review* by Dr J. B. Sykes, 67
Atomnaya Energiya · Vol. 3, No 11, Soviet Reviews of Nuclear Science on the 40th Anniversary of the October Revolution, *review* by Dr T. E. Allibone, 917
Atoms for Peace Award for 1959 awarded jointly to Prof. Leo Szilard and Prof Eugene P. Wigner, 357
Atoms for Peace Award for 1960 awarded jointly to Dr. Walter H Zinn and Dr. Alvin M. Weinberg, 357
Atoms (Hydrogen): Mechanism of the Oxidation and Reduction of Metal Ions by (Prof J. Halpern, G. Czapski, J. Jortner and Dr. G. Stein), 629
Atoms (Hydrogen), existing in Aqueous Solutions of Potassium Iodide irradiated with Ultra-violet Light · Use of Nitrous Oxide to discriminate between Various Forms of (Prof F S. Dainton and S A. Sills), 879
Atoms (Hydrogen) (H· and H_2^+?) produced by γ-Irradiation of Aqueous Solutions: Use of Nitrous Oxide to discriminate between the Forms of (Prof F S Dainton and Dr D B Peterson), 878

Atria (Rat) : Intracellular Potentials in, during and after Vagal Stimulation or Acetylcholine Administration (P. A. Biersteker, J. Th. F. Boeles and L. N. Bouman), 637
Auricchio, S., and others : Interrelation of Tryptophan and Nicotinic Acid in Man during the First Month of Life, 639
Auroral Zone (Southern) · Geometry of the, and the Evidence for the Existence of an Inner Zone (Dr. T Hatherton), 288
Austen, Dr. K F., and Brocklehurst, Dr. W E : Inhibition of the Anaphylactic Release of Histamine from Chopped Guinea Pig Lung by Chymotrypsin Substrates and Inhibitors, 866
Australasian Conference on Radiation Biology, 938
Australia : Astronomy in—Stellar Interferometer of the School of Physics, University of Sydney, 270
  Mistletoe in (G. C. Greenham), 135
  Rheology in (Dr P. U. A. Grossman), 941
Australia (South) : Late Precambrian Fauna in (M F Glaessner and B. Daily), 205
Australian Academy of Science : Election of new Fellows, 519
  Thomas Ranken Lyle Medal for 1959 presented to Prof E S. Barnes, 519
Australian Atomic Energy Commission : Conference on the Technological Use of Radiation, 126
Australian Cattle Tick . Sulphydryl Content of the Embryos of the (W. J. Roulston and C. A. Schuntner), 1069
Australian Commonwealth Scientific and Industrial Research Organization · Appointment of Lord Casey and E. P. S. Roberts as members of the Executive, 12
  Rural Research, 29, Mistletoe in Australia (G. C Greenham), 135
  Appointment of Dr Geoffrey Kesteven as director of fisheries research in the Division of Fisheries and Oceanography at Cronulla, 280
  Appointment of Dr Douglas F. Waterhouse as chief of the Division of Entomology, 763
  Symposium on Nitrogen in Tropical Agriculture, 941
  Symposium on Visco-Elastic Systems, 942
Australian Defence Standards Laboratories : Annual Report (1958-59), 366
Australian Irradiation Conference, 126
Australian Museum · Exhibit entitled 'These are Invertebrates', 438
Australopithecine (Olduvai) The Affinities of the New (Dr J. T. Robinson), 456 ; (Dr L S B Leakey), 458
Australopithecine Tools (Prof R. A. Dart, Dr. Kitching and Revil J. Mason), 205
Austria and Germany Frequencies of the Haptoglobin Serum Groups among Blood Donors from (Dr. H. Baitsch, G. Meier, L. Scogller and D. M. Kahlich-Koenner), 976
Austrian Academy of Science (German Academy of Science and the) : Preparation of an edition of the letters of Alexander von Humboldt (1769-1859), 685
Autocatalytic Particles and Steady States (Dr. Allan Campbell), 256
Automatic Control : First International Congress on, 439
Automatic Control in Soviet Industry (Department of Scientific and Industrial Research), 287
Automation : Study Group on the Mental Health Problems of (World Health Organization, Report Series No. 183), 364
Automation and its Human Repercussions, 364
Automobile Engineering, Advanced School of (Cranfield) · Appointment of J. R. Ellis as professor of automobile engineering and first director, 762
Autoxidation Reaction A New Type of—Cause of the Instability of Cytochrome c Reductase (Dr. Malcolm Dixon, J. M. Maynard and P. F. W. Morrow), 1032 ; Flavin Dissociation and Inactivation of Cytochrome b_2 by Oxygen (J. McD. Armstrong, Dr. J H. Coates and Prof. R K Morton), 1033
Auxiliary Grid · Use of an, to stabilize the Gain of a Photomultiplier (Dr. C. F G. Delaney and Dr. A J. Walton), 625
Aviation, Ministry of Promotion of D. G A. Rendel to Deputy Chief Scientific Officer and appointment as head of the Mechanical Engineering Department of the Royal Aircraft Establishment, 12
  Promotion of E. B. Carter to Deputy Chief Scientific Officer and appointment as director of engine production, 518
  Promotion of J D Clare to Deputy Chief Scientific Officer and appointment as director of guided weapons research and development (Air), 518
Axelrod, Daniel I (Chaney, Ralph W., and) : Miocene Floras of the Columbia Plateau, Part 2, Systematic Considerations, *review* by Prof. J. Walton, 66
Azam, M N, and Dickinson, H. : Time-lags in the Intrinsic Electrical Breakdown of Glass, 146
Azide (α-Lead) : Radiation-induced Changes in (G Todd and E. Parry), 543
Azotobacter vinelandii · Nitrogen Fixation in Extracts of (Dr D. J D. Nicholas and D J Fisher), 735

BAARLI, J (Madshus, K, and) Radiocaesium and Potassium-40 in Norwegian-produced Milk, 527
Baas Becking, Dr. L. G M., and Moore, Dr. D. · Iron Bacteria in Mine-waters, 670
Bacilli (Phenol-killed Tubercle) : Enhanced Resistance of Mice to Infection with *Pasteurella pestis* following Vaccination with Fractions of (Prof. David W. Weiss), 1060
Bacillus subtilis : Physiology of D-Glutamic Acid-resisting Mutants of (Haruo Momose and Prof. Yônosuke Ikeda), 818
Bacillus subtilis (Mutants of), requiring D-Glutamic Acid : Isolation of (Haruo Momose and Prof. Yônosuke Ikeda), 567
Back, Dr. —. (MacIver, Dr. —., and) · Medical Research in the British Caribbean (Megaloblastic Anaemia in Malnourished Infants), 863
Backeberg, Curt · Die Cactaceae, Band 3, Cereoideae (Austrocactinae), *review*, 347
Bacon, F. T Fuel Cells—Will they soon Become a Major Source of Electrical Energy?, 589
Bacq, Prof. Zenon M, and Beaumariage, Dr. Marie L. : Inability of Methionine to affect Lethality in Mice and Rats exposed to X-Rays, 1064
Bacteria : Fate of, in the Small Intestine (J. M. S. Dixon), 521
  L Forms of, as Contaminants in Tissue Culture (Dr I A. Macpherson and K Allner), 992
Bacteria (Iron), in Mine-waters (Dr L G. M Baas Becking and Dr. D. Moore), 670
Bacterial Dextranase : Action of a, on Branched Dextrans (R. W. Bailey, Dr. D. H. Hutson and Dr. H. Weigel), 553
Bacterial Flora of Roots : Influence of Light on (J. W. Rouatt and Dr. H. Katznelson), 659
Bacterial Photosynthesis : Equivalence of Light and Adenosine Triphosphate in (Dr. M Losada, Dr A. V. Trebst, S Ogata and Prof. Daniel I Arnon), 753
Bacterial Physiology : An Introduction to (E L Oginsky and Wayne W. Umbreit), second edition, *review* by Dr. R H. Gorrill, 111
Bacterially Mediated False-Positive Reactions in Lytic Blood-Typing Tests (Prof Clyde Stormont, Yoshiko Suzuki and W. J. Miller), 247
Bacteriology at St Mary's Hospital, London, 1016
Bacteriology : A Guide to the History of (Prof. Thomas H. Grainer, Jr), *review* by Dr R H. Gorrill, 111
  Text-Book of, *review* by Dr R H. Gorrill, 111
  A Text-Book of (Dr R. W. Fairbrother), eighth edition, *review* by Dr. R. H. Gorrill, 111
Bacteriology (Applied), Society for Annual Meeting and Summer Conference, 523
Bacteriology (Applied), Society for, and the Microbiology Group of the Society of Chemical Industry . Symposium on Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds, 131, *erratum*, 206
Bacteriophage in the Presence of Sulphydryl Compounds · Effect of Oxygen on the Radiosensitivity of (Dr. P Howard-Flanders), 485
Baddeley, A D, and others · Letter Structure of the English Language, 414
Baden-Powell, D F W. The Pleistocene Era, *review*, 833
Badger, Prof G M · Elected a Fellow of the Australian Academy of Science, 519
Baez, Dr. Albert V . A Self-supporting Metal Fresnel Zone-plate to Focus Extreme Ultra-violet and Soft X-Rays, 958
Bahadur, K., and Sastry, P. V : Thin Films of Silver–Cadmium Alloy, 467
Bailey, Dr J Leggett : Appointed to the Biochemistry Section of Twyford Laboratories, Ltd., London, 523
Bailey, Dr Norman T J. Statistical Methods in Biology, *review* by R M Cormack, 746
Bailey, R W., and others : Action of a Bacterial Dextranase on Branched Dextrans, 553
Bailey, Prof V. A. : Existence of Net Electric Charges on Stars, 508
Bain, R. V S · Mechanism of Immunity in Haemorrhagic Septicaemia, 734
Baitsch, Dr H., and others · Frequencies of the Haptoglobin Serum Groups among Blood Donors from Austria and Germany, 976
Baker, A, and others : Psychiatric Services and Architecture, 936
Baker, Prof H. Wright · Retirement from the chair of mechanical engineering in the University of Manchester, 1015, work of, 1015
Baker, Dr Robert H. Astronomy, a Text-book for University and College Students, seventh edition, *review* by D H. P Jones, 69
Baker, Dr. R. W R. : A Biochemical Approach to Pathology, *review*, 921
Bakerspigel, A. : The Nucleus in a Basidiomycete, 522
Bakker, Prof. C J · *Obituary* by J B. Adams, 761
Balance of Fundamental and Applied Research, 341
Balance of Scientific and Industrial Research, 997
Balbinder, Elias (Rudner, Rivka, and) : Reversions induced by Base Analogues in *Salmonella typhimurium*, 180
Balch, Dr. C. C. : Dairying in Great Britain, *review*, 504
Ballantyne, A. M., and others (edited by) Advances in Aeronautical Sciences—Proceedings of the First International Congress on the Aeronautical Sciences (Madrid 1958), *review* by Prof. A R. Collar, 665
Ballantyne, E. R Visco-Elastic Systems (Practical Requirements of Glazing Compounds), 943
Ballio, Dr. Alessandro, and others : Characterization of a New Purine Riboside isolated from *Fusarium* Species, 968
Ballistic Missile Early Warning Station at Fylingdales Moor, 357
Ballistic Missiles : Development of, 358
Bamford, Dr. C. H., and others · The Tesla-coil Method for Producing Free Radicals from Solids, 712
Bamford, Dr. C H., and others : Polymerization of Crystalline Methacrylic Acid initiated by Ultra-Violet Radiation, 713
Banana · The, *review* by Prof. C. W Wardlaw, 48
Bananas (N. W Simmonds), *review* by Prof C W. Wardlaw, 48
Band Systems · Interpretation of Intensity Distributions in the N_2 Lyman–Birge–Hopfield and CO Fourth Positive (Prof. R. W Nicholls), 958
Band-width of a Gas Discharge Harmonic Generator : Coherence and (N. R. Bierrum, D. Walsh and J C. Vokes), 626
Banerjee, D. D., and others : Alkylation of Coal by Benzyl Chloride–Aluminium Chloride, 387
Banerjee, D K., and others · Alkylation of Coal by Benzyl Chloride–Aluminium Chloride, 387
Banerji, Prof. R. B · A Systematic Method for the Construction of Error-correcting Group Codes, 627
Banwell, C. N. · Awarded a Ciba Fellowship for 1960-61, 684
Barber, Prof H J. : Chemical Nomenclature, *review*, 54
Bardgett, W E . Elected president of the Institution of Metallurgists, 854
Barer, Dr. R · Co-ordination of Light and Electron Microscopy, 672
Barium Chloride · Micromosaic Patterns in Single Crystals of Potassium Chloride containing (J. Ewles and J. B. Dawson), 381
Barker, Dr. S A, and others . Infra-red Spectra of Deuterium-labelled Carbohydrates, 307
  Behaviour of some Aldehydes on a Sulphonated Polystyrene Resin, 469
Barley Convention (European) . Ninth Annual Report of the Barley Committee, 16
Barnard, Dr E A. : Quantitative Cytochemical Observations on a Specific Nucleo-protein Reaction in Cell Nuclei, 447
Barnes, Dr. C. J., and Ferguson, Dr. L. N. : Amino-Acid Composition of Proteins from Surface Tissue of the Tongue, 617
Barnes, Prof E S · Presented with the Thomas Ranken Lyle Medal for 1959 of the Australian Academy of Science, 519
Barnes, H., and Barnes, Margaret : *Elminius modestus* Darwin in South-West Scotland, 989
Barnes, Margaret (Barnes, H., and) : *Elminius modestus* Darwin in South-West Scotland, 989
Barnett, J A. Comparative Studies of Yeasts, 449

INDEX

Barrère, Marcel, and others : Rocket Propulsion, *review* by J E P. Dunning, 186
Barry, H D. (Humphreys, K W., and) : Cost of Scientific Periodical Publications, 124
Bars (Terminal), and Terminal Web in Many Types of Cells Structures corresponding to (Prof C. P. Leblond, Holde Puchtler and Y. Clermont), 784
Bartl, Dr. P., and others : Water-Soluble Methacrylates as Embedding Media for Preparation of Ultra-Thin Sections, 494
Bartlett, Prof M S : Appointed to the chair of statistics in University College, London, 599 ; work of, 599
Bartók, I., and others · Histochemical and Biochemical Studies of Rat Liver in Experimental Cirrhosis after Partial Hepatectomy, 397
Barytes Suspensions Rheological Properties of (A. W Earnshaw and J. C. Sproson), 378
Bascon, William R., and Herskovits, Melville J (edited by) Continuity and Change in African Cultures, *review* by G. W B Huntingford, 38
Base Analogues Reversions induced by, in *Salmonella typhimurium* (Rivka Rudner and Elias Balbinder), 180
Bases Fondamentales et Applications de la Thermodynamique Chimique (Prof. Maurice Dodé), Tome I, Les Principes, les Systèmes ideaux Gazeux, et avec Phases Condensées pures, *review* by Prof A. R Ubbelohde, 55
Bases (Organic) . Addition Compounds between Copper Complexes and (R C Traill), 631
Basic Chromosome Numbers in *Silene* and *Saponaria* (Dr T N Khoshoo), 412
Basidiomycete The Nucleus in a (A Bakerspigel), 522
Basimetric Society, International (Society for Biological Rhythm and the) . Seventh International Conference, 604
Basis for a General System of Insect Migration and Dispersal by Flight (C G. Johnson), 348
Basis (An Enzymic), for Pathogenic Specificity (Elizabeth M C. Turner), 325
Basis (Genetic), of Two Melanin Inhibitors in *Drosophila melanogaster* (Dr. R. A Kroman and Dr P A. Parsons), 411
Basis (Physiochemical), of the Analysis of the Paragenesis of Minerals (D. S Korzhinskii), translated from the Russian, *review* by Dr Bernard E. Leake, 745
Basis (A Possible), for Immunological Tolerance (Dr D T. Denhardt), 728
Baskin, R. J (Abbott, Prof. B C , and) Determination of Small Rapid Volume Changes in a Muscle during Activity, 1055
Bassett, D. C. (Keller, Dr A , and) · Co-ordination of Light and Electron Microscopy (Light and Electron Microscope Investigations of the Habit and Structure of Crystals), 672
Batchelor, Dr G. K . Fluid Dynamics—a Mixed Bag, *review*, 1000
Bathurst, R G C. · The Liverpool Geological Society, 1859-1959, 9
Batts, Dr C. C. V. Nature and Exploitation of Crop Plant Resistance to Disease (Distribution of Physiological Races of *Puccinia glumarum* in Britain since 1946), 858
Bawn, Prof. C E H · Analytical Chemistry of Polymers, *review*, 52
  Industrial Chemistry of the Lower Olefines (Newer Developments in the Polymerization of Olefines), 286
  Obituary of Prof. W E Garner, 760
Bayer, Leona M , and Bayley, Nancy · Growth Diagnosis, *review* by Dr. K M Hawkins, 45
Bayerische Akademie der Wissenschaften : Prize of 8,000 D. marks for an Essay on Die Ruckkoppelung als Urprinzip der Lebensvorgange, 938
Bayley, Nancy (Bayer, Leona M., and) Growth Diagnosis, *review* by Dr. K. M Hawkins, 45
Bayliss, W. M . Principles of General Physiology, fifth edition, by Dr. L. E. Bayliss, *review* by Prof. A St. G. Huggett, 52, 284
Bayreuther, Dr. K : Chromosomes in Primary Neoplastic Growth, 6
B B.C · The Public and the Programmes, an Audience Research Report on Listeners and Viewers, the Time they devote to Listening and Viewing, the Services they Patronize, their Selectiveness and their Tastes, 363
Beadle, Prof G. W. Elected a Foreign Member of the Royal Society, 435
  Awarded the Kimber Genetics Award of the United States National Academy of Sciences, 686 , work of, 686
Beaked Whale (True's), from the South-East Coast of South Africa (F. H. Talbot), 406
Beale, Dr. G. H (Bishop, J O., and) Genetical and Biochemical Studies of the Immobilization Antigens of *Paramecium aurelia*, 734
Beament, J W. L : Wetting Properties of Insect Cuticle, 408
Bean, A D. (Goldacre, Dr. R J , and) A Model for Morphogenesis, 294
Beard, Harold C. The Radiochemistry of Arsenic, 602
Bearings on Cancer : Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in Animal Cells, and its (Prof A. Sibatani, K Yamana, K. Kimura and T Takahashi), 215
Beattie, H E. R. (Jakovljevic, Dusan, and) : Simplified Bulk Growth of *Vibrio foetus*, 736
Beaufoy, S · Some East Anglian Butterflies (Presidential Address to the Zoological Section of the South-Eastern Union of Scientific Societies), 771
Beaumariage, Dr. Marie L. (Bacq, Prof Zenon M , and) : Inability of Methionine to affect Lethality in Mice and Rats exposed to X-Rays, 1064
Beaumont, A. : Diseases of Farm Crops, *review* by J. M. Hirst, 65
Beaven, M. A , and others : Paper Chromatography—Multiple Spot Formation by Pure Substances, 775
Beck, Dr M T., and Halmos, M · Acidic Dissociation Constant of Alcoholic Hydroxyls of Oxycarboxylic Acids—Mandelic Acid, 388
Beck, Stanley D . Effect of Temperature on the Hibernation of the European Corn Borer, 774
Beckett, Dr A. H , and others : Paper Chromatography—Multiple Spot Formation by Pure Substances, 775
Beckett, P H. T. : A Reversible Nitrate Electrode, 879
Beckman, Lars, and Cedermark, Gunilla : Haptoglobin Types in *Macaca Irus*, 643
Bed Sedimene · Haemoglobin Content of the Larvae of *Tendipes f. l. plumosus* L from Various Levels of (B Czeczuga), 484
Bederke, Dr. E. · Orogens (Relationship between Stress and Regional Metamorphic Effects), 690
Bedford, Ronald (edited by) . Guide to Press Arrangements for Scientific, Medical and Technical Conferences, 437
Bee (Honey-) Larval Food : Electrophoretic Components of the Proteins in (N. G. Patel, M. H. Haydak and T. A. Gochnauer), 633
Beerthuis, R. K , and Recourt, J. H. : Sterol Analysis by Gas Chromatography, 372
Beeson, Gillian E. : Chromosome Numbers of Slugs, 257
Begg, R W. (edited by) Canadian Cancer Conference, Vol. 3, Proceedings of the Third Canadian Cancer Conference, 1958, *review* by Dr. I. Hieger, 1001
Begonia evansiana Andr. : Factors affecting Tubers in (Esashi and Nagao), 766 ; (Nagao and Mitsui), 766
Behavior (Interpersonal) : Person Perception and (edited by Renato Tagiuri and Lugi Petrullo), *review* by Prof M D. Vernon, 919
Behaviour . Instinctive—the Development of a Modern Concept (translated and edited by Claire H. Schiller), *review* by Dr. R. A. Hinde, 43
Behaviour of some Aldehydes on a Sulphonated Polystyrene Resin (Dr S. A. Barker, K Murray and Prof M Stacey), 469
Behaviour of Young Nidifugous Birds : A Possible Fundamental in the (Dr Peter M. Driver), 416
Behaviour (Diploid-like Meiotic), of Wheat . Position of the Gene determining the (Dr. Ralph Riley, Victor Chapman and Gordon Kimber), 259
Behaviour (Exploratory), in the Rat (Roger G A Stretch), 454
Behaviour (Tensile), of Pyrolytic Graphite at 2,750°C. (H E Martens and W. V. Kotlensky), 960
Beit Memorial Trust : Elections to Fellowships for Medical Research, 520
Belgian Congo Flora of the, 764
Belgium Ionospheric Observations over, during the International Geophysical Year (Royal Meteorological Institute of Belgium), 203
Bell, Eugene · Culture of Human Leucocytes on the Chorioallantoic Membrane of the Chick, 403
Bell, Dr. G. D. H Nature and Exploitation of Crop Plant Resistance to Disease (Studies on the Host Plant), 857
Bell, Dr W A · Catalytic Effects in the Alkaline Oxidation of Cellulose, 963
Bellamy, D J : Appointed lecturer in botany at the University of Durham, 937
Bellamy, Dr E H · Appointed to the University of London chair of physics in Westfield College, 440
Bellchambers, W. H., and Piggott, W. R. · Results of the Royal Society's International Geophysical Year Expedition (Ionospheric Measurements), 191
Benactyzine *in vitro* and *in vivo* Inhibition of Monoamine Oxidase by (Dr V Vítek and K. Ryšánek), 244
Bendall, Dr Fay (Hill, Dr. R., and) · Function of the Two Cytochrome Components in Chloroplasts—a Working Hypothesis, 136
Benditt, E P., and others Vanadium Catalysis of the Oxidation of Catechol Amines, Dihydroxyphenylalanine and 5-Hydroxyindoles, 884
Bennett, Dr. J E. : Study of the Oxidation of Hindered Phenols by Electron Spin Resonance, 385
Bentley, Dr R E , and others · Detection of Recently Produced Fission Products in the Atmosphere, 223
  Radioactive Fallout during 1959, 925
Bentzon, M W (Reyn, Alice, and) . Resistance of Gonococcus Strains to Penicillin, 608
Benzene · Reaction of *p*-*n*-Decyloxybenzene-diazonium Fluoborate with Sodium Iodide in (Prof W. Bradley and J D Thompson), 631
Benzidine Sulphate Precipitate : A Modification for Washing the, in the Determination of Sulphate (Dr I P. T. Hakkinen), 232
Benzoate (Polyvinyl) Monolayers (Herman E. Ries, jun , Nicky Beredjick and Joseph Gabor), 883
3:4-Benzpyrenols in Mouse Skin . Conjugation of (Dr K H Harper and Dr G. Calcutt), 80
Benzyl Chloride–Aluminium Chloride Alkylation of Coal by (M. S Iyengar, D. D. Banerjee and D K. Banerjee), 387
Benzyloxyl Free Radical in Solution · Disproportionation and Dimerization of the (Dr J. B. de Sousa and S K Ho), 776
Berechnungsmethoden (Petrochemische), auf aquivalenter Grundlage (Prof. Conrad Burri), *review* by Prof K C. Dunham, 56
Beredjick, Nicky, and others : Polyvinyl Benzoate Monolayers, 883
Berenblum, Prof. I. · Appointed to the chair of experimental biology in the Weizmann Institute of Science, Rehovoth, Israel, 681 ; work of, 681
Bergan, Per · Blocking of Mitosis by Heat Shock, 905
Berkeley, Edmund C : Symbolic Logic and Intelligent Machines, *review* by Dr A. D Booth, 422
Berkner, Dr. Lloyd V. · Elected treasurer of the United States National Academy of Sciences, 773
Bernal, Prof J D : Thermodynamics and Kinetics of Spontaneous Generation, 694
Berry, Prof. H : *Obituary* of Dr. Eric Boehm, 517
Berry, Dr. R J., and others : Mechanism of the Radiation Effect of the Synthesis of Deoxyribonucleic Acid, 563
Beryllium · Formation of Beryllium Carbide during the Corrosion of, in Carbon Monoxide and in Carbon Dioxide Gas (V D. Scott), 466
  Oxidation of, in Carbon Dioxide and in Carbon Monoxide (Dr. S. J Gregg, Dr. R. J Hussey and Dr. W B. Jepson), 468
Beryllium Carbide : Formation of, during the Corrosion of Beryllium in Carbon Monoxide and in Carbon Dioxide Gas (V D Scott), 466
Bessemer Gold Medal for 1960 of the Iron and Steel Institute awarded to Prof Hermann Schenck, 13
β-Acetamidoglutarate (Diethyl) · Requirements for Stereospecificity in Hydrolysis by Chymotrypsin— (Prof. Saul G Cohen and Ezra Khedouri), 75
β-Aminoisobutyric Acid . Urinary Excretion of a Ninhydrin-positive Compound, probably a Peptide, after Administration of, to the Mouse (Dr. James B. Gilbert and Dr. Yuoh Ku), 160
β-Carotene Triiodide Electrical and Magnetic Properties of (Dr Charles M. Huggins and Dr Oliver H. Le Blanc, jun.), 552
β-Chains (*α*- and) of Globins · Separation of the, by means of Starch-gel Electrophoresis (C. J Muller), 643
β-Globulin : A Haemoglobin-binding, in Human Serum (Dr M. P Tombs), 1055
β-Globulin Polymorphism in the Serum Proteins of Pigs : Thread Protein and (G. C. Ashton), 991
β-Globulins in Serum and Milk from Cattle · Inheritance of (Bo Gahne, Jan Rendel and Dr Ole Venge), 907

Between Earth and Space (Dr. Clyde Orr, Jr), *review* by B. R Leaton, 68
Beveridge, G. S. G. : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Bhilawanol : Structure of (Dr. Bernard Loev), 389
Bianchi, P. A., and others Infra-Red Spectra of Deoxyribonucleic Acids from Human Leucocytes, 964
Bibliographical Index of Literature in Russian Language for 1958 (Academy of Sciences of the U S S.R), 359
Bibliography on the Economic and Social Implications of Scientific Research and Development (United States National Science Foundation), 14
Bibliography on Plasma Physics and Magnetohydrodynamics and their Applications to Controlled Thermonuclear Reactions (J D. Ramer), 522
Bibliography (Scientific), of Latin America, 203
Bier, G : Polymeric Progress (The Use of Ziegler Catalysts), 441
Bierrum, N. R., and others : Coherence and Band-width of a Gas Discharge Harmonic Generator, 626
Biersteker, P. A , and others : Intracellular Potentials in Rat Atria during and after Vagal Stimulation or Acetylcholine Administration, 637
Bletti, G. B., and others (edited by) . Documenta Ophthalmologica (Advances in Ophthalmology, Vol. 13), *review* by R. C. Davenport, 42
Bigland, Dr C H., and Triantaphyllopoulos, Dr. D C. · A Re-Evaluation of the Clotting Time of Chicken Blood, 644
Bile (Human) : Seromucoid Contents of (Dr C. Mihaescu and Edith Mihaescu), 394
Billing, Eve · An Association between Capsulation and Phage Sensitivity in *Erwinia amylovora*, 819
Binary Systems in Concentrated Solutions : The Physico-chemical Constants of (Prof. Jean Timmermans), Vol. 1, Two Organic Compounds (without Hydroxyl Derivatives) ; Vol. 2, Two Organic Compounds (at least one a Hydroxyl Derivative), *review* by Dr E. F G. Herington, 918
Bindal, V. N. (Parthasarathy, Dr. S., and) : Ultrasonic Propagation Constants in Supercooled Salol, 145
Binding of a Hepatocarcinogen to the Structural Lipoprotein of Rat Liver—its Bearing on the Immunological Theory of Cancer (J. W. Westrop and Prof. H. N. Green), 350
Binding (Calcium), in Homogenates of Ehrlich Ascites Tumour Cells (R. Schofield and D Thomason), 656
Bindra, Prof. Dalbir : Motivation, *review* by Prof. J. Drever, 39
Binnie, A. M. : Elected a Fellow of the Royal Society, 11
Binomial Distribution : The Meaning of (A. W. F. Edwards), 1074
Biochemical Approach to Pathology (M. J. R. Dawkins and Dr. K R. Rees), *review* by Dr. R. W. R. Baker, 921
Biochemical Data, *review* by Dr. K S. Dodgson, 50
Biochemical Research : Data for (edited by R. M. C. Dawson, Daphne C. Elliott, W. H. Elliott and K. M Jones), *review* by Dr. K. S. Dodgson, 50
Biochemical Society : Symposium No 17 (1958), Glutathione (edited by E. M. Crook), *review*, 669
  Careers in Biochemistry, 854
Biochemical Society and the Societé de Chimie Biologique · Joint Meeting to be held in Paris, 440
Biochemical Studies (Genetical and), of the Immobilization Antigens of *Paramecium aurelia* (J. O. Bishop and Dr G. H. Beale), 734
Biochemical Studies (Histochemical and), of Rat Liver in Experimental Cirrhosis after Partial Hepatectomy (I Bartók, Gy. Domján, E. Horváth and Prof. B. Korpássy), 397
Biochemical and Biophysical Research Communications, Vol. 1, No. 1, 124
Biochemistry : Careers in (Biochemical Society), 854
  General, *review* by Prof. F G. Young, 51
  A Guide-Book to (Kenneth Harrison), *review* by Prof. D. C. Harrison, 583
  Ultracentrifugation in (Dr. Howard K Schachman), *review* by Dr. K. V. Shooter, 56
Biochemistry of the Eye (Dr. Antionette Pirie), 352
Biochemistry in relation to Medicine (C W. Carter, Dr. R. V. Coxon, D. S. Parsons and Prof R H S Thompson), third edition, *review* by Prof. D. C Harrison, 422
Biochemistry and Medicine, *review* by Prof D. C Harrison, 422
Biochemistry and Physiology Comparative, Vol. 1, No. 1, 764
Biochemistry (Microbial) · Annual Ciba Lectures in (Dr. M. R. J. Salton), 284
Biochimie Générale Traité de (M. Javillier, M Polonovski, M Florkin, P. Boulanger, M Lemoigne, J Roche et R. Wurmser), Tome I, Composition Chimique des Organismes, *review* by Prof. F. G. Young, 51
Bio-electric Potentials of Plants (D. S. Fensom), 853
Biographical Memoirs of the National Academy of Sciences of the United States of America, Vol 33, *review*, 70
Biological Activity of Pregnant Mare Serum Gonadotropin : Effect of *p*H on (Bengt H Persson and Stig E J. Melander), 163
Biological Engineering Society : Inauguration of the, 1019
  Election of Officers, 1019
Biological Equilibria in Human Cancer (Dr. Kenneth W. Starr), 1006
Biological Problems of Grafting—a Symposium sponsored by the Commission Administrative du Patrimoine Universitaire de Liège and the Council for International Organizations of Medical Sciences), *review* by Dr. D. M. V. Parrott, 51
Biological Properties (Gibberellin-like) : Distribution and Prevalence of *Fusarium moniliforme* Sheld. (*Gibberella fujikurio* (Saw.) Wr.) producing Substances with (Prof. W. L. Gordon), 698
Biological Rhythm, Society for, and the International Basimetric Society : Seventh International Conference, 604
Biological Sciences : Elementary Statistics with Applications in Medicine and the (Prof. Frederick E. Croxton), *review* by R. M. Cormack, 746
Biological Sciences (Medical and) : Current Indexing and Abstracting Periodicals in the (United Nations, World Health Organization, Library News, Vol. 12, Supp. 2), 936
Biological Significance of Peptide containing Hydroxyproline during the Development of Carrageenin Granuloma (Dr. M. Chvapil and B. Cmuchalová), 806
Biological Standardization of Drugs, 438
Biological and Medical Sciences Statistical Methods in, *review* by R M. Cormack, 746
Biological and Social Aspects : Intraspecific Differentiation— (Dr. Max Pettersson), 431
Biologists (Applied), Association of, and the British Mycological Society Symposium on the Nature and Exploitation of Crop Plant Resistance to Disease, 857
Biology at Oregon, 681
Biology . Arrow Symbol in (Dr. A. E. Needham), 103
  Radiation (Australasian Conference on), 938
  Statistical Methods in (Dr Norman T. J Bailey), *review* by R M. Cormack, 746
  The Teaching of Veterinary Anatomy as a Branch of—its Relationships to Human Anatomy (Dr R. A Green), 192
  Brookhaven Symposia in, No 12, Structure and Function of Genetic Elements (June 1959), *review* by Prof. S. C. Harland, 63
  Brookhaven Symposia in, No. 13, Protein Structure and Function, 361
Biology, Institute of New format of the *Journal*, 282
Biology of Mycorrhiza (Dr J. L. Harley), *review* by Dr J. Warren Wilson, 48
Biology (Experimental), at Rehovoth, 681
Biology (Human), Society for the Study of · Symposium on Human Growth, 19
Biology (Marine), or Oceanography Grants for research in (Challenger Society), 854
Biology (Quantitative) : Cold Spring Harbor Symposia on, Vol. 23, Exchange of Genetic Material—Mechanisms and Consequences, *review* by Prof Kenneth Mather, 832
Biology Building (New), of the University College of Wales, Aberystwyth (Prof T A. Stephenson and Prof P. F. Wareing), 1021
Biology Staining Schedules (R. R. Fowell), sixth edition, 125
Biophysical Journal (Biophysical Society and the Rockefeller Institute Press), 282
Biophysical Research Communications Biochemical and, Vol. 1, No. 1, 124
Biophysical Society and the Rockefeller Institute Press : To publish the *Biophysical Journal*, 282
Biophysics (International Congress on), 1020
Biosynthesis of Colchicine (Dr. A. I Scott), 556
Biosynthesis of Flavonoids (W E. Hillis), 635
Biosynthesis of Terpenes and Sterols : Ciba Foundation Symposium on the (edited by G. E. W. Wolstenholme and Meave O'Connor), *review* by Dr. D. T. Elmore, 745
Biotin-deficient Yeast Excretion of Nicotinic Acid and Nicotinic Acid Adenine Dinucleotide by (Dr. Anthony H. Rose), 139
Bird (Oliver) Trust : Oliver Bird Prize for 1959 awarded to H. M. Bunce, 17
Birds (Nidifugous) : A Possible Fundamental in the Behaviour of Young (Dr. Peter M. Driver), 416
Birmingham College of Advanced Technology : Appointment of K. L. Stretch as vice-principal, 12
Birnbaum, Debora, and others : Blood Groups in Rabbits, 321
Birth · Dependence of the Sex Ratio at, on the Age of the Father (Dr. Leo Szilard), 649 ; (Dr A. Comfort), 1065
Bishop, Dr A. C., and Marshall, Dr R. D : Optical Properties of the $\alpha\omega$-Dimethanesulphonoxyalkanes, 74
Bishop, Dr. J. F. M. : Reactor Fuel Element Technology (Theoretical Evalution of a Fuel Element), 1025
Bishop, J. O., and Beale, Dr G. H : Genetical and Biochemical Studies of the Immobilization Antigens of *Paramecium aurelia*, 734
Bishop (Bernice P.) Museum, and others · Tenth Pacific Science Congress of the Pacific Science Association, 604
Bismuth : Optical Properties of (H D. Mallon and I G. Runciman), 709
Biswas, Dr. B B., and Myers, J · A Methyl Cytidine from the Ribonucleic Acid of *Anacystis nidulans*, 238
Bivalve Gastropod : A (Robert Burn), 179 ; (Prof. A. Myra Keen), 406
Black, T. J · Appointed lecturer in mechanical engineering at the Queen's University, Belfast, 767
Black, Dr. W : Nature and Exploitation of Crop Plant Resistance to Disease (Problem of Resistance to Potato Blight, *Phytophthora Infestans*), 858
Blackmore, Dr. A. V., and Warkentin, Prof. B P. . Swelling of Calcium Montmorillonite, 823
Blackwood, Dr. H. J. J. : Appointed reader in oral anatomy at the Royal Dental Hospital of London School of Dental Surgery, 938
Blair, Dr. G. W. Scott : Flow of Blood through Narrow Tubes, 708
Blakey, Dr F A. : Visco-Elastic Systems (Relative Contribution of the Cement Paste and of the Aggregate to the Creep of Concrete), 942 ; (Factors Influencing the Creep of Gypsum Plaster), 943
Blenk, H , and others (edited by) : Advances in Aeronautical Sciences—Proceedings of the First International Congress on the Aeronautical Sciences (Madrid 1958), *review* by Prof A. R. Collar, 665
Blenkin, Dr J. : Gas Chromatography (Analysis of Hydrocarbon Elastomers by combined Pyrolysis and Gas Chromatography), 944
Blennorrhoea (Inclusion), and Lymphogranuloma (Trachoma,) : Transmission of the Viruses of, to Mice (Dr. E. Weston Hurst and P. Reeve), 336
Blepharisma : Effect of Centrifugation on the Macronucleus of *Spirostomum* and (Prof. B. R. Seshachar), 333
Blincoe, Clifton : Whole-Body Turnover of Selenium in the Rat, 398
Blind, Royal Commonwealth Society for the : Blindness in West Africa (Prof F C. Rodger), *review* by R C. Davenport, 64
Blindness in West Africa (Prof F. C. Rodger), *review* by R. C. Davenport, 64
Blitzer, Prof. Leon : Secular and Periodic Motions of the Node of an Artificial Earth Satellite, 874
Block, Dr. Stanley : Crystal Structure of Potassium Trivanadate, 540
Blocking of Mitosis by Heat Shock (Per Bergan), 905
Blocking Effect of Tetrahydroaminacrin on a New Psychotomimetic Agent (Dr. Samuel Gershon), 1072
Bloembergen, Prof. N. : Elected a member of the United States National Academy of Sciences, 773
Blomgren, Dr. Erik A., and Bockris, Dr. John O'M. : Determination of Adsorption in Double Layers involving Solid Metals, 305
Blomquist, Prof. A. T. : Elected a member of the United States National Academy of Sciences, 773
Blood · Flow of, through Narrow Tubes (Dr G. W. Scott Blair), 708
  Measurement of the Intrahepatic Shunted Flow of, in Cirrhosis of the Liver (T. Nakamura, S. Nakamura and K. Tokita), 243
Blood of Carcinoma Patients? : Subnormal Level of Carbonic Anhydrase in (Dr. N W. H. Addink), 253

Blood (Chick) Influence of Dietary Intake of certain Insecticides on the Haemoglobin and Erythrocyte Contents of (Prof. B. K Srivastava, H. C. Saxena and J C Sharma), 172
Blood (Chicken) . A Re-Evaluation of the Clotting Time of (Dr. C. H. Bigland and Dr. D. C. Triantophyllopoulos), 644
Blood (A Red Water), of Rotifers in Cook Strait, New Zealand (Vivienne Cassie), 328
Blood (Red) Cells of East Africans · Glucose-6-Phosphate Dehydrogenase Deficiency in (Dr. A. C. Allison), 531
Blood Coagulation in a Cold- and a Warm-blooded Animal : Influence of Temperature upon (Dr. H. B. Anstall and Dr R. G. Huntsman), 726
Blood Donors from Austria and Germany : Frequencies of the Haptoglobin Serum Groups among (Dr. H Baitsch, G Meier, L. Schoeller and D. M. Kahlich-Koenner), 976
Blood Formation in Rats : Effect of Manganese Edetate on (T. J Sullivan), 87
Blood Glucose in Crayfishes in relation to Moult and Handling (Dr. J. A. Riegel), 727
Blood-Group Antigen M (Human) . M_1, a Subdivision of the (J. A. Jack, Patricia Tippett, Jean Noades, Dr Ruth Sanger and Dr. R. R. Race), 642
Blood Group System (Kidd) : Evidence for a New Allele in the, In Indians of Northern Mato Grosso, Brazil (Dr. Richard T. Silver, Jane M. Haber and Dr Aaron Kellner), 481
Blood Groups : The ABO (Dr. A. E. Mourant, Ada C. Kopeć and Kazimiera Domaniewska-Sobczak), *review* by Dr. F. Stratton, 581
Blood Groups in Rabbits (Dr. D. Nelken, Debora Birnbaum and J. Gurevitch), 321
Blood Parasite from the California Yellow-legged Frog (Donald L. Lehmann), 765
Blood Serum : Determination of Calcium in, by Atomic Absorption Spectroscopy (J. B. Willis), 249
Blood-Typing Tests (Lytic) : Bacterially Mediated False-Positive Reactions in (Prof Clyde Stormont, Yoshiko Suzuki and W. J. Miller), 247
Blood Volumes (Mouse Tumour) : Estimation of, employing a Radioactive Isotope Technique (F. S. Stewart and Dr. A E. G Pearson), 250
Blumenthal-Goldschmidt, Dr. S., and Lang, Prof A. : Presence of Gibberellin-like Substances in Lettuce Seed, 815
Bochníček, Z. V. : Profile of Upper-Atmosphere Air Density at the Height of 180-212 km. derived from the Orbit of *Sputnik* III, 460
Bock, Fred G. (Burnham, Mary, and) : Effect of Molecular Structure upon Concentration of Hydrocarbons in 'Painted' Mouse Skin, 323
Bockris, Dr John O'M. (Blomgren, Dr. Erik A., and) : Determination of Adsorption in Double Layers Involving Solid Metals, 305
Bodmer, W. F. : Electronic Computers in Population Genetics, 851
Body-Weight and Age in relation to the Metabolic-Rate of the Young Pig (Dr. L. E. Mount and J. G. Rowell), 1054
Body-Weight and Liver–SH Levels of Mice (Dr. G. Calcutt), 84
Body-centred Cubic Lithium : An Energy Band Interpolation Scheme, with Application to (J. F. Cornwell and Dr. E. P. Wohlfarth), 379
Boehm, Dr Eric : *Obituary* by Prof. H Berry, 517
Boeles, J Th F., and others : Intracellular Potentials in Rat Atria during and after Vagal Stimulation or Acetylcholine Administration, 637
Bogoliubov, N. N., and others : A New Method in the Theory of Superconductivity (translated from the Russian), *review* by Dr. C. G. Kuper, 833
Bokhoven, C , and Dijkstra, A. : Effect of Carrier Gas on the Sensitivity of Thermal Conductivity Detectors, 793
Bollee, B , and de Vries, G : Experiments in the Field of Parametric Amplification, 1019
Bollmann, W., and Spreadborough, J. : Action of Graphite as a Lubricant, 29
Bolognari, A. : Yolk Formation in Oocytes of *Patella coerulea* L. and *Aplysia depilans* L. as observed in the Electron Microscope, 490
  Golgi Bodies and Golgi Zones in Molluscan Oocytes, 565
Bombyx mori L. (Silkworm) : Xanthine Dehydrogenase in the (Yoshiyuki Hayashi), 1053
Bomsel-Helmreich, O. (Piko, L., and) : Triploid Rat Embryos and other Chromosomal Deviants after Colchicine Treatment and Polyspermy, 737
Bonaduce, Luisa, and others · Enzymatic Deamination of 5-Deoxycytidylic Acid and of 5-Methyl-5'-deoxycytidylic Acid in Growing and in Non-growing Tissues, 237
S–S Bond Breakage and Inactivation by Radiation of a Dry Enzyme : A Connexion between (Dilip K. Ray, Dr. Franklin Hutchinson and H. J. Morowitz), 312
Bondi, Dr H. : Gravitational Waves in General Relativity, 535
Bonding : Rubber to Metal (Dr. S. Buchan), second edition, *review* by Dr. W. C. Wake, 189
Bonds between Rubber and Metal, *review* by Dr. W. C. Wake, 189
Booker, Prof H. G . Elected a member of the United States National Academy of Sciences, 773
Books : Recent Scientific and Technical, Supp. vi, April 30 ; Supp vi, May 28 ; Supp. vi, June 25
Books (British), for Export, 600
Books (Reference), on Mineralogy in the U.S S.R (Academy of Sciences of the U.S S R.), 203
Booth, Dr A D. · *Cogito ergo sum*, *review*, 422
Boray, J. C , and Pearson, I. G. : Anthelmintic Efficiency of Tetrachlorodifluoroethane against *Fasciola hepatica* in Sheep, 252
Borchert, Dr. H. : Orogens, 690
Boron Deficiency in *Grevillea robusta* (A N Smith), 987
Boron or Silicon : Absorption Spectra of Diatomic Radicals containing (Dr. B. A Thrush), 1044
Boroughs, Dr. Howard : An Inexpensive Castle and Sample Holder for Radioactive Counting, 145
Borrie, Prof. W. D. · The Dilemma of the Far East, *review*, 664
Bos, C. J , and others · Swelling of Fresh and Aged Liver Mitochondria as affected by Succinate, Adenine Nucleotides and Thyroxine, 556
Bose, A. K. (Jain, H. K., and) : Experimentally Induced Inter-bivalent Redistribution of Chiasmata in *Delphinium*, 260
Bosnich, B , and others . Rate of Ligand Exchange with its Metal Complex by a Polarimetric Method, 966
Botan, E A , and Brother, T. B · Liberation of Hexuronic Acid, Hexosamine and Hydroxyproline from Steer Hide by Stem Bromelain, 314
Botanical Laboratory (Central), Allahabad : Retirement of Dr E K. Janaki Ammal from the directorship, 519
  Appointment of Dr. G. S. Puri as director, 519
Botanist A Nineteenth-Century, *review* by Sir Edward Salisbury, 44
Botany at Cambridge, 356
Botany at Newcastle-upon-Tyne, 1016
Botany : Contributions to (National Museum of Canada, Bulletin No. 160), 1017
Botany (Agricultural), National Institute of: Thirty-ninth Report (1958), 287
Botany (Cryptogamic), at Manchester, 598
Bottom Cores (Some), from the Swedish Deep-Sea Expedition, 1947-48 (A. S Laughton), 609
Bottom Sections from the Central Pacific On the Stratigraphy of some, (F. Brotzen and A. Dinesen), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 10, Special Investigations, No. 4), 609
Bottuça, C , and Ferrari, I. : A Simplified Method for the Study of Chromosomes in Man, 904
Boulanger, P., et autres : Traité de Biochimie Générale, Vol. I, Composition Chimique des Organismes, *review* by Prof. F G. Young, 51
Bouman, L. N., and others : Intracellular Potentials in Rat Atria during and after Vagal Stimulation or Acetylcholine Administration, 637
Boundary Layer Research (NATO Advisory Group for Aeronautical Research and Development Discussion on), 1022
Bourne, Prof. Geoffrey H. (Tewari, Dr. H. B., and) : Neurokeratin Network of the Peripheral Nerve Fibre Myelin Sheath as a Centre of Metabolic Activity, 645
Bourne, Dr Gordon L., and Lacy, Dr. Dennis : Ultra-Structure of Human Amnion and its Possible Relation to the Circulation of Amniotic Fluid, 952
Boutry, Prof. E. A. : Work of the Abstracting Board of the International Council of Scientific Unions, 358
Bovey, Dr. F. A , and Yanari, S. S.: Effect of Solvent Polarizability on the Ultra-violet Spectral Shifts of Aromatic Compounds, 1042
Bovine Pineal Extract : Effects of Injection of, on the Nuclei of Rat Pineal Parenchymal Cells (Dr. Uno Holmgren, Dr. Mark D. Altschule and Dr. Richard J. Wurtman), 393
Bovine Serum Albumin · Iodination of Specific Sites on (Dr. David Pressman and Dr. Gerald Radzimski), 1049
Bowen, H. J. M., and others : Use of Ionizing Radiation in Spot Tests for Nitrogenous Compounds, 383
Bowen, Dr. Vaughan T., and Sugihara, Prof. Thomas T. : Strontium-90 in the 'Mixed Layer' of the Atlantic Ocean, 71
Bowles, P., and Burns, R H. : *Obituary* of Harold Tongue, 120
Bowles Memorial Travel Scholarship (Royal Horticultural Society), 206
Boyd, Dr. R L. F. : Space Science, 749
Boyer, Georgiana (Burnet, Sir Macfarlane, and) : Loss of Specificity on Passage of Immunologically Competent Cells in the Chick Embryo, 175
Boyle, Robert—Father of Chemistry (Dr. Roger Pilkington), *review* by Dr. W. A Smeaton, 63
Boyne, Dr. A. W. · Human Growth (Some Aspects of the Well-known Secular Trend to Higher Weight and Height of Children at all Ages), 20
Boys, Prof Floyd, and Smith, Prof. Hobart M. : Poisonous Amphibians and Reptiles, *review* by A. G. C. Grandison, 269
Brabazon of Tara, Lord : Elected president of the Royal Institution, 440
Brace, R O., and others : Microquantitative Infra-Red Analysis—Application to Gas Chromatographic Fractions, 628
Bracewell, Prof R. N. : Communications from Superior Galactic Communities, 670
Brachet, Prof. J : Ribonucleic Acids and the Synthesis of Cellular Proteins, 194
  Modern Trends in Enzymology, *review*, 267
Bradford Institute of Technology (Department of Chemical Technology) : Symposium on Co-ordination Compounds, their Chemistry and Applications, 440
Bradley, Prof W., and Thompson, J. D. : Reaction of *p*-*n*-Decyloxybenzenediazonium Fluoborate with Sodium Iodide in Benzene, 631
Bradley, Dr W H · Publication by the *American Journal of Science* of a Bradley Volume (258-A) in appreciation of his work with the United States Geological Survey, 934
Bradykinin Activity of some Synthetic Peptides with only Slight Structural Resemblance to Natural Bradykinin (Dr. G. L. Tritsch and Prof D W Woolley), 76
Bradykinin (Natural) : Bradykinin Activity of some Synthetic Peptides with only Slight Structural Resemblance to (Dr. G. L. Tritsch and Prof D. W. Woolley), 76
Braekkan, O. R , and others : Vitamin A Isomers in the Liver of Rats and Chicks, 312
Braganca, Dr. B. M. : Awarded a Grant from the Tata Memorial Trust, for research on leukaemia and allied diseases, 1020
Brain : Dipeptidase Activity of (L. Lahut Uzman, Marilynn K. Rumley and Stanley van den Noort), 559
Brain in Response, *review* by Prof M D. Vernon, 919
Brain as Regulator (Dr W. Ross Ashby), 413
Brain—Memory—Learning—a Neurologist's View (Dr W. Ritchie Russell), *review* by Dr. Gilbert Hall, 39
Brain (Mammalian) : Histochemical Demonstration of Ascorbic Acid in the Locus Coeruleus of the (Dr. Nobuo Shimizu, Tomokazu Matsunami and Satoko Onishi), 479
Brain (Rat's) · Effect of Methylpentynol on Acetylcholine in the (Giancarlo Pepeu and Prof Nicholas J Giarman), 638
Brain Cortex Slices · Active Transport of γ-Aminobutyric Acid in, with special reference to Phosphorus-32 Turnover in Phospholipids in Cytoplasmic Particulates (Yasuzo Tsukada, Yutaka Nagata and Shusuke Hirano), 474
Brain Tissue in Culture : Spontaneous Potentials from Explants of (Prof. A W. B. Cunningham, Marshall Dougherty and B. J Rylander), 477
Branch of Biology : The Teaching of Veterinary Anatomy as a—its Relationships to Human Anatomy (Dr. R A. Green), 192
Branched Dextrans · Action of a Bacterial Dextranase on (R. W. Bailey, Dr. D. H. Hutson and Dr H. Weigel), 553
Branching and Root Formation (Repeated)· Foliar Abnormalities, including, induced by Kinetin in Attached Leaves of *Marsilea* (Dr. A. Allsopp and Alicja Szweykowska), 813

Bras, Prof. G . Medical Research in the British Caribbean, 863
Braun, Prof. A. C.: Elected a member of the United States National Academy of Sciences, 773
Braun, Armin C., and others : Purification of a Specific Inducer of the Male Sex Organ in certain Fern Species, 1066
Brazil (Northern Mato Grosso,) : Evidence for a New Allele in the Kidd Blood Group System in Indians of (Dr. Richard T. Silver, Jane M. Haber and Dr. Aaron Kellner), 481
Breakage (S–S Bond), and Inactivation by Radiation of a Dry Enzyme : A Connexion between (Dilip K. Ray, Dr. Franklin Hutchinson and H. J. Morowitz), 312
Breakdown (Intrinsic Electrical), of Glass · Time-lags in the (M. N. Azam and H Dickinson), 146
Brenan, J. P. M : A Handbook of West African Flowers, *review*, 65
  Central African Savannahs, *review*, 505
Brenan, P. M., and Harrison, D. P. : Results of the Royal Society's International Geophysical Year Expedition (Work in Radio Astronomy), 191
Brentani, Dr. R., and others . Increase in 'Alkaline' Ribonuclease of Rat Kidney Cortex after Lysozyme and Egg-White Administration, 158
Bretscher, Dr E. · Low-Energy Nuclear Physics, *review*, 58
  Obituary of Dr Donald J. Hughes, 848
Brian, Dr. P. W. : Research into Griseofulvin (Presidential Address to the British Mycological Society), 853
Bridges, Dr. C. D. B. . Regeneration of Visual Pigments from their Low-Temperature Photoproducts, 292
Briggs, Prof. G. E. · Retirement from the professorship of botany in the University of Cambridge, 356 , work of, 356
Briggs, J. B. : Nature and Exploitation of Crop Plant Resistance to Disease (Possible Control of a Disease by Breeding for Resistance to its Vector), 858
Brighteners for Nickel Plating and Polarographic Maxima (Hideya Okada and Takeo Ishida), 152
Brightman, R. : British Industries and their Organization, *review*, 70
  Classification and Indexing in Science, *review*, 190
  British Industrialists, *review*, 347
Britain : Amenities and Development in, 265
  Apprenticeship Training in, 436
  Dental Research in, 600
  Development of Nuclear Energy in, 1
  Employment of Women in, 365
  Mapping (Seventy-fifth Anniversary Exhibition of the Royal Scottish Geographical Society), 523
  The Public and the Broadcasting Programmes in, 363
  Recruitment of Teachers in, 600
  Science in Secondary Schools in, 663
  See *also under* Great Britain
Britain's National Parks (edited by Harold M. Abrahams), *review*, 70
British Association for the Advancement of Science . Guide to Press Arrangements for Scientific, Medical and Technical Conferences (edited by Ronald Bedford), 437
British Association of Chemists : Hinchley Medal awarded to Dr. C. J. T. Cronshaw, 685
British Books for Export, 600
British Broadcasting Corporation : The Public and the Programmes, an Audience Research Report on Listeners and Viewers, the Time they devote to Listening and Viewing, the Services they Patronize, their Selectiveness and their Tastes, 363
British Caenozoic Fossils (Tertiary and Quaternary), (British Museum (Natural History)), *review*, 669
British Coke Research Association : Grant of £3,500 to the Houldsworth School of Applied Science in the University of Leeds, 767
British Commonwealth : Scientific Research in the Overseas Territories of the, 501
  Teaching within the, 281
British Commonwealth, Association of Universities of the : Report for 1958-59, 600
British Computer : A New, 201
British Computer Society, Ltd. : Second Annual Conference, 361
British Diet : Strontium-90 Content of, 852
British Dyestuffs and Wider Co-operation in Europe, 829
British Flour Millers, Research Association of—New Laboratories (Dr. T. Moran), 856
British Industrialists—Steel and Hosiery, 1850-1950 (Charlotte Erickson), *review* by R. Brightman, 347
British Industries, Federation of : Handbook on the Technical Colleges and their Government, 769
British Industries and their Organization (Prof G. C. Allen), fourth edition, *review* by R Brightman, 70
British Industries Technical Colleges Committee, Joint Federation of : The Technical Colleges and their Government, 769
British Iron and Steel Research Association : Grant of £1,000 to the University of Oxford for the continuation of research on the melting- and freezing-points of alloys, being carried out in the Department of Metallurgy, 126
  Conference on Heat-Treatment Practice, 523
British Leather Manufacturers Research Association : Open Days, 17
  Open Days (Dr. K W. Pepper), 1024
British Library of Political and Economic Science · Annual Report for 1958-59, 520
British Museum (Natural History) : New Exhibits, 14
  Catalogue of the Type Specimens of Microlepidoptera in the, described by Edward Meyrick (J. F. Gates Clarke), Vol 3, Tortricidae, Olethreutidae, Noctuidae, *review* by R. G. Fennah, 188
  The Neolithic Revolution (Sonia Cole), 360
  British Caenozoic Fossils (Tertiary and Quaternary), *review*, 669
British Mycological Society : Applications invited from members, and heads of departments, for grants from the Cheesman and Pethybridge funds to enable students of mycology to attend the Spring or Autumn Foray, or the Plant Pathology Field Meeting, 440
  Presidential Address, Research into Griseofulvin (Dr. P. W. Brian), 853
British Mycological Society (Association of Applied Biologists and the) : Symposium on the Nature and Exploitation of Crop Plant Resistance to Disease, 857
British Occupational Hygiene Society : International Symposium on Inhaled Particles and Vapours, 524
British Rayon Research Association : Open Days, 284
British Science Writers, Association of · Guide to Press Arrangements for Scientific, Medical and Technical Conferences (edited by Ronald Bedford), 437
British Scientific Instrument Research Association : *Instrument Abstracts*, Vol. 15, No. 1, 359, *erratum*, 685
British Scientific Instrument Research Association (Optical Panel) : Optimization Methods used for Optical Design, 17
British Scientist : The Wandering, 436
British Transistorized Computer : A New (General Electric Co., and International Computers and Tabulators, Ltd), 936
British Universities : The Postgraduate Training of Physicists in—the Report of a Joint Committee appointed by the Institute of Physics and the Physical Society, 915
  The Use of Film in Teaching and Research in, 1959 (British Universities Film Council), 444
British Universities Film Council : The Use of Film in Teaching and Research in British Universities (1959), 444
British Veterinary Codex 1953 : 1959 Supplement to, *review* by Dr. P. Jewell, 507
British Veterinary Association : *Research in Veterinary Science*, Vol. 1, No. 1, 16
British Water Research Association : Fourth Annual Report (1958-59), 683
Brittle Materials for Microdiffraction : A Technique for Sampling Oxide Layers and (A M. Adams, M. A. Silva and Veronica M. Spiers), 147
Broadcasting Programmes in Britain, 363
Broadening of the Water Proton Line in High-Resolution Nuclear Magnetic Resonance Spectra of Starch Gels (Dr. Roger Collison and Dr. M. P. McDonald), 548
Brock, Sir Russell . Medicine in Shakespeare's Writings, *review*, 35
Brocklehurst, Dr. W. E. (Austen, Dr. K. F., and) : Inhibition of the Anaphylactic Release of Histamine from Chopped Guinea Pig Lung by Chymotrypsin Substrates and Inhibitors, 866
Brockmann, Prof. Hans : The Actinomycins and their Importance in the Treatment of Tumours in Animals and Man (Chemistry of the Actinomycins), 772
Brombacher, P. J., and others : Swelling of Fresh and Aged Liver Mitochondria as affected by Succinate, Adenine Nucleotides and Thyroxine, 556
Bromelain (Stem) : Liberation of Hexuronic Acid, Hexosamine and Hydroxyproline from Steer Hide by (E. A. Botan and T. B. Brother), 314
Bromide Hydrobromide (S-*β*-aminoethylisothiouronium) . Effect of, on X-Ray Damage to Guinea Pig Skin (Dr. J. B. Walter and Prof. D. Slome), 177
Brompton Hospital Reports : Vol. 27, 1958, *review* by Dr G. Lapage, 507
Brookhaven Symposia in Biology : No 12, Structure and Function of Genetic Elements (June 1959), *review* by Prof. S. C. Harland, 63
  No. 13, Protein Structure and Function, 361
Brooks, Dr. G. T. : Mechanisms of Resistance of the Adult Housefly (*Musca domestica*) to 'Cyclodiene' Insecticides, 96
Brossel, J. : Awarded the Holweck Medal and Prize (given jointly by the Société Française de Physique and the Physical Society), 440
  Optical Detection of Nuclear Magnetic Resonance (Holweck Lecture), 440
Brother, T. B. (Botan, E. A., and) : Liberation of Hexuronic Acid, Hexosamine and Hydroxyproline from Steer Hide by Stem Bromelain, 314
Brotzen, F., and Dinesen, A. : On the Stratigraphy of some Bottom Sections from the Central Pacific (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 10, Special Investigations, No. 4), 609
Brown, Ltd., John, and the Institution of Chemical Engineers : Scholarships in Chemical Engineering, 522
Brown, Prof. R. Hanbury : Elected a Fellow of the Royal Society, 11
Brown, T. D., and Onions, W. J. : Anomalies in the Microscopic Structure of some Wools, 93
Brown, W. : Electromagnetic Radiation from Cylindrical Structures, *review*, 583
Brown University (Office of Ordnance Research of the United States Army and) : Conference on the Mechanisms of Peroxide Reactions, 127
Brucer, Dr. Marshall : Thyroid Radioiodine Uptake Measurement, *review* by Dr E. E Pochin, 424
Bruun, Dr. Anton Frederick : Awarded the Agassiz Medal of the United States National Academy of Sciences, 686 ; work of, 686
Bryan, W. W. : Nitrogen in Tropical Agriculture (The Three Symbioses Legume/Rhizobium, Legume/Grass and Pasture/Herbivore), 942
Bryant, P. M. : Awarded a Ciba Fellowship for 1960-61, 684
Buchan, Dr. S : Rubber to Metal Bonding, second edition, *review* by Dr. W. C Wake, 189
Buchan Prize for 1955-59 of the Royal Meteorological Society awarded to Dr. R J. Murgatroyd, 440
Buckle, Dr. E R. · Reduced Temperatures for Nucleation in Supercooled Liquids, 875
Bulbring, Dr E. · Appointed reader in pharmacology at the University of Oxford, 767
Bulk Conductivity in Organic Crystals (Dr. H Kallmann and Dr. M. Pope), 31
Bulk Growth (Simplified), of *Vibrio foetus* (Dusan Jakovljevic and H. E. R. Beattie), 736
Bull, Frances, and others Mud Fauna of the Stour Estuary, 1018
Buller, A J. : Appointed reader in physiology at King's College, London, 938
Bulletin of the Provisional International Computation Centre, No 8, 764
Bunce, H. M : Awarded the Oliver Bird Prize for 1959, 17
Bunyan, J , and others . Ubiquinones and Ubichromenols in the Rat, 554
  Effect of Thyroxine and 2,4-Dinitrophenol on Levels of Ubiquinone and Ubichromenol in the Rat, 725
Burch, John B. · Chromosomes of *Gyraulus circumstratus*, a Freshwater Snail, 497
Burdon, Dr J., and others : Pentafluoropyridine, 231
Burdon-Jones, C., and McIntyre, A. D. : *Stereobalanus*, a Genus New to the Old World, 491
Bureau Européen de l'Education Populaire Notes et Études, No. 15, European Calendar of Short Summer Courses, 685

Burges, Prof Alan, and Latter, Pamela . Decomposition of Humic Acid by Fungi, 404
Burkhardt, Dr. G H : Appointed lecturer in mathematical physics at the University of Birmingham, 522, 767
Burn, Prof. J. H : Cardiovascular Effects of Nicotine and of Smoking, 525
Burn, Robert A Bivalve Gastropod, 179
Burnet, Sir Macfarlane, and Boyer, Georgiana Loss of Specificity on Passage of Immunologically Competent Cells in the Chick Embryo, 175
Burnham, Mary, and Bock, Fred G . Effect of Molecular Structure upon Concentration of Hydrocarbons in 'Painted' Mouse Skin, 323
Burns, Prof B. Delisle, and Robson, Dr. J. G . 'Weightless' Microelectrodes for Recording Extracellular Unit Action Potentials from the Central Nervous System, 246
Burns, R. H (Bowles, P., and) . *Obituary* of Harold Tongue, 120
Burns, Tom, and Stalker, G. M : Human Problems of Innovation—Based on a Study of some Scottish Firms (Department of Scientific and Industrial Research, Problems of Progress in Industry No 5), 419
Burnstock, G : Membrane Potential Changes associated with Stimulation of Smooth Muscle by Adrenalin, 727
Burr, E J : Earthquakes and Uranus—Misuse of a Statistical Test of Significance, 336
Burri, Prof Conrad Petrochemische Berechnungsmethoden auf Äquivalenter Grundlage, *review* by Prof. K C. Dunham, 56
Bursaries and a Scholarship (Institution of Agricultural Engineers), 284
Burton, D , and Ettlinger, Dr. G. · Cross-Modal Transfer of Training in Monkeys, 1071
Burton, J M C. : Results of the Royal Society's International Geophysical Year Expedition (Nature of the Ice Shelf), 191
Burton, L. K , and others . Detection of Recently Produced Fission Products in the Atmosphere, 223
  Radioactive Fallout during 1959, 925
Burton, W. M , and Stewart, N G. : Use of Long-lived Natural Radioactivity as an Atmospheric Tracer, 584
Bushnell, Dr. G. H. S. Excavations at La Venta, Mexico, 134
  Maya Hieroglyphics, *review*, 580
Business Studies : The Future Development of Management Education and of—Revision of Joint Examination Schemes (Ministry of Education, Circular 1/60), 743
  Management, Education and, 743
Butane Gas (Helium–) Mixtures as Fillings for Geiger-Muller Tubes (Dr V. Moses and Dr. J. F. Fowler), 538
Butler, Prof. J. A. V , and Robins, Dr. A. B. · Effect of Oxygen on the Inactivation of Trypsin by Ionizing Radiation, 697
Butler, Prof. S T , and Messel, Prof H (edited by) From Nucleus to Universe—a Course of Selected Lectures in Physics and Astronomy, University of Sydney, 1960, *review* by G R. Noakes, 748
Butterflies : Selective Visits of, to Flowers—a Possible Factor in Sympatric Speciation (K. R Dronamraju), 178
  Some East Anglian (S Beaufoy), 771
Buxton, Dr E. W : Nature and Exploitation of Crop Plant Resistance to Disease (Studies with Pea Wilt Resistance), 858
Buyske, Donald A. (Hlavka, Dr. Joseph J , and) : Radioactive 7-Iodo-6-Deoxytetracycline in Tumour Tissue, 1064
Buzzard, Dr R B . Awarded the Vernon Prize for 1960 of the National Institute of Industrial Psychology, 938
Buzzard · The (Frank Wenzel), translated from the Danish by Reginald Spink, *review* by Frances Pitt, 65
By-Ways : Geological Ways and, *review* by Dr. J. V. Harrison, 57, 440
Bygdeman, M , and Stjarne, L Effects of 1,4-Dihydrazinophthalazine on the Catechol Amines, 82

CABBAGE (Goitrogenous and Non-goitrogenous) Level of Sulphydryl Compounds in Rat Liver following Feeding with (Jozef Sedlák), 892
Cacace, Fulvio, and Guarino, Angelo : Radiation Labelling with Carbon-14 of Aliphatic Hydrocarbons, 632
Cactaceae · Die (Curt Backeberg), Band 3, Cereoideae (Austrocactinae), *review*, 347
Cadmium : The Radiochemistry of (James R DeVoe), 602
Cadogan, Dr J I G. : Awarded a Meldola Medal for 1959 of the Society of Maccabaeans, 519
Cainozoic Fossils : British (Tertiary and Quaternary), (British Museum (Natural History)), *review*, 669
Caesium-137 in Spray-dried Danish Milk (Per Gert Jensen), 562
Caesium-137 in Toronto Milk during 1959 (Prof. K G McNeill and O. A. D Trojan), 399
Cahn, Dr. R. S. An Introduction to Chemical Nomenclature, *review* by Prof. H. J. Barber, 54
Calcareous Algae in a Sediment Core from the Mindanao Trough Fragments of (H. Horn af Rantzien), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific No. 7), 609
Calcium in Blood Serum : Determination of, by Atomic Absorption Spectroscopy (J. B. Willis), 249
Calcium-47 · International Co-operation and the Production of, 1018
Calcium and Contractility in Depolarized Smooth Muscle (Dr. P. A. Robertson), 316
Calcium and Magnesium in Human Cerebrospinal Fluid (Dr G. Hunter and Honor V. Smith), 161
Calcium Binding in Homogenates of Ehrlich Ascites Tumour Cells (R. Schofield and D Thomason), 656
Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith) Effect of a Sewage Effluent Discharge on the Deposition of (R. W. Edwards and J. Heywood), 492
Calcium Montmorillonite : Swelling of (Dr. A. V. Blackmore and Prof. B. P. Warkentin), 823
Calcium–Montmorillonite with Polymers : Complexes of (W. W Emerson), 573
Calcutt, Dr. G. : Body-Weight and Liver–SH Levels of Mice, 84
Calcutt, Dr G. (Harper, Dr. K. H , and) : Conjugation of 3·4-Benzpyrenols in Mouse Skin, 80
Calder, Ritchie : The Hand of Life—the Story of the Weizmann Institute, *review*, 64
Calendar (European), of Short Summer Courses (Bureau Européen de l'Education Populaire), 685
California Academy of Sciences : Occasional Papers No 25, The Galápagos Islands, a History of their Exploration (Joseph Richard Slevin), 365
California Department of Fish and Game : Bulletin No 107, Trout and Salmon Culture—Hatchery Methods (Earl Leitritz), 204
California Sea-lion, *Zalophus californianus* Chronic Aortitis in the (Dr. Arthur L. Kelly and Dr David Jensen), 731
California Yellow-legged Frog A Blood Parasite from the (Donald L. Lehmann), 765
Callow, Dr. R. K · At the Scientific Publications Council's Discussion on the Rapid Increase in the number of New Scientific Journals, 18
Calne, R. Y Elected to a Harkess Fellowship for 1960 of the Commonwealth Fund, 15
Calorimetry Conference, 604
Calyptraea chinensis (L.) . Response of Larvae of, to Light (H V. Wyatt), 328
Campbell, Dr Allan : Autocatalytic Particles and Steady States, 256
Canada, Geological Survey of : Bulletin No 54, Helicopter Operations of the Geological Survey of Canada, 521
Canada, National Museum of : Natural History Paper No 3, *Anchiceratops* from the Oldman Formation of Alberta (Wann Langston), 522
  Bulletin No 160, Contributions to Botany, 1017
  Bulletin No 162, Contributions to Anthropology, 1017
  Bulletin No. 166, Contributions to Zoology, 1017
Canada, National Research Council of Appointment of Ralph E McBurney as head of the Technical Information Service, 17
  Review (1959), 124
  Scholarships for 1960-61, 854
Canada Council : Second Annual Report (1958-59), 15
Canadian Cancer Conference Vol 3, Proceedings of the Third Canadian Cancer Conference, 1958 (edited by R W. Begg), *review* by Dr. I. Hieger, 1001
Canaline : Chemical Degradation of Canavanine to (Dr H Rinderknecht), 1047
Canavanine to Canaline · Chemical Degradation of (Dr. H. Rinderknecht), 1047
Cancer Binding of a Hepatocarcinogen to the Structural Lipoprotein of Rat Liver—its Bearing on the Immunological Theory of (J. W. Westrop and Prof H. N Green), 350
  Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in Animal Cells and its Bearings on (Prof A. Sibatani, K. Yamana, K Kimura and T Takahashi), 215
Cancer Conference : Canadian, Vol 3, Proceedings of the Third Canadian Cancer Conference, 1958 (edited by R W Begg), *review* by Dr I. Heiger, 1001
Cancer Research in the U.S S R., *review* by Dr. P. A. Gorer, 420
Cancer (Human) · Biological Equilibria in (Dr. Kenneth W. Starr), 1006
Cancer (Liver) · Effect of 3-Amino-1,2,4-triazole on the Experimental Production of (Munemitsu Hoshino), 174
Capillary Movement of Nitrate towards Tropical Soil Surfaces (R Wetselaar), 572
Capillary Permeability (Increased), in Injury by Monoamine Oxidase Inhibitors : Suppression of (W G Spector and D A Willoughby), 162
Capsulation and Phage Sensitivity in *Erwinia amylovora* : An Association between (Eve Billing), 819
Carbide (Beryllium) Formation of, during the Corrosion of Beryllium in Carbon Monoxide and in Carbon Dioxide Gas (V. D. Scott), 466
Carbohydrates (Deuterium-labelled) : Infra-red Spectra of (Dr S A. Moore, Prof M Stacey and Dr D. H. Whiffen), 307
Carbon-14 : Enzymic Oxidation of Stilboestrol labelled with (P H Jellinck), 157
  Radiation Labelling with, of Aliphatic Hydrocarbons (Fulvio Cacace and Angelo Guarino), 632
  Radioassay by Gas Chromatography of Compounds labelled with (Dr. Arthur Karmen and Harold R. Tritch), 150
  Scintillation Counting of (David S. Jenkinson), 613
Carbon Dioxide and in Carbon Monoxide Oxidation of Beryllium in (Dr S. J Gregg, Dr R. J. Hussey and Dr. W B Jepson), 468
Carbon Dioxide Gas Formation of Beryllium Carbide during the Corrosion of Beryllium in Carbon Monoxide and in (V. D. Scott), 466
Carbon Monoxide Carbonization of Beryllium in Carbon Dioxide and in (Dr S J. Gregg, Dr R. J. Hussey and Dr W. B. Jepson), 468
Carbon Monoxide and in Carbon Dioxide Gas · Formation of Beryllium Carbide during the Corrosion of Beryllium in (V. D Scott), 466
CO Fourth Positive Band Systems · Interpretation of Intensity Distributions in the N_2 Lyman–Birge–Hopfield and (Prof R. W. Nicholls), 958
Carbonate (Calcium), on Shells of the Snail *Potamopyrgus jenkinsi* (Smith) · Effect of a Sewage Effluent Discharge on the Deposition of (R W. Edwards and J. Heywood), 492
Carbonic Anhydrase : Subnormal Level of, in Blood of Carcinoma Patients ? (Dr N W. H Addink), 253
Carboniferous Rocks of Great Britain : Fossil Plants of the (Dr. Robert Crookall), second edition, *review* by T. M Harris, 66
Carbonized Coals : X-Ray Studies of some (R. Diamond and P. B. Hirsch), 204
Carbons Adsorption of Helium on—Influence on Measurement of Density (Dr F. A. P. Maggs, P. H. Schwabe and J. H. Williams), 956
Carbonyl (Tetraphenyl*cyclo*butadiene Iron) · Crystal Structure of (R. P. Dodge and Dr. V Schomaker), 798
'Carbowax' Systems (Hoagland's) : Freezing-Point Depressions of (Howard G. Applegate), 232
Carboxylic Acid Adsorption to Steel Effect of Moisture on (M. E. Schrader and J. L. Kalinsky), 710
Carcinoma Patients ? : Subnormal Level of Carbonic Anhydrase in Blood of (Dr. N W. H. Addink), 253
Carcinomas (Renal) Ultrastructure of the Clear Cells in, and its Importance for the Demonstration of their Renal Origin (Prof. Ch. Oberling, M. Rivière and Fr. Haguenau), 402
Cardew, Dr. P N. (Hughes, Dr. W H , and) : An Apparatus for Panning in Ciné Micrography, 258
Cardiac Activity in Quantitative Tissue Culture : Effect of Supernatant Potassium-Level on (Prof A W. B Cunningham, K Kleutch and W. Herbst), 241

- Cardiac Neuroses, *review* by Dr. D. C. Deuchar, 423
  - The Chemical Prevention of (Prof. Hans Selye), *review* by Dr. D. C. Deuchar, 423
- Cardioactive Acetone Extracts of Ox Spleen : Absence of Catecholamines in (Dr. L. B. Cobbin and Prof. R. H. Thorp), 473
- Cardiovascular Effects of Nicotine and of Smoking (New York Academy of Sciences Symposium on), 525
- Care of Works of Art : Scientific Methods in the (F. I. G. Rawlins), 437
- Career : Choosing your (Ministry of Labour and National Service, Choice of Careers Series No. 1), 682
- Careers in Biochemistry (Biochemical Society), 854
- *Caretta kempi* Garman on Welsh Coast (Colin Matheson), 989
- Carey, Barbara J. (Skyring, G. W., and) Nitrogen in Tropical Agriculture (Microbial Species involved in Nitrification and Denitrification), 941
- Caribbean Commission, 281
- Caries (Dental), and certain Soil Conditions in New Zealand : An Association between (T. G. Ludwig, W. B. Healy and Capt. F. L. Losee), 695
- Carlsberg–Wellcome Travelling Research Fellowships (Wellcome Trust), 283
- Carman, P. C. (Miller, L., and) : Analogy to the Kirkendall Effect in the Gas Phase, 549
- Carnegie Institution of Washington : Publication No. 617, Miocene Floras of the Columbia Plateau, Part 1, Composition and Interpretation (Ralph W. Chaney) ; Part 2, Systematic Considerations (Ralph W. Chaney and Daniel I. Axelrod), *review* by Prof. J. Walton, 66
  - Year Book No. 58 (1958-59), 207
- Carnegie Silver Medal for 1959 of the Iron and Steel Institute awarded to Dr. P. R. V. Evans, 13
- Carnegie Trust for the Universities of Scotland : Fifty-eighth Annual Report (1958-59), 359
- Carotene : Effect of Diphenylamine on the Synthesis of (Gy. Schneider, Dr. B. Matkovics, J. Zsolt and Ö. Kovács), 235
- β-Carotene Triiodide : Electrical and Magnetic Properties of (Dr. Charles M. Huggins and Dr. Oliver H LeBlanc, jun), 552
- Carr, J. G., and Shimwell, J. L. : Pigment-producing Strains of *Acetobacter aceti*, 331
- Carrangeenin Granuloma · Biological Significance of Peptide containing Hydroxyproline during the Development of (Dr. M Chvapil and B. Cmuchalová), 806
- Carrier Gas · Effect of, on the Sensitivity of Thermal Conductivity Detectors (C. Bokhoven and A. Dijkstra), 793
- Carslaw, Prof. H S., and Jaeger, Prof. J C. : Conduction of Heat in Solids, second edition, *review* by Prof L. S. Goddard, 421
- Carson, John F., and others : A Rapid Method for Qualitative Analysis of Volatile Mercaptan Mixtures, 801
- Carter, Dr. C. O. · Chromosome Abnormalities in Man, 683
- Carter, C W., and others : Biochemistry in relation to Medicine, third edition, *review* by Prof D. C. Harrison, 422
- Carter, E. B. · Promoted to Deputy Chief Scientific Officer and appointed director of engine production at the Ministry of Aviation, 518 ; work of, 518
- Cartledge, Dr. G. H. : Significance of the 'Equivalent Redox Potential' in Aqueous Solutions under Ionizing Radiation, 370
- Cartmill, W. J. : Nitrogen in Tropical Agriculture (Nitrogen Fertilizing of Cotton), 942
- Cartwright, W. F : Elected president for 1960-61 of the Iron and Steel Institute, 13
- Casey, Lord : Appointed a member of the Executive of the Australian Commonwealth Scientific and Industrial Research Organization, 12
- Casley-Smith, J R. : Elected to a Beit Memorial Junior Fellowship for Medical Research, 520
- Cassels, Prof J. M : Appointed to the Lyon Jones chair of physics at the University of Liverpool, 201 ; work of, 201
- Cassie, Vivienne : A Red Water Bloom of Rotifers in Cook Strait, New Zealand, 328
- Castle and Sample Holder for Radioactive Counting : An Inexpensive (Dr. Howard Boroughs), 145
- Castner Memorial Lecture of the Society of Chemical Industry (Dr. W. J. Kroll), 685
- *Casuarina cunninghamiana* : Haemoglobin in the Root Nodules of (Dr. H E. Davenport), 653
- Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick (J. F. Gates Clarke), Vol. 3, Tortricidae, Olethreutidae, Noctuidae, *review* by R. G. Fennah, 188
- Catalogue Cards : The Reproduction of (Philip S Pargeter), 1020
- Catalysis : Second Congress on, 523
- Catalysis (Vanadium), of the Oxidation of Catechol Amines, Dihydroxyphenylalanine and 5-Hydroxyindoles (Dr G. M Martin, E. P. Benditt and N. Eriksen), 884
- Catalysts (Silica–Alumina) : Infra-Red Spectra of Ammonia adsorbed on (D. E Nicholson), 630
- Catalytic Effects in the Alkaline Oxidation of Cellulose (Dr. W. A. Bell), 963
- Catecholamines : Absence of, in Cardioactive Acetone Extracts of Ox Spleen (Dr. L. B Cobbin and Prof R. H. Thorp), 473
  - Effects of 1,4-Dihydrazinophthalazine on the (M. Bygdeman and L. Stjarne), 82
- Catechol Amines, Dihydroxyphenylalanine and 5-Hydroxyindoles : Vanadium Catalysis of the Oxidation of (Dr. G. M. Martin, E. P. Benditt and N Eriksen), 884
- Cathode Surface Roughness and Oxidation · Effect of, on Arc Movement (Dr. T. J. Lewis and Dr. P. E. Secker), 30
- Cattle : Artificial Insemination in, *review* by Sir John Hammond, 667
  - Inheritance of β-Globulins in Serum and Milk from (Bo Gahne, Jan Rendel and Dr. Ole Venge), 907
  - Isolation of a Cytopathogenic Agent from Skin Lesions of (Dr. C. Huygelen, D. Thienpont and M. Vandervelden), 979
  - Oxygen Consumption in, in relation to Rate of Increase in Environmental Temperature (Prof. H. H. Kibler), 972
  - Zinc Sulphate Treatment of Parakeratosis in (S. P. Legg and L. Sears), 1061
- Cattle Tick (Australian) : Sulphydryl Content of the Embryos of the (W. J. Roulston and C. A. Schuntner), 1069
- Cattle and other Animals : Precipitating Antibody in Trypanosomiasis of (A. R. Gray), 1058
- Caughley, Graeme (Riney, Thane, and) : Home Range in a Feral Goat Herd, 125
- Cauliflower Mosaic Virus : Purification and Properties of (Prof. Thomas P. Pirone, Glenn S. Pound and Robert J. Shepherd), 656
- Cause of the Instability of Cytochrome c Reductase (A New Type of Autoxidation Reaction), (Dr. Malcolm Dixon, J. M. Maynard and P. F. W. Morrow), 1032
- Causes of Infective Diseases : Factors and, *review* by Dr. G. Lapage, 581
- Cavallini, Dr. D., and Tentori, L. : Inability of Thiotaurine to protect Mice against Ionizing Radiation, 254
- Cave-dwelling Shrimps (A Snell), 521
- Cawse, P. A., and others Use of Ionizing Radiation in Spot Tests for Nitrogenous Compounds, 383
- Cawthron (Thomas) Memorial Lecture, No. 33, The New Zealand Antarctic Expedition (Sir Edmund Hillary), 526
- Cawthron Institute, Nelson, New Zealand : Annual Report for 1958-59, 123
  - Thomas Cawthron Memorial Lecture No 33, The New Zealand Antarctic Expedition (Sir Edmund Hillary), 526
- Cecil, S. Robert : Recent Advances in Coconut Research in India, 861
- Cedermark, Gunilla (Beckman, Lars, and) : Haptoglobin Types in *Macaca irus*, 643
- Celestial Bodies : Figures of Equilibrium of, with Emphasis on Problems of Motion of Artificial Satellites (Prof. Zdenek Kopal), *review* by D. G. King-Hele, 747
- Celestial Mechanics (R Finlay-Freundlich), *review* by Dr. R. H. Garstang, 60
  - Stability in (Prof. Yusoke Hagihara), *review* by Dr. R. H. Garstang, 60
- Cell (Ascites Tumour) : Effect of Antibody and Complement on Volume Control in an (Dr. H. Green and Dr. F. Silverblatt), 646
- Cell Granules (Mast) . A Specific Stain for (Dr. B G. Radden), 400
- Cell Nuclei : Quantitative Cytochemical Observations on a Specific Nucleoprotein Reaction in (Dr. E. A. Barnard), 447
- Cell Nucleus (Testicular Interstitial), in the Adult Rat . Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the (S. L. Liu), 475
- Cell-Wall : The Plant (Prof. Pieter A. Roelofsen), *review* by Prof R. D. Preston, 920
- Cell Wall Formation in Spores of the Fungus *Allomyces* (J. M. Aronson and Prof. R. D. Preston), 95
- Cell Walls : Microbial (Annual Ciba Lectures in Microbial Biochemistry), (Dr M. R. J Salton), 284
  - Structure and Growth of Plant, *review* by Prof R. D. Preston, 920
- Cell-stimulating Hormone (Interstitial) : Histophotometrical Study of the Effect of, on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat (S. L. Liu), 475
- Cells : Fuel—Will they soon Become a Major Source of Electrical Energy ? (F. T Bacon), 589
  - Structures corresponding to Terminal Bars and Terminal Web in Many Types of (Prof C P. Leblond, Holde Puchtler and Y. Clermont), 784
- Cells—Normal and Abnormal : Chemical Organization of (Conference at the University of Wisconsin), 604
- Cells (Animal) : Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in, and its Bearings on Cancer (Prof. A. Sibatani, K. Yamana, K. Kimura and T. Takahashi), 215
- Cells (Clear), in Renal Carcinomas . Ultrastructure of the, and its Importance for the Demonstration of their Renal Origin (Prof Ch Oberling, M. Rivière and Fr. Haguenau), 402
- Cells (Ectromelia Virus-infected) : Filamentous Structures in (Dr. Benjamin V Siegel), 820
- Cells (Ehrlich Ascites Tumour) : Calcium Binding in Homogenates of (R. Schofield and D Thomason), 656
- Cells (Human), in Tissue Culture : Effect of Oxygen and Nitric Oxide on the Radiosensitivity of (Dr. D. L Dewey), 780
- Cells (Immunologically Competent), in the Chick Embryo : Loss of Specificity on Passage of (Sir Macfarlane Burnet and Georgiana Boyer), 175
- Cells (Intact) : Glutathione Stability and Pyrophosphatase Activity in Reticulocytes—Direct Evidence for the Importance of Glutathione for the Enzyme Status in (Prof S Rapoport and D. Scheuch), 967
- Cells (Isolated Mammalian) Are Macromolecules required for Growth of Single? (Ralph B Gwatkin), 984
- Cells (Lipophilic Agar) : Diffusion of Proteins through (Dr. Ch. Wunderly), 885
- Cells (Mast) · Antigen-induced Damage to Isolated Sensitized (Dr. I. Mota and W. Dias da Silva), 245
- Cells (Mouse Sarcoma 37) : Changes in the Deoxyribonucleic Acid Content of, following Serial Irradiation (Dr. A E. G. Pearson and N. B. Atkin), 647
- Cells (Plant) · Life-like Preservation of Cytoplasmic Detail in (Dr. J. Chayen, Prof G. J Cunningham, P. B. Gahan and A A. Silcox), 1068
- Cells (Rat Pineal Parenchymal) : Effects of Injection of Bovine Pineal Extract on the Nuclei of (Dr. Uno Holmgren, Dr. Mark D. Altschule and Dr Richard J. Wurtman), 393
- Cells (Red Blood), of East Africans : Glucose-6-Phosphate Dehydrogenase Deficient in (Dr. A. C. Allison), 531
- Cells (Sense) : Selective Elimination of Single, with Methylene Blue (Dr. Ulrich Clever), 812
- Cells (Single), of Mouse Parotid Tumours : Virus Release from (Dr. Mathilde Krim and Dr Leo Sachs), 262
- Cells (White) and Platelets · Micro-electrophoresis of Human (Dr. William P. Creger and Phyllis Menna Thomas), 171
- Cellular Proteins : Ribonucleic Acids and the Synthesis of (Prof. J. Brachet), 194
- Cellulose : Catalytic Effects in the Alkaline Oxidation of (Dr. W. A. Bell), 963
- CENTO Institute of Nuclear Science in Tehran (H. A. C. McKay), 513
  - Symposium on Recent Developments in the Applications of Nuclear Science for Peaceful Purposes, 685
- Central Advisory Water Committee · Final Report of the Trade Effluents Sub-Committee (Ministry of Housing and Local Government), 210
- Central African Savannahs, *review* by J P. M. Brenan, 505
- Central Botanical Laboratory, Allahabad : Retirement of Dr. E. K. Janaki Ammal from the directorship, 519
  - Appointment of Dr. G. S. Puri as director, 519
- Central Nervous System : 'Weightless' Micro-electrodes for Recording Extracellular Unit Action Potentials from the (Prof. B. Delisle Burns and Dr. J. G. Robson), 246

Central Institute for Scientific Cinematography, 444
Centre of Metabolic Activity : Neurokeratin Network of the Peripheral Nerve Fibre Myelin Sheath as a (Dr. H. B. Tewari and Prof. Geoffrey H. Bourne), 645
Centrifugation . Effect of, on the Macronucleus of *Spirostomum* and *Blepharisma* (Prof. B. R. Seshachar), 333
Centriole (Proximal), in Flagellate Spermatozoa : Position of the (Prof. Vishwa Nath, Brij L. Gupta and L. C. Mittal), 899 , (Dr. J. Bronte Gatenby and R S. Mathur), 900
Centro Brasileiro de Pesquisas Fisicas : Latin American School of Physics, 361
Cephalin : Interaction between Albumin, Lecithin and (Dr. Eric Ponder and Ruth V. Ponder), 235
Cerebrospinal Fluid (Human) : Calcium and Magnesium in (Dr. G. Hunter and Honor V. Smith), 161
Cerebrospinal Fluids (Human) 5-Hydroxyindoles in (G W Ashcroft and D. F. Sharman), 1050
CERN—*see under* European Organization for Nuclear Research
Cervical Sympathectomy and Pituitary Stalk Section · Influence of, upon Milk Secretion in Goats (G. B. Tverskoy), 782
Cessation of Treatment with Diethylstilboestrol : Duration of Stimulation of Phagocytic Activity of the Reticulo-Endothelial System after (C. C. Ware and Prof T Nicol), 974
Chadderton, Lewis T. : Electron Microscopy and the Crystal Structure of Indanthrene, 541
Chadwick, C. S., and others Depolarization of the Fluorescence of Proteins labelled with various Fluorescent Dyes, 239
Chains (α- and β-) of Globins : Separation of the, by means of Starch-gel Electrophoresis (C. J. Muller), 643
Chakravarti, D., and others : Smilagenone and *Epi*-Smilagenin from *Dioscorea* Saponin, 236
Chakravarti, Prof. R. N., and others : Smilagenone and *Epi*-Smilagenin from *Dioscorea* Saponin, 236
Challenger, Prof. Frederick : Apsects of the Organic Chemistry of Sulphur, *review* by Dr F. G. Mann, 53
Challenger Society . Grants for research in Marine Biology or Oceanography, 854
Challenger Society and representatives from the Marine Laboratories (Development Commissioners Scheme) : Joint Meeting in Cambridge, 685, 938
Chalmers, Dr. Bruce, and King, Dr. R (edited by) : Progress in Metal Physics, Vol. 7 (1958), Vol. 8 (1959), *review* by Prof. F. C. Thompson, 666
Chamberlain, Prof. O : Elected a member of the United States National Academy of Sciences, 773
Chambers, Prof. Kenton L. : Appointed associate professor and curator of the Herbarium in Oregon State College, 1020
Chambers, Rosalind (Barbara Wootton, assisted by Vera G. Seal and) : Social Science and Social Pathology, *review* by Prof. E. Stengel, 41
Chambers, Dr R. D. Appointed lecturer in chemistry at the University of Durham, 937
Champeney, Dr. D C. : Appointed lecturer in physics at the University of Birmingham, 522, 767
Champion, Sir Harry . *Obituary* of Prof. E. P. Stebbing, 515
Chaney, Ralph W. : Miocene Floras of the Columbia Plateau, Part 1, Composition and Interpretation, *review* by Prof. J. Walton, 66
Chaney, Ralph W., and Axelrod, Daniel I. · Miocene Floras of the Columbia Plateau, Part 2, Systematic Considerations, *review* by Prof. J. Walton, 66
Change in African Cultures : Continuity and (edited by William R. Bascon and Melville J. Herskovits), *review* by G. W. B Huntingford, 38
Change (Colour), in Amphibians : Control of (C. Barker Jørgensen and Lis Olesen Larsen), 641
Changes in the Deoxyribonucleic Acid Content of Mouse Sarcoma 37 Cells following Serial Irradiation (Dr. A E G. Pearson and N B. Atkin), 647
Changes in the Levels of Adenosine Triphosphate and Glycogen in the Liver caused by Protein Administration (Dr Catherine M. Clark, Dr G. A. J. Goodlad, Dr J Chisholm and Dr H N. Munro), 719
Changes in Structure of a Periclinal Chromosomal Chimera of Apple following X-Irradiation (Charlotte Pratt), 255
Changes in the Suffolk Flora during the Past 100 Years (F. W. Simpson), 771
Changes (Age), in Performance : Construct 'Reactive Inhibition' in the Interpretation of (Dr S. Griew and Dr R Lynn), 182
Changes (Heritable), in Lactic Streptococci induced by Physical Treatments (B. S. Gossling), 868
Changes (Membrane Potential), associated with Stimulation of Smooth Muscle by Adrenalin (G. Burnstock), 727
Changes (Postural), in Chlorpromazine Hypothermia (Dr D. Svorad), 240
Changes (Radiation-induced), in α-Lead Azide (G Todd and E Perry), 543
Changes (Small Rapid Volume), in a Muscle during Activity Determination of (Prof. B. C. Abbott and R J Baskin), 1055
Changes (Temperature), in the Antarctic Atmosphere (Dr. H. Wexler), 445
Channey, P V. · Recent Advances in Coconut Research in India, 861
Chapman, Victor, and others Position of the Gene determining the Diploid-like Meiotic Behaviour of Wheat, 259
Characteristics (Driver) · Traffic Accidents and (Sauli Hakkinen), 273
Characterization of a New Purine Riboside isolated from *Fusarium* Species (Dr Alessandro Ballio, Dr. Carlo Delfini and Dr. Serena Russi), 968
Characterizing *Pseudomonas solanacearum* . A Method for (A. C. Hayward), 405
Charge Transfer : Detection of Negative Ions formed by (T. M Donahue and F. Hushfar), 1038
Charges of the Electron, Proton and Neutron Comparison of the (A. M Hillas and T. E. Cranshaw), 459
Charlson, Dr. A. J. : Appointed an I.C.I. Research Fellow in the University of Edinburgh, 767
Chatt, E. M. : Minor Elements in Nutrition (Adventitious Metals in Processed Foods), 940
Chaudhury, Prof Ranjit Roy, and Dikshit, Mandakini B. : Milk-ejecting Action of Ergot, 722
Chayen, Dr. J., and others : Life-like Preservation of Cytoplasmic Detail in Plant Cells, 1068
Chemical Analyses of Rocks, *review* by Prof. K. C Dunham, 56
Chemical Constants (Physical and) Tables of, and some Mathematical Functions (Dr. G W. C Kaye and Dr. T. H Laby), twelfth edition, *review* by T. M. Yarwood, 67
Chemical Degradation of Canavanine to Canaline (Dr. H. Rinderknecht), 1047
Chemical Effects of Ionizing Radiation on Deoxyribonucleic Acid in Dilute Aqueous Solution (G. Hems), 710
Chemical Engineering at Birmingham, 849
Chemical Engineering at Nottingham, 933
Chemical Engineering : Education and Training in (Supplement to Chemical Engineering, a Career), (Institution of Chemical Engineers), 125
  Scholarships in (John Brown, Ltd , and the Institution of Chemical Engineers), 522
Chemical Engineers, Institution of : Education and Training in Chemical Engineering (Supplement to Chemical Engineering, a Career), 125
Chemical Engineers, Institution of (John Brown, Ltd , and the) : Scholarships in Chemical Engineering, 522
Chemical Industry, Society of · Appointment of Dr. W. J. Kroll as the sixth Castner Memorial Lecturer, 685
  Castner Memorial Lecture, The Fusion Electrolysis of Titanium (Dr. W J. Kroll), 685
Chemical Industry, Society of (Microbiology Group), (Society for Applied Bacteriology and the) : Symposium on Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds, 131, *erratum*, 206
Chemical Industry, Society of, and others : Symposium on the Industrial Chemistry of the Lower Olefines, 285
Chemical Nomenclature, *review* by Prof H J Barber, 54
  An Introduction to (Dr. R. S. Cahn), *review* by Prof. H. J. Barber, 54
Chemical Organization of Cells, Normal and Abnormal (Conference at the University of Wisconsin), 604
Chemical Prevention of Cardiac Neuroses (Prof. Hans Selye), *review* by Dr D. C. Deuchar, 423
Chemical Process Principles (Prof. Olaf A. Hougen, Prof. Kenneth M. Watson and Prof. Roland A. Ragatz), Part 2, Thermodynamics, second edition, *review* by L. E. Marc de Chazal, 1003
Chemical Society, in co-operation with the Department of Scientific and Industrial Research : To issue a translation of the *Russian Journal of Physical Chemistry*, 601
Chemical Society, and others · Symposium on the Industrial Chemistry of the Lower Olefines, 285
Chemical Society (American) . Scientific Russian without Tears (Prof. J. W. Perry), 359
Chemical Thermodynamics, *review* by Prof. A. R Ubbelohde, 55
  An Introduction to the Study of (Prof. D H. Everett), *review* by Prof. A. R. Ubbelohde, 55
Chemische Reaktionen Ionisierender Strahlen (Radiation Chemistry), (herausgegeben von Prof. Hermann Mohler), *review* by Prof. F. S. Dainton, 344
Chemist · A Structural Tool for the, *review* by Prof. E. R Andrew, 55
Chemistry at Aberystwyth, 680
Chemistry at Queen Mary College, London, 762
Chemistry Robert Boyle—Father of (Dr. Roger Pilkington), *review* by Dr W. A. Smeaton, 63
  Status and Development of the Teaching of (Organization for European Economic Co-operation Seminar on the), 208
  Steroid, *review* by Dr. W Klyne, 668
Chemistry, Royal Institute of : Lectures, Monographs and Reports, 1959, No 5, Modern Explosives (the late Dr. Wilfrid Taylor), 204
  Monographs for Teachers No. 3, Principles of the Extraction of Metals (Dr. D J. G Ives), 765
Chemistry, Royal Institute of, and others : Symposium on the Industrial Chemistry of the Lower Olefines, 285
Chemistry and Applications Co-ordination Compounds, their (Department of Chemical Technology of the Bradford Institute of Technology Symposium on), 440
Chemistry (Analytical), of Polymers (edited by Gordon M Kline), Part 1, Analysis of Monomers and Polymeric Materials—Plastics, Resins, Rubbers, Fibres, *review* by Prof. C. E. H Bawn, 52
Chemistry (Electroanalytical), Journal of, 124
Chemistry (Industrial), of the Lower Olefines (Chemical Society, the Institute of Petroleum, the Royal Institute of Chemistry and the Society of Chemical Industry Symposium on), 285
Chemistry (Organic), in the University of New South Wales, 357
Chemistry (Organic) : Nuclear Magnetic Resonance—Applications to (Prof. J. D Roberts), *review* by Prof E. R. Andrew, 55
  Principles of (T. A Geissman), now available in England, 17
Chemistry (Organic), of Sulphur, *review* by Dr F G. Mann, 53
  Aspects of the (Prof Frederick Challenger), *review* by Dr F. G. Mann, 53
Chemistry (Osseous), in Lathyritic Rats · Aortic, Serum, Connective Tissue and (Dr. R. A. Grant, M. Hathorn and Prof. Theodore Gillman), 164
Chemistry (Physical), Russian Journal of A translation to be issued by the Chemical Society in co-operation with the Department of Scientific and Industrial Research, 601
Chemistry (Physics and) of Glass, Vol. 1, No 1 (Society of Glass Technology), 601
Chemistry (Radiation) : Applied, *review* by Prof F. S. Dainton, 344
Chemistry (Superficial), and Solid Imperfections (Prof. F C. Tompkins), 3
Chemists, British Association of : Hinchley Medal awarded to Dr C. J. T. Cronshaw, 685
Cherry, Prof Colin ˙ The Measurement of Information, *review*, 506
Cherts (Mohgaonkalan) A New Specimen of *Nipa* Fruit from (Dr. S D. Chitaley), 495
Chester, C. E. : *Obituary* of Prof. H. Stansfield, 517
Chettiar, M. R. : Recent Advances in Coconut Research in India, 861
Chevrier, Lionel : The St. Lawrence Seaway, *review* by Prof. R W. Steel, 110
Chiasmata in *Delphinium* : Experimentally Induced Inter-bivalent Redistribution of (H. K. Jain and A. K. Bose), 260
Chick : Culture of Human Leucocytes on the Chorioallantoic Membrane of the (Eugene Bell), 403
Chick Blood : Influence of Dietary Intake of certain Insecticides on the Haemoglobin and Erythrocyte Contents of (Prof. B. K. Srivastava, H. C Saxena and J. C. Sharma), 172

Chick Embryo : Loss of Specificity on Passage of Immunologically Competent Cells in the (Sir Macfarlane Burnet and Georgiana Boyer), 175
Chicken Blood : A Re-Evaluation of the Clotting Time of (Dr. C. H. Bigland and Dr. D. C. Triantophyllopoulos), 644
Chicken Tumour Virus : Presence of, in the Sarcoma of the Adult Rat inoculated after Birth with Rous Sarcoma Tissue (Dr. Jan Svoboda), 980
Chickens · Differences in Numbers of Erythrocytes between Inbred Lines of (Dr. P. Jaffe), 978
Chickens receiving Differently Saturated Fats for Three Years : Essential Fatty Acids of Normal and Atherosclerotic Aortas from (Prof. H. Fisher and A S. Feigenbaum), 85
Chicks : Vitamin A Isomers in the Liver of Rats and (O. R. Braekkan, H. Myklestad, L R. Njaa and F. Utne), 312
Chieco-Bianchi, Dr. L. : Awarded a Scholarship by the Tata Memorial Trust, for research on leukaemia and allied diseases, 1020
Child, Dr. R., and Smith, A. N. Manganese Toxicity in *Grevillea robusta*, 1067
Child Psychology and Psychiatry and Allied Disciplines, Journal of, Vol. I, No. I, 935
Children . Self-Regulation for, *review* by Prof M D. Vernon, 38, 912 ; (Paul Ritter), 911
Children (Gifted) : Psychology of (Dr W D Wall), 692
Children (Nigerian) . Sickle-Cell Anaemia in (R G. Hendrickse), 1027
Chilton, D : Appointed keeper of the Department of Electrical Engineering and Communications in the Science Museum, London, 206
Chimera (Periclinal Chromosomal), of Apple . Changes in Structure of a, following X-irradiation (Charlotte Pratt), 255
Chimie Biologique, Société de (Biochemical Society and the) : Joint Meeting to be held in Paris, 440
Chimie Physique, Société de : Conference on the Structure of Graphite and the Kinetics of its Reactions, 284
Chimique (Composition), des Organismes (Traité de Biochimie Générale, par M Javillier, M. Polonovski, M. Florkin, P. Boulanger, M. Lemoigne, J Roche et R. Wurmser, Tome I), *review* by Prof. F. G. Young, 51
Chimique (Thermodynamique) : Bases Fondamentales et Applications de la (Prof. Maurice Dodé), Tome I, Les Principes, les Systèmes ideaux Gazeux, et avec Phases Condensées pures, *review* by Prof. A. R. Ubbelohde, 55
Chin, Y Ch., and others : Antimalarial Properties of some Guanidine Derivatives, 170
China : Early Science in, *review* by Prof W. M. Smart, 36
  Science and Civilization in (Dr. Joseph Needham, with the collaboration of Dr. Wang Ling), Vol 3, Mathematics and the Sciences of the Heavens and the Earth, *review* by Prof. W. M. Smart, 36
China (Medieval) Horology in, *review* by Dr F. A B Ward, 834
Chippendale, F : Nitrogen in Tropical Agriculture (Nitrogen Fertilizing of Tobacco and Horticultural Crops), 942
Chisholm, Dr J , and others : Changes in the Levels of Adenosine Triphosphate and Glycogen in the Liver caused by Protein Administration, 719
Chitaley, Dr. S. D : A New Specimen of *Nipa* Fruit from Mohgaonkalan Cherts, 495
Chloramphenicol : Effects of, on the Recovery of Ultra-violet-irradiated *Escherichia coli B* (H. Okagaki and Prof A. Sibatani), 818
Chlorella ellipsoidea . A New Copper Protein from (Dr. Sakae Katoh), 533
Chloride (Aluminium) (Benzyl Chloride–) . Alkylation of Coal by (M. S. Iyengar, D. D. Banerjee and D. K. Banerjee), 387
Chloride (Barium) . Micromosaic Patterns in Single Crystals of Potassium Chloride containing (J. Ewles and J. B. Dawson), 381
Chloride (Benzyl)–Aluminium Chloride · Alkylation of Coal by (M. S. Iyengar, D D Banerjee and D K. Banerjee), 387
Chloride (Potassium), (Single Crystals of), containing Barium Chloride : Micromosaic Patterns in (J. Ewles and J B. Dawson), 381
Chlorite–Vermiculite Mineral : A Regular Mixed-Layer (Dr. M. Nakahira and S. Sugiura), 877
Chlorophyll Role of the Triplet State in the Photoreduction of (Prof. Robert Livingston and Dr. A C P. Pugh), 969
Chlorophyll Content of Gibberellin-treated Wheat Seedlings (Prof. Frederick T. Wolf and Dr Alan H. Haber), 217
Chloroplasts : Function of the Two Cytochrome Components in—a Working Hypothesis (Dr R Hill and Dr. Fay Bendall), 136
Chloroplasts (Isolated Spinach) : Induction Phenomena in Photosynthesis of (Dr Knud Vejlby), 652
Chlorpromazine Hypothermia : Postural Changes in (Dr. D Svorad), 240
Cholesterol (Prof. David Kritchevsky), *review* by Dr. D. T Elmore, 745
Cholesterol and Lecithin (Cortisone Acetate,) : Enhancement of Staphylococcal Virulence for Mice by Intraperitoneal (Dr. Daniel Amsterdam and Dr. S. Stanley Schneierson), 101
Chondrites (Enstatite) · Silicon in the Metal Phase of (A. E. Ringwood), 465
Chondritic Meteorites : Abundances of the Rare-Earth Elements, Lanthanum to Lutetium, in (Dr. R A. Schmitt, A. W. Mosen, C. S. Suffredini, J. E Lasch, Dr R. A. Sharp and D. A Olehy), 863
  Origin of Chondrules and (Dr. Brian Mason), 230
Chondroitin Sulphates (Isomeric) : Identification of (J B. Adams), 555
Chondrules and Chondritic Meteroites : Origin of (Dr Brian Mason), 230
Choosing your Career (Ministry of Labour and National Service, Choice of Careers Series No I), 682
Chopped Guinea Pig Lung : Inhibition of the Anaphylactic Release of Histamine from, by Chymotrypsin Substrates and Inhibitors (Dr. K F Austen and Dr W E Brocklehurst), 866
Chorioallantoic Membrane of the Chick Culture of Human Leucocytes on the (Eugene Bell), 403
Chorion-epitheliomatous Tumour in the Rat Induction of a (R. Stein-Werblowsky), 980
Christensen, Dr. G. N : Visco-Elastic Systems (Effect of Rheological Properties on Sorption), 943
Christopherson, Prof D. G : Elected a Fellow of the Royal Society, 11
  Appointed Warden of the Durham Colleges, 604
Chromactivating Hormones in the Pituitary of the Minnow : Distribution of (A. K. Kent), 395
Chromatograms (Paper) : Specific Detection of Glucose on (Dr. M. R. J. Salton), 966
Chromatograph · A Micro Gas (Prof. Nobuji Sasaki, Kimimichi Tominaga and Masaya Aoyagi), 309
Chromatographic (Gas) Fractions : Microquantitative Infra-Red Analysis—Application to (J. E. Stewart, R O. Brace, T. Johns and W. F. Ulrich), 628
Chromatography : Gas (Gas Chromatography Discussion Group of the Institute of Petroleum Hydrocarbon Research Group Symposium on), 127, 943
  Paper—Multiple Spot Formation by Pure Substances (Dr. A. H. Beckett, M A. Beaven and Dr Ann E Robinson), 775
Chromatography (Gas) : Analysis of Anaesthetic Mixtures by (E. R. Adlard and D. W Hill), 1045
  Radioassay by, of Compounds labelled with Carbon-14 (Dr. Arthur Karmen and Harold R. Tritch), 150
  Sterol Analysis by (R. K Beerthuis and J H. Recourt), 372
Chromatography (Gas–Liquid) : Non-Equilibrium Theory of (Dr M. A. Khan), 800
Chromosomal Chimera (Periclinal), of Apple · Changes in Structure of a, following X-Irradiation (Charlotte Pratt), 255
Chromosomal Deviants . Triploid Rat Embryos and other, after Colchicine Treatment and Polyspermy (L Piko and O. Bomsel-Helmreich), 737
Chromosome Abnormalities in Man (Dr. C. O. Carter), 683
Chromosome Numbers of Four Species of the Genus *Dendrocoelum* Œrsted (*Turbellaria tricladida paludicola*), (Dr. Anders G Dahm), 334
Chromosome Numbers of Slugs (Gillian E. Beeson), 257
Chromosome Numbers (Basic), in *Silene* and *Saponaria* (Dr T N. Khoshoo), 412
Chromosomes of *Gyraulus circumstratius*, a Freshwater Snail (John B. Burch), 497
Chromosomes in Man : A Simplified Method for the Study of (C Bottura and I. Ferrari), 904
Chromosomes in Primary Neoplastic Growth (Dr. K. Bayreuther), 6
Chrones, J , and James, J L. : Industrial Chemistry of the Lower Olefines (The Economics of Ethylene Production from Light Naphtha), 285
Chronic Aortitis in the California Sea-lion, *Zalophus californianus* (Dr. Arthur L Kelly and Dr David Jensen), 731
Churchill, D. M. · Living and Fossil Unicellular Algae and Aplanospores, 493
Churchill College, Cambridge · Election of Dr. F H Hahn to an Official Fellowship, and College lecturer in economics, 440
  Election of Dr D J Thouless to an Official Fellowship, and College lecturer in mathematics, 440
  Election of Dr F H C. Crick to an Extraordinary Fellowship, 440
  Election of Prof S. B. Treiman to an Overseas Fellowship, 440
Chvapil, Dr M., and Cmuchalová, B : Biological Significance of Peptide containing Hydroxyproline during the Development of Carrageenin Granuloma, 806
Chymotrypsin : Requirements for Stereospecificity in Hydrolysis by—Diethyl β-Acetamidoglutarate (Prof. Saul G. Cohen and Ezra Khedouri), 75
Chymotrypsin Substrates and Inhibitors : Inhibition of the Anaphylactic Release of Histamine from Chopped Guinea Pig Lung by (Dr. K. F. Austen and Dr W. E. Brocklehurst), 866
Ciampolini, M , and others · Heats and Entropies of Reaction of Transition Metal Ions with Ethylenediamine, 880
Ciba (A R L.), Ltd. · Technical Notes No 206, Model-Making with 'Araldite', (E. J. R. Thomas), 360
Ciba Clayton, Ltd. : Demonstration of the 'Eidophor' Television Technique, 773
Ciba Fellowship Trust : Fellowship Awards for 1960–61, 684
Ciba Foundation : Symposium on Significant Trends in Medical Research (edited by G. E. W. Wolstenholme, Cecilia O'Connor and Maeve O'Connor), *review* by Prof. L. J. Witts, 42
  Symposium on the Biosynthesis of Terpenes and Sterols (edited by G. E. W. Wolstenholme and Maeve O'Connor), *review* by Dr. D. T. Elmore, 745
  Study Group No. 2, Steric Course in Microbiological Reactions (edited by G. E. W. Wolstenholme and Cecilia O'Connor), *review* by Prof. D. C. Harrison, 835
  Report for 1959, 850
  Seventy-fifth Anniversary issue of the *Journal* of the, 853
Ciba Lectures in Microbial Biochemistry (Dr. M. R. J. Salton), 284
Ciné Micrography : An Apparatus for Panning in (Dr. W. H. Hughes and Dr. P. N. Cardew), 258
Cinematography (Scientific) : A Central Institute for, 444
Circulation of Amniotic Fluid : Ultra-Structure of Human Amnion and its Possible Relation to the (Dr. Gordon L. Bourne and Dr. Dennis Lacy), 952
Cirrhosis of the Liver : Measurement of the Intrahepatic Shunted Flow of Blood in (T. Nakamura, S. Nakamura and K Tokita), 243
Cirrhosis of the Liver induced in Rabbits by Gastric Instillation of 3-Monohydroxycholanic Acid (Dr. Paul Holsti), 250
Cirrhosis (Experimental) · Histochemical and Biochemical Studies of Rat Liver in, after Partial Hepatectomy (I. Bartók, Gy. Domján, E. Horváth and Prof. B. Korpássy), 397
City and Guilds of London Institute · Conferment of Fellowships, 13
Civil Servants (Professional), Institution of : Fifteenth Annual Report (1959), 436, 1017
Civil Services (Scientific) : Payment of, 436
Civilian Application Releases through 1959 (Sandia Corporation), 854
Civilization in China : Science and (Dr. Joseph Needham, with the collaboration of Dr. Wang Ling), Vol. 3, Mathematics and the Sciences of the Heavens and the Earth, *review* by Prof W. M Smart, 36
Clare, J. D. : Promoted to Deputy Chief Scientific Officer and appointed director of guided weapons research and development (Air) at the Ministry of Aviation Headquarters, 518 ; work of, 518
Clare, T. H. · At the Scientific Publications Council's Discussion on the Rapid Increase in the number of New Scientific Journals, 18
Clark, Dr Catherine M , and others : Changes in the Levels of Adenosine Triphosphate and Glycogen in the Liver caused by Protein Administration, 719
Clark, Prof. Sir Wilfrid E. Le Gros · The Antecedents of Man, *review* by Dr. G. G. Simpson, 665

Clarke, J. F. Gates : Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick, Vol. 3, Tortricidae, Olethreutidae, Noctuidae, *review* by R. G. Fennah, 188
Clarke, Dr. K. U., and Grenville, H. : Nervous Control of Movements in the Foregut of *Schistocerca gregaria* Forsk., 98
Class (A New), of Hormonally Active Steroids (Dr. E. H. Reerink, H. F. L. Scholer, P Westerhof, A. Querido, A. A. H. Kassenaar, E. Diczfalusy and K. C. Tillinger), 168
Class (A New), of Type-Specific Glycolipids of *Mycobacteria* : Mycosides, a (Donald W. Smith, H. M. Randall, A. P. MacLennan and E. Lederer), 887
Classification of the Aradidae (*Hemiptera-Heteroptera*), (Prof. Robert L. Usinger and Ryuichi Matsuda), *review* by R. G. Fennah, 46
Classification of Elements : Periodic (W. P Thistlethwaite), 153 ; (L. M. Simmons), 154 ; (A. A. Clifford), 154
Classification and Indexing in Science (B. C. Vickery and D. J. Foskett), second edition, *review* by R. Brightman, 190
Clathrate Compounds (New), of the Inert Gases (J. G. Waller), 429
Cleaning of Fossils by Ultrasonic Waves (J. N. M. Firth), 684
Cleaning (Dry) : Solvents and, 764
Clear Cells in Renal Carcinomas : Ultrastructure of the, and its Importance for the Demonstration of their Renal Origin (Prof. Ch. Oberling, M. Rivière and Fr. Haguenau), 402
Clearance Rates of Sodium-24 ,Potassium-42 and Iodine-131 in Normal Dog Hip Joints (Prof. Patrick G Laing and Dr. Ik Dong Kim), 898
Clermont, Y., and others : Structures corresponding to Terminal Bars and Terminal Web in Many Types of Cells, 784
Clever, Dr. Ulrich : Selective Elimination of Single Sense Cells with Methylene Blue, 812
Clifford, A A. : Periodic Classification of Elements, 154
Clifton, Charles E., and others (edited by) : Annual Review of Microbiology, Vol. 13, *review* by Dr. B. A Newton, 49
Clock (Atomic) : Preliminary Flight Tests of an, in Preparation of Long-range Clock Synchronization Experiments (Friedrich H Reder and Gernot M. R Winkler), 592
Clock Synchronization Experiments (Long-range) : Preliminary Flight Tests of an Atomic Clock in Preparation of (Friedrich H. Reder and Gernot M. R. Winkler), 592
Clockwork : Heavenly—the Great Astronomical Clocks of Medieval China (Dr. Joseph Needham, Dr. Wang Ling and Dr Derek J. de Solla Price), *review* by Dr F. A. B. Ward, 834
Clones of *Hevea brasiliensis* : Developments in the Propagation of, by Cuttings (G H. Tinley and R. J. Garner), 407
Clotting : Initiation of, in Normal and Hageman Plasma by Glass (Dr. Preben Ollendorff), 173
Clotting Time of Chicken Blood : A Re-Evaluation of the (Dr. C. H. Bigland and Dr. D. C. Triantophyllopoulos), 644
Club Alpin Sous-Marin : International Colloquium on Sub-aquatic Medicine, 440
Clusters : Globular (Dr. T. D Kinman), 608
Cmuchalová, B. (Chvapil, Dr. M , and) : Biological Significance of Peptide containing Hydroxyproline during the Development of Carrageenin Granuloma, 806
Coagulation (Blood), in a Cold- and a Warm-blooded Animal : Influence of Temperature upon (Dr. H B Anstall and Dr. R. G. Huntsman), 726
Coal : Alkylation of, by Benzyl Chloride–Aluminium Chloride (M. S. Iyengar, D. D. Banerjee and D. K. Banerjee), 387
Coal Board, National : Grant of £1,600 to the University of Oxford, for the continuation of research on hot and humid conditions, being carried out in the Department of Human Anatomy, 126
Coal Vitrains in the Visible and Ultra-Violet : Reflectance of, compared with that of Graphite (L. A. Gilbert), 143
Coaldrake, J. E. : Nitrogen in Tropical Agriculture (Slower Turnover of Nitrogen in Natural Communities compared with Pastures), 941
Coals (Carbonized) : X-Ray Studies of some (R. Diamond and P. B. Hirsch), 204
Coals (High-Rank) : Structures of, deduced from Helium Densities (T. S. Polansky, H. J. Donald and Prof. C. R Kinney), 792
Coast (Welsh) : *Caretta kempi* Garman on (Colin Matheson), 989
Coast (West) of Scotland : Occurrence of *Falkenbergia rufolanosa* on the (Dr. Elsie Conway), 566
Coates, Dr. J H , and others : A New Type of Autoxidation Reaction—Flavin Dissociation and Inactivation of Cytochrome b_5 by Oxygen, 1033
Cobalt in Nitrogen Fixation by a Legume (Prof. H. M. Reisenauer), 375
Cobbin, Dr. L. B., and Thorp, Prof R. H : Absence of Catecholamines in Cardioactive Acetone Extracts of Ox Spleen, 473
Cockayne, B. : Appointed William Gibbins Research Fellow in the Department of Physical Metallurgy in the University of Birmingham, 937
Cockcroft, Sir John : Elected president of the Institute of Physics and the Physical Society, 681
Coconut Committee, Indian Central : Conference on Recent Advances in Coconut Research in India, 860
Coconut Research in India : Recent Advances in (Indian Central Coconut Committee Conference on), 860
Codes (Error-correcting Group) : A Systematic Method for the Construction of (Prof. R. B. Banerji), 627
Coelenterates : 5-Hydroxytryptamine in (Prof J. H. Welsh), 811
Coenzyme A Content of Adipose Tissue (Marilyn M. Thompson and Prof. Jean Mayer), 640
Coenzyme I : Non-Enzymic Reactions of Indoles with (Prof. S. G. A. Allivisatos, G. A Mourkides and A. Jibril), 718
Cogito ergo sum, *review* by Dr. A. D. Booth, 422
Cohen, Dr. Jerome (Veis, Dr. Arthur, and) : Reversible Transformation of Gelatin to the Collagen Structure, 720
Cohen, Prof. Morris R , and Drabkin, Dr. I. E. : A Source Book in Greek Science, second printing, with corrections, *review*, 63
Cohen, Prof Saul G., and Khedouri, Ezra : Requirements for Stereospecificity in Hydrolysis by Chymotrypsin—Diethyl β-Acetamidoglutarate, 75
Coherence and Band-width of a Gas Discharge Harmonic Generator (N. R. Bierrum, D. Walsh and J. C. Vokes), 626
Coherence Properties of Electromagnetic Radiation (United States Air Force, the Optical Society of America and the University of Rochester Conference on), 127
Coid, Dr. C. R. : Monkeys and Disease, *review*, 506
Coke Research Association (British) : Grant of £3,500 to the Houldsworth School of Applied Science in the University of Leeds, 767
Colchicine : Biosynthesis of (Dr. A. I Scott), 556
Colchicine Treatment and Polyspermy : Triploid Rat Embryos and other Chromosomal Deviants after (L. Piko and O Bomsel-Helmreich), 737
Cold Box : A Commercial Thermoelectric (General Electric Co., Ltd.), 439
Cold- and a Warm-blooded Animal : Influence of Temperature upon Blood Coagulation in a (Dr H. B Anstall and Dr R. G. Huntsman), 726
Cold Spring Harbor Symposia on Quantitative Biology : Vol. 23, Exchange of Genetic Material—Mechanisms and Consequences, *review* by Prof. Kenneth Mather, 832
Cole, Dr G. H. A. : The Liquid Friction Constant, 301
Cole, K. D. : Solar Terrestrial Relationships, 874
Cole, Sonia : The Neolithic Revolution, 360
Coleby, B. : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Coleman, R G. : Nitrogen in Tropical Agriculture (Interference with Amino-acid Metabolism caused by Mineral Deficiency), 941
Colhoun, Dr. John : Appointed to the chair of cryptogamic botany in the University of Manchester, 598 ; work of, 598
Coli-Phage (T_2) Preparations : Plaque-forming Ability of Urea- or Phenol-treated (Dr. P. H. Hofschneider), 330
Collagen Structure : Reversible Transformation of Gelatin to the (Dr. Arthur Veis and Dr. Jerome Cohen), 720
Collagenase Maceration of Kidney for Microdissection (Nancy J. Hayward), 403
Collar, Prof A. R. : Aspects of Aeronautical Sciences, *review*, 665
College of Aeronautics : Appointment of J R. Ellis as professor of automobile engineering and first director of the Advanced School of Automobile Engineering at Cranfield, 762
College (A Staff), for Technical Teachers, 185
College Graduates : Fertility of (Population Reference Bureau, Inc , *Population Bulletin*, Vol 15, No. 6), 22
College Graduates (American) : Marriage-Rate of, 22
Colleges and Universities : Research and Development in, in the Fiscal Year 1958 (United States National Science Foundation Report on), 1016
Colleges (Technical) : Governing, 769
  The Supply and Training of Teachers for (Ministry of Education), 185
Colleges (Technical), and their Government (Joint Federation of British Industries Technical Colleges Committee), 769
Collier, K. G. : The Social Purposes of Education, *review* by Prof. H. L. Elvin, 420
Collins, Dr. F. D. : Heterogeneity of Lecithins labelled with Phosphorus-32, 366
Collins, W. G. : Appointed lecturer in civil engineering at the University of Leeds, 767
Collinson, A. J. L , and others : Self-Quenching Geiger Counters containing Mixtures of Permanent Gases, 876
Collison, Dr. Roger, and McDonald, Dr M. P. : Broadening of the Water Proton Line in High-Resolution Nuclear Magnetic Resonance Spectra of Starch Gels, 548
Colonial Agricultural, Animal Health and Forestry Research, Committee for : Report for 1958-59, 501
Colonial Economic Research Committee : Report for 1958-59, 501
Colonial Fisheries Advisory Committee : Report for 1958-59, 501
Colonial Medical Research Committee : Report for 1958-59, 501
Colonial Office : Colonial Research 1958-1959—Reports of the Colonial Research Council, Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Economic Research Committee, Colonial Fisheries Advisory Committee, Colonial Medical Research Committee, Colonial Pesticides Research Committee, Colonial Products Council, Colonial Road Research Committee, Colonial Social Sciences Research Council, Tsetse Fly and Trypanosomiasis Committee, Director of the Anti-Locust Research Centre, and Research Matters not covered by the above Reports of the Specialist Advisory Bodies, 501
Colonial Pesticides Research Committee : Report for 1958-59, 501
Colonial Products Council : Report for 1958-59, 501
Colonial Research 1958-59—Reports of the Colonial Research Council, Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Economic Research Committee, Colonial Fisheries Advisory Committee, Colonial Medical Research Committee, Colonial Pesticides Research Committee, Colonial Products Council, Colonial Road Research Committee, Colonial Social Sciences Research Council, Tsetse Fly and Trypanosomiasis Committee, Director of the Anti-Locust Research Centre, and Research Matters not covered by the above Reports of the Specialist Advisory Bodies (Colonial Office), 501
Colonial Research Committees, 280
Colonial Research Council : Report for 1958-59, 501
Colonial Road Research Committee : Report for 1958-59, 501
Colonial Social Sciences Research Council : Report for 1958-59, 501
Colour Change in Amphibians : Control of (C. Barker Jørgensen and Lis Olesen Larsen), 641
Colour Modifier in *Aspergillus nidulans* 'Sage', a (B. J. Kilbey), 906
Colour-forming Species in Peroxy Titanium Sulphate : Nature of the (Dr. C. C. Patel and M. S. Mohan), 803
Coloured Sulphur Deposits at Low Temperatures (Dr. B. Meyer and Prof. E Schumacher), 801
Colton, R , and others : Some New Complexes of Rhenium, 233
Columbia Plateau : Miocene Floras of the, Part 1, Composition and Interpretation (Ralph W Chaney) ; Part 2, Systematic Considerations (Ralph W. Chaney and Daniel I. Axelrod), *review* by Prof J. Walton, 66
Comber, H. F. : Elected an Associate *honoris causa* of the Linnean Society of London, 766
Combined Application of Hydrogen Peroxide and Ionizing Rays in Animal Experiments (E. Fleischmann, H Werkgartner and K. Karrer), 324
Combustion (International Symposium on), 938
Comfort, Dr. A. : Dependence of the Sex Ratio at Birth on the Age of the Father, 1065
Comitato Nazionale per le Richerche Nucleari : Fifth Nuclear Congress, 127
Commerce : Appointments in Industry and, 682

Commercial Thermoelectric Cold Box (General Electric Co., Ltd.), 439
Commons, House of : Adjournment Debate on Marine Nuclear Propulsion, 122
  Debate on the Ballistic Missile Early Warning Station at Fylingdales Moor, 357
  Debate on the Crowther Report, 577
  Debate on the Supply of Teachers of Mathematics, 600
Commonwealth : Teachers for the (Conference on), 281
Commonwealth Agricultural Bureaux : Plants Recorded as Resistant to Root-Knot Nematodes (*Meloidogyne* spp.), (Mary T. Franklin and D. J. Hooper), 684
Commonwealth Conference on Mycology (Commonwealth Mycological Institute, 361, 523
Commonwealth Co-operation : State Scholarships and, 935
Commonwealth Entomological Conference (Commonwealth Institute of Entomology), 603
Commonwealth Fund : Harkness Fellowships for 1960, 15
Commonwealth Institute of Entomology : Seventh Commonwealth Entomological Conference, 603
Commonwealth Mycological Conference : Sixth (Commonwealth Mycological Institute), 361, 523
Commonwealth Mycological Institute : Sixth Commonwealth Mycological Conference, 361, 523
Commonwealth Scientific and Industrial Research Organization (Australian) : Appointment of Lord Casey and E. P S. Roberts as members of the Executive, 12
  Rural Research, 29, Mistletoe in Australia (G. C. Greenham), 135
  Appointment of Dr Geoffrey Kesteven as director of fisheries research in the Division of Fisheries and Oceanography at Cronulla, 280
  Appointment of Dr. Douglas F. Waterhouse as chief of the Division of Entomology, 763
  Symposium on Nitrogen in Tropical Agriculture, 941
  Symposium on Visco-Elastic Systems, 942
Commonwealth Society for the Blind (Royal) : Blindness in West Africa (Prof F. C. Rodger), *review* by R. C. Davenport, 64
Commonwealth (British) . Scientific Research in the Overseas Territories of the, 501
  Teaching within the, 281
Commonwealth (British), Association of Universities of the : Report for 1958-59, 600
Communication Research at Keele, 599
Communications from Superior Galactic Communities (Prof. R. N. Bracewell), 670
Communications (International), and Scientific Journals, 358
Communities (Superior Galactic) : Communications from (Prof. R. N. Bracewell), 670
Comparative Biochemistry and Physiology, Vol 1, No. 1, 764
Comparative Studies of Yeasts (J. A. Barnett), 449
Comparison of Adhering and Abscising Fruits of Peach treated with N-1-Naphthyl Phthalamic Acid (Prof. Loyd E. Powell and Charlotte Pratt), 814
Comparison of the Charges of the Electron, Proton and Neutron (A. M. Hillas and T. E. Cranshaw), 459
Comparison of Iodine-124 and Iodine-131 Thyroid Dosimetry (Dr. C. M. E. Matthews and Dr. J. F. Fowler), 983
Competent Cells (Immunologically), in the Chick Embryo : Loss of Specificity on Passage of (Sir Macfarlane Burnet and Georgiana Boyer), 175
Competition for Science Teachers (*Teaching Science*), 126
Complement : Effect of Antibody and, on Volume Control in an Ascites Tumour Cell (Dr H Green and Dr. F. Silverblatt), 646
  Further Evidence for the Dual Nature of the Third Component of (Dr. J. D. Hawkins), 483
C'_4 : Role of, in the Antiglobulin Reaction (G. C Jenkins, Margaret J. Polley and Dr. P L. Mollison), 482
Complex (Metal) : Rate of Ligand Exchange with its, by a Polarimetric Method (B. Bosnich, Dr. F. P. Dwyer and Dr. A. M. Sargeson), 966
Complex (Polynucleotide) : Polyinosinic plus Polycytidylic Acid—a Crystalline (Dr David R Davies), 1030
Complexes of Calcium–Montmorillonite with Polymers (W. W. Emerson), 573
Complexes of Rhenium : Some New (R. Colton, R Levitus and Prof. G. Wilkinson), 233
Complexes of the Type $[M(NH_3)_5X]^{n+}$: Mechanism of the Electroreduction of (Prof. George W Watt and Joe W. Vaughn), 309
Complexes (Copper), and Organic Bases Addition Compounds between (R. C. Traill), 631
Complexes (Metal Hydrazine) · The 'Irving–Williams' Order in the Metal-ligand Stretching Frequencies of some (Prof. L. Sacconi and A. Sabatini), 549
Component (Indoxyl-acetate Splitting), in the α_2-Globulin Region of Normal Human Sera : Agar-gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an (Dr. Jan Hirschfeld), 321
Component (Third), of Complement : Further Evidence for the Dual Nature of the (Dr. J D. Hawkins), 483
Components : Semiconductors, 602
Components (Cytochrome), in Chloroplasts · Function of the Two—a Working Hypothesis (Dr. R. Hill and Dr. Fay Bendall), 136
Components (Electrophoretic), of the Proteins in Honeybee Larval Food (N G Patel, M H. Haydak and T. A. Gochnauer), 633
Components (Protein), from Turnip Yellow Mosaic Virus (Dr. J. M. Kaper), 219
Composition (Amino-Acid), of Proteins from Surface Tissue of the Tongue (Dr. C J. Barnes and Dr. L. N Ferguson), 617
Composition (Isotopic), of Potassium (B. R F Kendall), 225
Composition (Mineralogical), of some <2 Micron Fractions in a Sediment Core from the Mindanao Trough (J. Ch. L. Favejee), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No. 5), 609
Composition, Structure, Shape and Function of a Salivary Mucoprotein : Correlation between (Dr Alfred Gottschalk), 949
Compound (Ninhydrin-positive), probably a Peptide : Urinary Excretion of a, after Administration of β-Aminoisobutyric Acid to the Mouse (Dr. James B. Gilbert and Dr. Yuoh Ku), 160
Compounds : Co-ordination—their Chemistry and Applications (Department of Chemical Technology of the Bradford Institute of Technology Symposium on), 440
Compounds labelled with Carbon-14 : Radioassay by Gas Chromatography of (Dr. Arthur Karmen and Harold R. Tritch), 150
Compounds (Addition), between Copper Complexes and Organic Bases (R. C. Traill), 631
Compounds (Aromatic) : Effect of Solvent Polarizability on the Ultraviolet Spectral Shifts of (Dr. F. A. Bovey and S. S. Yanari), 1042
Compounds (Flavonoid), in the Inflorescence of *Helichrysum arenarium* (Z. I. Jerzmanowska and J. T. Grzybowska), 807
Compounds (New Clathrate), of the Inert Gases (J. G. Waller), 429
Compounds (Nitrogenous) : Use of Ionizing Radiation in Spot Tests for (H. J. M. Bowen, E. Arter and P. A. Cawse), 383
Compounds (Organic) : Use of Solvents containing Ethyl Iodide in the Investigation of Phosphorescence Spectra of (Dr. I. J. Graham-Bryce and J. M. Corkill), 965
Compounds (Sulphur) : The Metabolism of (Leslie Young and George A. Maw), *review* by Dr. G D. Greville, 424
Compounds (Sulphydryl) : Effect of Oxygen on the Radiosensitivity of Bacteriophage in the Presence of (Dr. P. Howard-Flanders), 485
Compounds (Sulphydryl), in Rat Liver : Level of, following Feeding with Goitrogenous and Nongoitrogenous Cabbage (Jozef Sedlák), 892
Compounds (Surface-Active) Methods for the Evaluation of the Antibacterial Activity of (Society for Applied Bacteriology and the Microbiology Group of the Society of Chemical Industry Symposium on), 131, *erratum*, 206
Compressible Flow . Introduction to the Theory of (Prof. Shih-I Pai), *review* by Dr. G K Batchelor, 1000
Compston, Dr W , and others : Age of Emplacement of Granites, 702
Computation Centre, Provisional International . *Bulletin*, No. 8, 764
Computer . A New British, 201
  A New British Transistorized (General Electric Co., and International Computers and Tabulators, Ltd), 936
Computer Society, Ltd. (British) : Second Annual Conference, 361
Computers (Electronic), in Population Genetics (W. F. Bodmer), 851 ; (J. L. Crosby), 851
Computers and Tabulators, Ltd., International, (General Electric Co., and) : A New British Transistorized Computer, 936
Concentrated Sodium Hydroxide or Potassium Hydroxide : Photo-stimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with (J. Wawrzyniak and Dr. B. Sujak), 467
Concentrated Solutions : The Physico-chemical Constants of Binary Systems in (Prof. Jean Timmermans), Vol. 1, Two Organic Compounds (without Hydroxyl Derivatives) ; Vol. 2, Two Organic Compounds (at least one a Hydroxyl Derivative), *review* by Dr. E. F. G Herington, 918
Concentration of Hydrocarbons in 'Painted' Mouse Skin · Effect of Molecular Structure upon (Mary Burnham and Fred G. Bock), 323
Concentration-Dependent Sedimentation of Aggregating Proteins in the Ultracentrifuge (Dr G. A. Gilbert), 882
Concrete Approach to Abstract Algebra (Prof. W. W. Sawyer), *review*, 69, 440
Concurrent Translocation : Evidence of (C. D. Nelson, H. J. Perkins and P. R. Gorham), 205
Condensation Product of Ethylenediamine with Noradrenaline or 3,4-Dihydroxymandelic Acid (Kunio Yagi, Toshiharu Nagatsu and Ikuko Nagatsu), 310
Conditions (Normal and Experimental) : Diurnal Temperature Variation in the Rhesus Monkey under (Dr. Lloyd B. Erikson), 83
Conduction of Heat in Solids (Prof. H. S. Carslaw and Prof J. C. Jaeger), second edition, *review* by Prof. L. S. Goddard, 421
  Mathematics and the, *review* by Prof L. S. Goddard, 421
Conduction in Myelinated, Isolated Nerve Fibres of the Frog : Effect of Curare on (Dr. Wolf D. Dettbarn), 891
Conductivity (Bulk), in Organic Crystals (Dr. H. Kallmann and Dr. M. Pope), 31
Conductivity Detectors (Thermal) : Effect of Carrier Gas on the Sensitivity of (C Bokhoven and A. Dijkstra), 793
Conferences : Guide to Press Arrangements for Scientific, Medical and Technical (edited by Ronald Bedford), 437
Congenital Malformations (International Medical Congress, Ltd., International Conference on), 685
Congo (Belgian) Flora of the, 764
Congo Belge et du Ruanda-Urundi · Flore du (Institut National pour l'Étude Agronomique du Congo Belge), Vol. 9, 764
Conjugation of 3·4-Benzpyrenols in Mouse Skin (Dr. K. H. Harper and Dr. G. Calcutt), 80
Connective Tissue and Osseous Chemistry in Lathyritic Rats : Aortic, Serum, (Dr. R A. Grant, M. Hathorn and Prof. Theodore Gillman), 164
Connell, G E. (Murray, R. K., and) : Elevation of Serum Haptoglobin in Rabbits in Response to Experimental Inflammation, 86
Connexion between S–S Bond Breakage and Inactivation by Radiation of a Dry Enzyme (Dilip K. Ray, Dr. Franklin Hutchinson and H. J. Morowitz), 312
Conquest of the Stars : Man's (Pierre Rousseau), *review* by D. H. P. Jones, 69
Conrad, R , and others : Letter Structure of the English Language, 414
Conrad (Capt. Robert Dexter) Award presented to Dr. R. E. Gibson, 122
Conservation of Nature and Natural Resources, International Union for · Seventh General Assembly, jointly with the eighth Technical Meeting, 206
Conservation of Paintings : Scientific Techniques in the, 437
Consisting Predominantly of Feldspar ? : Do Meteorites exist (Prof. K. Przibram), 300
Constant : The Liquid Friction (Dr. G. H. A. Cole), 301
Constant (Acidic Dissociation), of Alcoholic Hydroxyls of Oxycarboxylic Acids—Mandelic Acid (Dr. M T. Beck and M. Halmos), 388
Constants Galore, *review* by Dr. E. F. G Herington, 918
Constants (Physical and Chemical) : Tables of, and some Mathematical Functions (Dr G W C Kaye and Dr. T. H. Laby), twelfth edition, *review* by T. M. Yarwood, 67
Constants (Physico-chemical), of Binary Systems in Concentrated Solutions (Prof. Jean Timmermans), Vol 1, Two Organic Compounds (without Hydroxyl Derivatives) ; Vol 2, Two Organic Compounds (at least one a Hydroxyl Derivative), *review* by Dr. E. F. G. Herington, 918

Constants (Ultrasonic Propagation), in Supercooled Salol (Dr. S. Parthasarathy and V. N Bindal), 145
Constitution and Properties of the Iridium–Platinum Alloys (Dr. A. S. Darling), 211
Construct 'Reactive Inhibition' in the Interpretation of Age Changes in Performance (Dr. S. Griew and Dr R. Lynn), 182
Construction of Error-correcting Group Codes : A Systematic Method for the (Prof R B. Banerji), 627
Consulting Scientists, Association of Election of Officers for 1960-61, 766
Consumption and Refinery Production, 1958 and 1959 : United Kingdom Petroleum Industry Statistics relating to (Petroleum Information Bureau), 851
Contaminants in Tissue Culture : *L* Forms of Bacteria as (Dr I A. Macpherson and K. Allner), 992
Contamination (Aerial), of Agricultural Land : An Assessment of the Quantities of Fission Products likely to be found in Milk in the Event of (Dr R. J Garner), 1063
Continuity and Change in African Cultures (edited by William R. Bascon and Melville J. Kerskovits), *review* by G W. B. Huntingford, 38
Contractile Proteins in the X-Irradiated Embryo : Synthesis of (Dr. Yoshito Ogawa), 77
Contractility in Depolarized Smooth Muscle . Calcium and (Dr. P. A. Robertson), 316
Control of Colour Change in Amphibians (C Barker Jorgensen and Lis Olesen Larsen), 641
Control (Automatic) : First International Congress on, 439
Control (Automatic), in Soviet Industry (Department of Scientific and Industrial Research), 287
Control (Electronics and), Journal of, Vol. 4, 685
Control (Endocrine), of Sexual Reproduction in *Opalina ranarum* Parasitic in *Rana temporaria* (Dr M El Mofty and Prof. J. D. Smyth), 559
Control (International), of Narcotic Drugs, 21
Control (Nervous), of Movements in the Foregut of *Schistocerca gregaria* Forsk (Dr. K. U. Clarke and H Grenville), 98
Control (Noise) · Acoustic Tiles for, 602
Control (Volume), in an Ascites Tumour Cell : Effect of Antibody and Complement on (Dr H. Green and Dr F Silverblatt), 646
Control and Synthesis in Micro-organisms : Organization, *review* by Dr. B. A. Newton, 49
Controlled Thermonuclear Reactions : Bibliography on Plasma Physics and Magneto-hydrodynamics and their Applications to (J. D Ramer), 522
Convection (Royal Meteorological Society Symposium on), 604
Conversion (Alkaline), of 4-Hydroxyphenylpyruvic Acid to 4-Hydroxybenzaldehyde (Dr. C. H Doy), 529
Conversion (Hydrocarbon) Hydrocarbon Synthesis and (Indian Institute of Science Symposium on), 691
Conway, Dr Elsie . Occurrence of *Falkenbergia rufolanosa* on the West Coast of Scotland, 566
Cook, B. P (Steward, E G , and) . Mosaic Texture of Graphites, 797
Cook, E. R., and others : Synovial Proliferation induced by Polysaccharides, 251
Cook, Dr Gerald B. . Appointed chief chemist of the International Atomic Energy Agency, 854 ; work of, 854
Cook Strait, New Zealand : A Red Water Bloom of Rotifers in (Vivienne Cassie), 328
Cooke, Dr G. V. · Fertilizers and Profitable Farming, *review* by G. V. Jacks, 424
Cooper, J. S. : Appointed lecturer in prosthetics at the University of Bristol, 284
Co-operation in the Field of Scientific and Technical Research (Organization for European Economic Co-operation), 998
Co-operation (Commonwealth) : State Scholarships and, 935
Co-operation (European), for Science, 600
Co-operation (International), and the Production of Calcium-47, 1018
Co-operation (Wider), in Europe : British Dyestuffs and, 829
Co-operative Research in Europe, 520
Co-ordination of Light and Electron Microscopy (Royal Microscopical Society and the Electron Microscopy Group of the Institute of Physics Symposium on), 672
Co-ordination Compounds, their Chemistry and Applications (Department of Chemical Technology of the Bradford Institute of Technology Symposium on), 440
Copan, Thomas P. (Gulbransen, Earl A., and) : Crystal Growths and the Corrosion of Iron, 959
Cope, Dr. R. G : The Delta Plutonium Transition Temperature, 539
Cope, Sir Zachary · The Royal College of Surgeons of England—a History, *review* by Prof. Charles Singer, 35
Copisarow, A. C. . Appointed director of the Forest Products Research Laboratory, 934 ; work of, 934
Coppen, Dr. A J , and Gibbons, Dr. J. L. · Saliva–Serum Ratios of Tritium after the Administration of Tritiated Water, 724
Copper : Growth of Single Crystals of (Rev. D. S. Kemsley), 33 ; (Prof. E N. da C. Andrade), 540
Copper Complexes and Organic Bases : Addition Compounds between (R C. Traill), 631
Copper Protein (A New), from *Chlorella ellipsoidea* (Dr Sakae Katoh), 533
Copper and Solid Oxygen condensed at Very Low Temperatures from a Gas Discharge : Reaction between (Jerome Kruger and William J Ambs), 794
Corbino Disk : The Possibility of a Self-sustaining (Dr. D. Midgley), 377
Core 72 and 723 . Examinations of (W. Dekeyser), (Reports of the Swedish Deep-Sea Expedition, 1947-58, Vol. 10, Special Investigations, No. 2), 609
Core (Sediment), from the Central Equatorial Pacific : X-Ray Determination of Phillipsite in a (F. Lippman), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 10, Special Investigations, No 3), 609
Core (Sediment), from the Mindanao Trough (K. Fredriksson), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No 4), 609
  Mineralogical Composition of some <2 Micron Fractions in a (J. Ch L. Favejee), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No. 5), 609
  A Note on the Foraminifera in a (R A. Reyment), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No 6), 609
  Fragments of Calcareous Algae in a (H Horn af Rantzien), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No. 7), 609
Cores (Some Bottom), from the Swedish Deep-Sea Expedition, 1947-48 (A. S. Laughton), 609
Cores (Sediment), from the Mediterranean Sea and the Red Sea (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 8, No. 1), 609
Cores (Sediment) from the North Atlantic Ocean (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Nos. 4-5), 609
Cores (Sediment) from the West Pacific (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Nos. 4-7), 609
Corkill, J M (Graham-Bryce, Dr. I J , and) · Use of Solvents containing Ethyl Iodide in the Investigation of Phosphorescence Spectra of Organic Compounds, 965
Corlett, E. N. · Appointed senior Research Fellow in the Department of Engineering Production in the University of Birmingham, 937
Cormack, R. M. Statistical Methods in Biological and Medical Sciences, *review*, 746
Corn Borer (European) · Effect of Temperature on the Hibernation of the (Stanley D Beck), 774
Cornell University : Summer Laboratory Course in Techniques and Applications of the Electron Microscope, 127
Cornwell, J. F , and Wohlfarth, Dr E. P. : An Energy Band Interpolation Scheme, with Application to Body-centred Cubic Lithium, 379
Correlation : West-Pacific Stratigraphic (Dr. M F Glaessner), 1039
Correlation between Composition, Structure, Shape and Function of a Salivary Mucoprotein (Dr. Alfred Gottschalk), 949
Correlation of Occurrence of Whistlers with Geomagnetic Activities (Atsushi Kimpara), 230
Corrosion of Beryllium in Carbon Monoxide and in Carbon Dioxide Gas : Formation of Beryllium Carbide during the (V. D Scott), 466
Corrosion of Iron : Crystal Growths and the (Earl A Gulbransen and Thomas P. Copan), 959
Corsair, a Digital Differential Analyser (Royal Aircraft Establishment and Semiconductors, Ltd), 201
Corson, Dr Joseph M , and others · The Respiratory Dead Space of the Giraffe, 24
Cortex (Brain) Slices Active Transport of γ-Aminobutyric Acid in, with special reference to Phosphorus-32 Turnover in Phospholipids in Cytoplasmic Particulates (Yasuzo Tsukada, Yutaka Nagata and Shusuke Hirano), 474
Cortex (Rat Kidney) · Increase in 'Alkaline' Ribonuclease of, after Lysozyme and Egg-White Administration (Dr T. Maack, Dr R. Brentani and Dr. M. Rabinovitch), 158
Corticosteroids · Accumulation of Substrate by Isolated Rat Diaphragm—a Possible Mechanism for the Anti-Inflammatory Action of (Prof. Ira G. Wool), 728
Corticosterone Microbiological 11β-Hydroxy Dehydrogenation of (M. Shirasaka, R. Takasaki and M. Tsuruta), 390
Cortisone Acetate, Cholesterol and Lecithin : Enhancement of Staphylococcal Virulence for Mice by Intraperitoneal (Dr Daniel Amsterdam and Dr. S Stanley Schneierson), 101
Corwin, Dr. Laurence M , and Schwarz, Dr. Klaus : Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine, 1048
Cosmic Noise : A Relation between Solar Radio Emission and Solar Cap Absorption of (Dr. M R. Kundu and Prof. F T. Haddock), 610
Cosmic Ray Intensity in Interplanetary Space (Dr. H. Elliot), 299
Cosmical Physics : Electromagnetic Phenomena in (edited by B Lehnert), (International Astronomical Union Symposium No. 6, Stockholm 1956), *review* by Dr. R. H Garstang, 67
Cosmography : The New, *review* by Dr D W. Dewhirst, 109
Cosmology : The Interpretation of (Prof. W. H. McCrea), 1035
Cosmology (Dirac's), and the Origin of the Solar System (Prof. L Egyed), 621
Cosslett, Dr. Anna . Co-ordination of Light and Electron Microscopy (Use of some of the Optical Techniques in association with Electron Microscopy), 673
Cosslett, Dr. V. E. : Co-ordination of Light and Electron Microscopy, 672
Cost of the Radio Telescope at Jodrell Bank, 13
Cost of Scientific Periodical Publications (K. W. Humphreys and H D Barry), 124
Coulson, Prof C A . Electronic Structure of Molecules, *review*, 54
Counting (Radioactive) : An Inexpensive Castle and Sample Holder for (Dr. Howard Boroughs), 145
Counting (Scintillation), of Carbon-14 (David S Jenkinson), 613
Countryside (North Devon) : Preservation of, 935
Course in Practical Field Techniques in Physical and Cultural Geography (Geographical Association), 1020
Course (International Summer), on Plasma Physics (Danish Atomic Energy Commission), 938
Course (Summer Laboratory), in Techniques and Applications of the Electron Microscope (Cornell University), 127
Course (Theoretical and Technical), on Aerial Photogrammetry (École Nationale des Sciences Géographiques), 127
Courses : Residential Short (National Institute of Adult Education), 685
Courses (Short Summer), European Calendar of (Bureau Européen de l'Education Populaire), 685
Cousins, Christina M : Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds (The Assessment of Surface-Active Agents as Disinfectants in Milk Production and Processing), 132
Coward, Dr. H. F. : Flame and Explosion of Gases and Vapours, *review*, 666
Cox, Sir Harold Roxbee · Elected to Fellowship of the Imperial College of Science and Technology, London, 522
Coxon, Dr. R. V., and others . Biochemistry in relation to Medicine, third edition, *review* by Prof D. C Harrison, 422
Crab (Horseshoe), *Limulus polyphemus* : Visual Pigment of the (Dr Ruth Hubbard and Prof George Wald), 212
Craft, C. C., and others : Ethylene Production by Tomato and Apple Fruits, 902
Craig, P. P , and others : Ultra-High Resolution γ-Ray Resonance in Zinc-67, 707

Cranbrook, Lord : East Anglian Mammals (Presidential Address to the South-Eastern Union of Scientific Societies), 770
Cranshaw, T. E. (Hillas, A. M., and) Comparison of the Charges of the Electron, Proton and Neutron, 459
Cranwell, Dr Lucy M. (Mrs. Watson Smith), and others : Lower Tertiary Microfossils from McMurdo Sound, Antarctica, 700
Crayfish Neuromuscular Junctions : Spontaneous Potential Changes at (Dr. Josef Dudel and Richard K. Orkand), 476
Crayfishes · Blood Glucose in, in relation to Moult and Handling (Dr J A. Riegel), 727
Cresser, Dr. E. H. : Appointed senior lecturer in microbiology at the University of Birmingham, 937
Creep in the Post-yield Region · Supercontraction of Wool Fibres and (Dr. K. J. Whiteley), 473
Creep (High-Temperature), of Graphite (Dr. D. B. Fischbach), 795
Creger, Dr William P., and Thomas, Phyllis Menna : Micro-electrophoresis of Human White Cells and Platelets, 171
Crepidula fornicata L (Slipper Limpet), in Ireland : Occurrence of the (D. C. Arnold), 95
Cresswell, E. : Methane Exhalation in Sheep, 560
Crick, Dr. F H. C Elected to an Extraordinary Fellowship of Churchill College, Cambridge, 440
Criminology and Psychiatry . Social Science, *review* by Prof E. Stengel, 41
Cristallographie . Société Française de Minéralogie et de : Index of Crystallographic Supplies (edited by Dr. A J. Rose), second edition, 1019
Cronshaw, Dr C. J. T. · Awarded the Hinchley Medal of the British Association of Chemists, 685
Crook, E. M. (edited by) . Glutathione (Biochemical Society, Symposium No. 17, 1958), *review*, 669
Crookall, J. O., and others : Radioactive Fallout during 1959, 925
Crookall, Dr. Robert : Fossil Plants of the Carboniferous Rocks of Great Britain, second edition, *review* by T. M. Harris, 66
Crooks, R. N , and others · Radioactivity of the Atmosphere due to Distant Nuclear Test Explosions, 224
Crop Plant Resistance to Disease · Nature and Exploitation of (Association of Applied Biologists and the British Mycological Society Symposium on), 857
Crop Protection : Scientific Problems of (Hungarian Academy of Sciences International Conference on), 523
Crop Yield : Plant Population and (R Holliday), 22
Crops (Farm) Diseases of (A. Beaumont), *review* by J. M Hirst, 85
Crosby, J. L : Electronic Computers in Population Genetics, 851
Cross, Dr. K. W · Appointed to the University of London chair of physiology in the London Hospital Medical College, 522, 598 ; work of, 598
Cross-Linking (Radiation-induced), in Hydrocarbon Polymers : Mode of (T. F. Williams), 544
Cross-Modal Transfer of Training in Monkeys (D. Burton and Dr. G. Ettlinger), 1071
Crossing-Over (Apparent Double), in a Short Genetic Interval in *Drosophila melanogaster* (Prof. M. M. Green), 990
Crossley, Prof E. L. (edited by) : The United Kingdom Dairy Industry, *review* by Dr. C C. Balch, 504
Crowther, Dr. B M. : At the Scientific Publications Council's Discussion on the Rapid Increase in the number of New Scientific Journals, 18
Croxton, Prof Frederick E. : Elementary Statistics with Applications in Medicine and the Biological Sciences, *review* by R. M. Cormack, 746
Cruickshank, Prof. E. K., and Rodgers, Dr. P. E. Medical Research in the British Caribbean (Spinal Arachnoiditis in Jamaica), 863
Cryptogamic Botany at Manchester, 598
Crystal Growths and the Corrosion of Iron (Earl A. Gulbransen and Thomas P Copan), 959
Crystal Structure of Adenosine-5'-phosphate (J Kraut and L. H Jensen), 798
Crystal Structure of Indanthrene : Electron Microscopy and the (Lewis T. Chadderton), 541
Crystal Structure of Mellitic Acid (S. F. Darlow), 542
Crystal Structure of Potassium Trivanadate (Dr. Stanley Block), 540
Crystal Structure of Tetraphenyl*cyclo*butadiene Iron Tricarbonyl (R. P. Dodge and Dr V. Schomaker), 798
Crystal Structure Determination · Modern Methods of (Manchester College of Science and Technology Summer School in), 766
Crystalline Methacrylic Acid : Polymerization of, initiated by Ultra-violet Radiation (Dr C. H. Bamford, A. D. Jenkins and J C. Ward), 713
Crystalline Modification (Second), in Polyethylene . Effect of a, on X-Ray Crystallinity Measurements (Dr C. G. Vonk), 962
Crystalline Polynucleotide Complex · Polyinosinic plus Polycytidylic Acid —a (Dr. David R. Davies), 1030
Crystallinity Measurements (X-Ray) : Effect of a Second Crystalline Modification in Polyethylene on (Dr. C. G. Vonk), 962
Crystallization of an Algal Cytochrome, *Porphyra tenera*–Cytochrome 553 (Dr. Sakae Katoh), 138
Crystallization of Purified Mouse Encephalomyocarditis Virus Particles (P. Faulkner, E. M. Martin, S. Sved and Dr. T. S Work), 908
Crystallographic Supplies : Index of (edited by Dr. A. J. Rose), second edition (Société Française de Minéralogie et de Cristallographie), 1019
Crystallography, International Union of : Fifth General Assembly, 1020
  Symposium on Thermal Motion in Crystals and Molecules, 1020
  Symposium on Lattice Defects and the Mechanical Properties of Solids, 1020
Crystallography, International Union of (Commission on Crystallographic Apparatus) : Index of Crystallographic Supplies (edited by Dr. A. J. Rose), second edition, 1019
Crystals (Aluminium Single) : First Stage of Work Hardening in (N. A. McKinnon), 148
Crystals (Organic) : Bulk Conductivity in (Dr. M. Kallmann and Dr. H. Pope), 31
Crystals (Silver Single) : Orientation of Stearic Acid Monolayers on (Robert T. Mathieson), 301
Crystals (Single), of Copper · Growth of (Rev. D. S. Kemsley), 33 ; (Prof. E. N da C. Andrade), 540
Crystals (Single), of Potassium Chloride containing Barium Chloride : Micromosaic Patterns in (J. Ewles and J. B. Dawson), 381
Crystals and Molecules : Thermal Motion in (International Union of Crystallography Symposium on), 1020
Cubic Lithium (Body-cenered) : An Energy Band Interpolation Scheme, with Application to (J. F. Cornwell and Dr. E. P. Wohlfarth), 379
Cultivation (Monoxenic), of an Enchytraeid Annelid (Dr. Ellsworth C. Dougherty and Bjørn Solberg), 1067
Cultural Geography (Physical and) : Practical Field Techniques in (Geographical Association Course in), 1020
Culture : Spontaneous Potentials from Explants of Brain Tissue in (Prof. A. W. B. Cunningham, Marshall Dougherty and B. J. Rylander), 477
  Trout and Salmon—Hatchery Methods (Earl Leitritz), 204
Culture of Human Leucocytes on the Chorioallantoic Membrane of the Chick (Eugene Bell), 403
Culture (Pure), of the Trichomycete, *Amoebidium parasiticum* (Dr. Howard C. Whisler), 732
Culture (Quantitative Tissue) · Effect of Supernatant Potassium-Level on Cardiac Activity in (Prof. A. W. B. Cunningham, K. Kleutch and W. Herbst), 241
Culture (Tissue) : Effect of Oxygen and Nitric Oxide on the Radiosensitivity of Human Cells in (Dr. D. L. Dewey), 780
  L Forms of Bacteria as Contaminants in (Dr I A. Macpherson and K. Allner), 992
Culture Filtrates of an Encapsulated *Staphylococcus aureus* : Isolation of a Phagocytosis-inhibiting Substance from (Dr Stephen I Morse), 102
Culture Filtrates (Heated) : Starch–Agar-Gel Electrophoresis of Tuberculoproteins from (T. P. Dekker), 392
Cultures : African, *review* by G. W. B. Huntingford, 38
Cultures (African) Continuity and Change in (edited by William R. Bascon and Melville J Herskovits), *review* by G. W B. Huntingford, 38
Cultures (Dried) · Recovery of Adult *Amoeba lescherae* from (Monica Taylor), 329
Cunningham, Prof. A. W. B., and others : Effect of Supernatant Potassium-Level on Cardiac Activity in Quantitative Tissue Culture, 241
  Spontaneous Potentials from Explants of Brain Tissue in Culture, 477
Cunningham, Dr C. A., and others : An Rh Antibody Specific for V and R's, 171
Cunningham, Prof G J., and others Life-like Preservation of Cytoplasmic Detail in Plant Cells, 1068
Cupric Alkanoate Solutions : Nature of (Dr. D. P Graddon), 715
Curare : Effect of, on Conduction in Myelinated, Isolated Nerve Fibres of the Frog (Dr Wolf D Dettbarn), 891
Curtis, Prof. W E. : *Obituary* of Prof. E. G. Richardson, 678
Curtiss, Dr. L. F. Introduction to Neutron Physics, *review* by Dr. P. A. Egelstaff, 187
Curzon, F. L., and others : Growth of Surface Instabilities in a Linear Pinched Discharge, 624
Cuthbertson, Dr D. P. : *Obituary* of Dr. John Duckworth, 678
  Minor Elements in Nutrition, 939
Cuticle (Insect) : Wetting Properties of (J. W. L. Beament), 408
Cuttings Developments in the Propagation of Clones of *Hevea brasiliensis* by (G H Tinley and R. J Garner), 407
Cyanamid Company (American) . Lederle Medical Student Research Fellowships, 283
Cyanamid European Research Institute, Geneva : Election of Dr. Richard O Roblin as president and director, 361
  Election of Dr Mario Scalera as a vice-president, 361
Cyanamid International, London : New List of Medical and Technical Papers prepared by Research Workers, 523
'Cyclodiene' Insecticides · Mechanisms of Resistance of the Adult Housefly (*Musca domestica*) to (Dr. G T Brooks), 96
Cylindrical Structures : Electromagnetic Radiation from (James R. Wait), *review* by W. Brown, 583
Cynkin, Dr. Morris A , and Ashwell, Dr. Gilbert : Estimation of 3-Deoxy Sugars by means of the Malonaldehyde–Thiobarbituric Acid Reaction, 155
'Cystase' (Snail) : *Volvox* Colonies and (Dr. B C Sharman), 90
Cystine Content in Skin of Rats · Effect of Vitamin A on the (Prof Tatsuo Koyanagi and Satoru Odagiri), 809
Cytidine (A Methyl), from the Ribonucleic Acid of *Anacystis nidulans* (Dr. B. B Biswas and J. Myers), 238
Cytochemical Observations (Quantitative), on a Specific Nucleoprotein Reaction in Cell Nuclei (Dr E. A. Barnard), 447
Cytochemical Reactions : A New Technique for Studying the Quantitative Aspects of, and Its Application to the Feulgen Reaction (P van Duijn and J.-P. Persijn), 805
Cytochrome b_5 (Inactivation of), by Oxygen Flavin Dissociation and (A New Type of Autoxidation Reaction), (J. McD. Armstrong, Dr. J H. Coates and Prof. R K. Morton), 1033
Cytochrome *c* Reductase · Cause of the Instability of (A New Type of Autoxidation Reaction), (Dr. Malcolm Dixon, J M Maynard and P. F W Morrow), 1032
Cytochrome Components in Chloroplasts : Function of the Two—a Working Hypothesis (Dr. R. Hill and Dr Fay Bendall), 136
Cytochrome (Algal), *Porphyra tenera*–Cytochrome 553 · Crystallization of an (Dr. Sakae Katoh), 138
Cytology, (in Russian), Vol. I, No. I, 601
Cytopathogenic Agent from Skin Lesions of Cattle · Isolation of a (Dr. C. Huygelen, D Thienpont and M. Vandervelden), 979
Cytoplasmic Detail in Plant Cells : Life-like Preservation of (Dr J. Chayen, Prof G J. Cunningham, P. B. Gahan and A. A Silcox), 1068
Cytoplasmic Inclusions of the Ageing Neurons of some Teleosts (Prof A. Stolk), 332
Cytoplasmic Particulates : Active Transport of γ-Aminobutyric Acid in Brain Cortex Slices, with special reference to Phosphorus-32 Turnover of Phospholipids in (Yasuzo Tsukada, Yutaka Nagata and Shusuke Hirano), 474
Czapski, G., and others Mechanism of the Oxidation and Reduction of Metal Ions by Hydrogen Atoms, 629
Czeczuga, B. : Haemoglobin Content of the Larvae of *Tendipes f.l. plumosus* L. from Various Levels of Bed Sediment, 484

da SILVA, W. Dias (Mota, Dr. I, and): Antigen-Induced Damage to Isolated Sensitized Mast Cells, 245
Daams, J. (Koopman, Dr. H., and): 2,6-Dichlorobenzonitrile, a New Herbicide, 89
Dachille, Frank, and Roy, Prof. Rustum: High-Pressure Phase Transformations in Laboratory Mechanical Mixers and Mortars, 34
Dahm, Dr. Anders G. Chromosome Numbers of Four Species of the Genus *Dendrocoelum* Œrsted (*Turbellaria tricladida paludicola*), 334
Daily, B. (Glaessner, Dr. M. F., and): Late Precambrian Fauna in South Australia, 205
Dainton, Prof. F. S: Applied Radiation Chemistry, *review*, 344
Dainton, Prof F. S, and Peterson, Dr. D. B. Use of Nitrous Oxide to discriminate between the Forms of Hydrogen Atoms ($H\cdot$ and H_2^+ ?) produced by γ-Irradiation of Aqueous Solutions, 878
Dainton, Prof. F. S, and Sills, S A · Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide irradiated with Ultra-violet Light, 879
Dairy Industry. The United Kingdom (edited by Prof E. L. Crossley), *review* by Dr C C. Balch, 504
Dairying in Great Britain, *review* by Dr. C C Balch, 504
Dalitz, Prof R. H. · Elected a Fellow of the Royal Society, 11
Dallner, Dr. Gustav · Viability and Tetrazolium Salt in Ascites Tumours, 176
Damage (Antigen-induced), to Isolated Sensitized Mast Cells (Dr. I. Mota and W. Dias da Silva), 245
Damage (X-Ray), to Guinea Pig Skin: Effect of S-β-aminoethylisothiouronium Bromide Hydrobromide on (Dr. J. B. Walter and Prof. D. Slome), 177
Dammin, Prof Gustave J., and others The Respiratory Dead Space of the Giraffe, 24
Dams: The Theory of, *review* by D. G Kendall, 344
Danish Atomic Energy Commission International Summer Course on Plasma Physics, 938
Danish Milk (Spray-dried): Caesium-137 in (Per Gert Jensen), 562
Dann, A T · Detection of N-Oxides of the Pyrrolizidine Alkaloids, 1051
Dannatt, Prof. C. W. Elected to Fellowship of the Imperial College of Science and Technology, London, 522
Darling, Dr. A S. · Constitution and Properties of the Iridium–Platinum Alloys, 211
Darlow, S F. Crystal Structure of Mellitic Acid, 542
Dart, Prof R A., and others: Australopithecine Tools, 205
Darton Prizes of the Royal Meteorological Society—(*a*) Home Awards, first prize to Dr. C. J. Adkins, and second prize to Dr J. A. Funk; (*b*) Canadian Awards, first prize jointly to R. H. Douglas and Dr. W. Hitschfeld, and second prize to D K. A. Gillies, 440
Darwin's Notebooks, 16
Das, K. C., and others Foetal Haemoglobin in the Monkey, 977
Data · Biochemical, *review* by Dr K. S. Dodgson, 50
Data for Biochemical Research (edited by R. M C Dawson, Daphne C. Elliott, W H. Elliott and K. M. Jones), *review* by Dr. K. S. Dodgson, 50
Data (Spray-Drop): Distribution-Free Interpretation of (John B. Opfell), 822
Dating System (Radiocarbon), using Scintillation Techniques (C. F. G. Delaney and I. R. McAulay), 204
Datta, Prof R L.: Indian Institute of Science, Bangalore—Golden Jubilee Symposia, 691
Datta, Dr R. M. *Obituary* of Prof G P Mazumdar, 356
Dauntsey's School Natural History Society: Report, 282
Davenport, Dr H E. Haemoglobin in the Root Nodules of *Casuarina cunninghamiana*, 653
Davenport, R. C.: The Eye and Vision, *review*, 42
    Blindness in West Africa, *review*, 64
David, R. W. · At the Scientific Publications Council's Discussion on the Rapid Increase in the number of New Scientific Journals, 18
Davidson, Prof C F. · *Obituary* of Dr W F. P McLintock, 200
    Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, held in Geneva, 1958, Vol. 2, Survey of Raw Material Resources, *review*, 921
Davidson, Dr. J: Minor Elements in Nutrition, 939
Davidson, Prof J N. · Elected a Fellow of the Royal Society, 11
Davidson, Prof N. R.: Elected a member of the United States National Academy of Sciences, 773
Davies, C. N · Inhaled Particles and Vapours, 524
Davies, Prof C. W · Retirement from the chair of chemistry in the University College of Wales, Aberystwyth, 680; work of, 680
Davies, Dr. David R. · Polyinosinic plus Polycytidylic Acid—a Crystalline Polynucleotide Complex, 1030
Davies, Dr. J. G. · Results of the Royal Society's International Geophysical Year Expedition (Work in Radio Astronomy), 192
Davies, Dr J. G.: Nitrogen in Tropical Agriculture, 941
Davies, Dr. J T: Appointed to the chair of chemical engineering in the University of Birmingham, 849; work of, 849
Davies, Dr R. D, and Palmer, Dr H P Radio Studies of the Universe, *review* by Dr. J S Hey, 59
Davies, R Llewelyn, and others Psychiatric Services and Architecture, 936
Davies, T. Glyn: A Spring Oat Variety resistant to the Stem Eelworm, 813
Davis, Dr. J G.: Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds (Technical Aspects of the Problem), 131
    Elected chairman for 1960–61 of the Association of Consulting Scientists, 766
    Milk Testing, second edition, *review* by A. L Provan, 835
Davson, Dr. Hugh: A Textbook of General Physiology, second edition, *review* by Prof A. St. G. Huggett, 52
Dawes, Dr. Ben Parasites, Imaginary and Real, *review*, 46
Dawkins, M. J. R, and Rees, Dr. K R: A Biochemical Approach to Pathology, *review* by Dr. R. W. R Baker, 921
Dawson, J. B. (Ewles, J., and): Micromosaic Patterns in Single Crystals of Potassium Chloride containing Barium Chloride, 381
Dawson, R. M. C., and others (edited by): Data for Biochemical Research, *review* by Dr. K. S Dodgson, 50
Day: Insects and Length of, 774
DDT and Dieldrin · Normal Susceptibility Levels of *Anopheles pharoensis* Theobald to (Dr. F. Kuhlow), 410
de Chazal, L. E. Marc: Chemical Process Principles, *review*, 1003
de Nahlik, A. J.: Wild Deer, *review* by R. S. R. Fitter, 45
De Petrocellis, Benita, and others: Enzymatic Deamination of 5-Deoxycytidylic Acid and of 5-Methyl-5'-deoxycytidylic Acid in Growing and in Non-growing Tissues, 237
de Reuck, A. V S.. At the Scientific Publications Council's Discussion on the Rapid Increase in the number of New Scientific Journals, 18
de Sousa, Dr. J B., and Ho, S K.: Disproportionation and Dimerization of the Benzyloxyl Free Radical in Solution, 776
de Veubeke, Prof. Baudouin Fraeijs, and others: Rocket Propulsion, *review* by J. E. P. Dunning, 186
DeVoe, James R.: The Radiochemistry of Cadmium, 602
de Vries, G. (Bollée, B, and): Experiments in the Field of Parametric Amplification, 1019
de Wet, J. F (van Niekerk, J. N, and): Trace Analysis by X-Ray Fluorescence using Ion Exchange Resins, 380
De Yong, J., and Higgins, H. G. · Visco-Elastic Systems (Draining Studies on a Pad of Cellulose Fibres), 943
Dead Space (Respiratory), of the Giraffe (Prof Eugene D. Robin, Dr. Joseph M. Corson and Prof Gustave J. Dammin), 24
Deamination (Enzymatic), of 5-Deoxycytidylic Acid and of 5-Methyl-5'-deoxycytidylic Acid in Growing and in Non-growing Tissues (Dr. Eduardo Scarano, Massimo Talarico, Luisa Bonaduce and Benita De Petrocellis), 237
Deanesly, Dr. Ruth: Normal Implantation in Ovariectomized Guinea Pigs, 327
Decarboxylase Activity (5-Hydroxytryptophan): Development of, in Rat Kidney (Dr Irene Huang, Sheila Tannenbaum and Dr. David Yi-Yung Hsia), 717
Decarboxylation of Glutamic Acid in Tobacco Leaves inoculated with Tobacco Mosaic Virus (M. S Gubanski), 657
Decker, Dr. Karl: Die Aktivierte Essigsaure, *review* by Prof. D. C Harrison, 66
Decomposition of Humic Acid by Fungi (Prof. Alan Burges and Pamela Latter), 404
Decomposition of Methyl Acetylene (F. Fitzgerald), 386
p-*n*-Decyloxybenzenediazonium Fluoborate: Reaction of, with Sodium Iodide in Benzene (Prof. W Bradley and J. D. Thompson), 631
Deep-Sea Expedition, 1947–48 (Swedish): Reports of the, Vol. 6, Sediment Cores from the West Pacific, Nos. 4–7; Vol. 7, Sediment Cores from the North Atlantic Ocean, Nos. 4–5; Vol. 8, Sediment Cores from the Mediterranean Sea and the Red Sea, No. 1; Vol. 10, Special Investigations, Nos. 2–4, 609
Deer: The Roe (Forestry Commission, Leaflet No. 45), 936
    Wild (A. J. de Nahlik), *review* by R. S R. Fitter, 45
Defects (Lattice), and the Mechanical Properties of Solids (International Union of Crystallography Symposium on), 1020
Defence Standards Laboratories (Australian). Annual Report (1958–59), 366
Deficiency (Boron), in *Grevillea robusta* (A. N. Smith), 987
Deficiency (Glucose-6-Phosphate Dehydrogenase), in Red Blood Cells of East Africans (Dr. A. C. Allison), 531
Degradation of γ-Methyleneglutamic Acid by Plants (Dr L. Fowden), 897
Degradation (Chemical), of Canavanine to Canaline (Dr. H Rinderknecht), 1047
'Degranol' on it: Heterogeneity of Tumour Ribonucleic Acid and the Effect of (F. Antoni, E J Hidvégi and K Lapis), 81
Dehydrogenase (Glucose-6-Phosphate) Deficiency in Red Blood Cells of East Africans (Dr. A C Allison), 531
Dehydrogenase (Triosephosphate), of Adult Male and Nymph Development Stages of *Triatoma infestans* Non-Identity of (Prof M. Agosin, A. Neghme and N. Scaramelli), 1052
Dehydrogenase (Xanthine), in the Silkworm, *Bombyx mori* L. (Yoshiyuki Hayashi), 1053
Dehydrogenation (Microbiological 11β-Hydroxy), of Corticosterone (M. Shirasaka, R. Takasaki and M Tsuruta), 390
Dekeyser, W: Examinations of Core 72 and 723 (Reports of the Swedish Deep-Sea Expedition, 1947–48, Vol 10, Special Investigations, No. 2), 609
Dekker, T. P.: Starch–Agar-Gel Electrophoresis of Tuberculoproteins from Heated Culture Filtrates, 392
Delaney, Dr. C F. G, and McAulay, I R. Radiocarbon Dating System using Scintillation Techniques, 204
Delaney, Dr C. F. G., and Walton, Dr. A. J.: Use of an Auxiliary Grid to stabilize the Gain of a Photomultiplier, 625
Delayed Effects (Abrupt and), of Insulin on the Distribution Space of Glucose in the Dog (Dr. G. Hetenyi, jun, and Prof G A. Wrenshall), 808
Delayed Potassium Permeability. Action Potentials in Active Tissue with (Dr. E. P George), 889
Delevoryas, Prof Theodore: Appointed associate professor in the Department of Botany in the University of Illinois, 1020
Delfini, Dr. Carlo, and others · Characterization of a New Purine Riboside isolated from *Fusarium* Species, 968
Delong, A. (Drahoš, V, and) · A Simple Method for Obtaining Perforated Supporting Membranes for Electron Microscopy, 104
Delphinium · Experimentally Induced Inter-bivalent Redistribution of Chiasmata in (H. K Jain and A. K. Bose), 260
Delta Plutonium Transition Temperature (Dr R G. Cope), 539
Demands (Environmental): Sensory Specialization in Response to (Zoological Society of London Symposium on), 688
Demer, L J. (Westwood, A. R. C., and): Piling-up of Dislocations beneath a Surface Film, 146
Demetsopoullos, I. C., and others: Self-Quenching Geiger Counters containing Mixtures of Permanent Gases, 876
Demonstration of Interference by Noncytocidal Strains of Rabies Virus: An Indicator Plaque-forming System for (Dr. Martin M Kaplan, Dr. Eberhard Wecker, Dr. Zlatko Forsek and Dr. Hilary Koprowski), 821
Demonstration of their Renal Origin: Ultrastructure of the Clear Cells in Renal Carcinomas and its Importance for the (Prof. Ch. Oberling, M. Rivière and Fr Haguenau), 402
Demonstration (Agar-gel Electrophoretic), of Individual Variations in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_2-Globulin Region of Normal Human Sera (Dr. Jan Hirschfeld), 321
Demonstration (Histochemical), of Ascorbic Acid in the Locus Coeruleus of the Mammalian Brain (Dr. Nobuo Shimizu, Tomokazu Matsunami and Satoko Onishi), 479

Denatured Ferritin and Apoferritin : X-Ray Diffraction Study of (Vladimir Kleinwachter), 313
Dendrocoelum Œrsted (Genus), (*Turbellaria tricladida paludicola*) Chromosome Numbers of Four Species of the (Dr. Anders G. Dahm), 334
Denervation: Effect of, on Potassium-42 Uptake by the Rat Muscle *in vitro* (Dr. Z Drahota and O. Hudlická), 396
Denhardt, Dr. D. T. : A Possible Basis for Immunological Tolerance, 728
Dennis, J. A., and others : Self-Quenching Geiger Counters containing Mixtures of Permanent Gases, 876
Densities (Helium) : Structure of High-Rank Coals deduced from (T. S. Polansky, H. J. Donald and Prof C R. Kinney), 792
Density : Adsorption of Helium on Carbons—Influence on Measurement of (Dr F. A. P. Maggs, P. H. Schwabe and J. H. Williams), 956
Density of the Upper Atmosphere and its Dependence on the Sun, as revealed by Satellite Orbits (D G King-Hele and D. M. C. Walker), 928
Density (Electron) Measurements in the Upper Ionosphere using the Faraday Rotation of Radio Signals from Artificial Satellites (Dr. D. McL. A. Wilson), 623
Density (Upper-Atmosphere Air), at the Height of 180-212 km derived from the Orbit of *Sputnik III* : Profile of (Z. V. Bochníček), 460
Dental Caries and certain Soil Conditions in New Zealand : An Association between (T. G. Ludwig, W B Healy and Capt. F L. Losee), 695
Dental Research in Britain, 600
Dental Hospital (Royal), of London School of Dental Surgery : Appointment of Dr H. J J Blackwood as reader in oral anatomy, 938
Denton, Dr. E. J : Sensory Specialization in Response to Environmental Demands (Design of Fish and Cephalopod Eyes in relation to their Environment), 689
3-Deoxy Sugars : Estimation of, by means of the Malonaldehyde–Thiobarbituric Acid Reaction (Dr. Morris A. Cynkin and Dr. Gilbert Ashwell), 155
Deoxy Sugars and Sialic Acids : Thiobarbituric Acid Spray Reagent for (Dr. Leonard Warren), 237
5-Deoxycytidylic Acid : Enzymatic Deamination of, and of 5-Methyl-5'-deoxycytidylic Acid in Growing and Non-growing Tissues (Dr. Eduardo Scarano, Massimo Talarico, Luisa Bonaduce and Benita De Petrocellis), 237
Deoxyribonucleic Acid : Mechanism of the Radiation Effect on the Synthesis of (Dr. R. J. Berry, E. Hell, Dr. L G. Lajtha and Dr. M. Ebert), 563
Deoxyribonucleic Acid in Dilute Aqueous Solution : Chemical Effects of Ionizing Radiation on (G. Hems), 710
Deoxyribonucleic Acid Content of Mouse Sarcoma 37 Cells : Changes in the, following Serial Irradiation (Dr. A. E. G. Pearson and N. B. Atkin), 647
Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat : Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the (S L. Liu), 475
Deoxyribonucleic Acid Label in Man : Hazard of Tritium as a (R. Oliver and Dr. L. J. Lajtha), 91
Deoxyribonucleic Acids from Human Leucocytes : Infra-Red Spectra of (G. Zerbi, P. A. Bianchi and E. E. Polli), 964
Dependence of the Sex Ratio at Birth on the Age of the Father (Dr. Leo Szilard), 649 ; (Dr. A. Comfort), 1065
Dependence on the Sun : Density of the Upper Atmosphere and its, as revealed by Satellite Orbits (D. G. King-Hele and D. M. C. Walker), 928
Depolarization of the Fluorescence of Proteins labelled with various Fluorescent Dyes (C S Chadwick, Dr. P. Johnson and E G. Richards), 239
Depolarized Smooth Muscle : Calcium and Contractility in (Dr. P. A. Robertson), 316
Deposition of Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith) : Effect of a Sewage Effluent Discharge on the (R. W. Edwards and J. Heywood), 492
Deposits (Dieldrin) : Determination of, on Sprayed Mud Surfaces (Dr R. E. Ford), 994
Depression : Treatment of, by Drugs and other Means (Dr. Linford Rees), 114
Depressions (Freezing-Point), of Hoagland's 'Carbowax' Systems (Howard G Applegate), 232
Derby, Earl of : Presidential Address to the Textile Institute, 436
Derivatives (Guanidine) : Antimalarial Properties of some (Y Ch. Chin, Y. Y. Wu, B. Skowrońska-Serafin, Prof. T. Urbański and J. Venulet), 170
Desalting of Urine by Electrodialysis (Dr. T. Wood), 634
Design (Optical) : Research in, at the Imperial College, London, 934
Designs (Roof) : Snow Loads and, 603
Detail (Cytoplasmic), in Plant Cells : Life-like Preservation of (Dr. J. Chayen, Prof. G. J. Cunningham, P. B. Gahan and A. A. Silcox), 1068
Detection of Negative Ions formed by Charge Transfer (T. M. Donahue and F. Hushfar), 1038
Detection of Nitrous Acid : Application of Pyramidone to (Dr. Wiktor Wawrzyczek), 883
Detection of N-Oxides of the Pyrrolizidine Alkaloids (A. T. Dann), 1051
Detection of Recently Produced Fission Products in the Atmosphere (Dr. W. Anderson, Dr. R. E. Bentley, L. K. Burton and Dr. C. A. Greatorex) 223
Detection (Optical), of Nuclear Magnetic Resonance (J. Brossel), 440
Detection (Specific), of Glucose on Paper Chromatograms (Dr. M. R. J. Salton), 966
Detection and Estimation of a Facial Eczema Toxin, Sporidesmin (G. R. Russell), 788
Detectors (Thermal Conductivity) : Effect of Carrier Gas on the Sensitivity of (C. Bokhoven and A Dijkstra), 793
Determination of Adsorption in Double Layers involving Solid Metals (Dr. Erik A. Blomgren and Dr. John O'M. Bockris), 305
Determination of Calcium in Blood Serum by Atomic Absorption Spectroscopy (J B. Willis), 249
Determination of Dieldrin Deposits on Sprayed Mud Surfaces (Dr. R. E. Ford), 994
Determination of Physiological Age for Female *Glossina morsitans* (D. S. Saunders), 651
Determination of Small Rapid Volume Changes in a Muscle during Activity (Prof. B. C. Abbott and R. J. Baskin), 1055
Determination of Sulphate : A Modification for Washing the Benzidine Sulphate Precipitate in the (Dr I. P T. Hakkinen), 232
Determination (Age), in the Harbour Seal, *Phoca vitulina* L. (A. W Mansfield and H. D. Fisher), 92
Determination (Crystal Structure) : Modern Methods of (Manchester College of Science and Technology Summer School in), 766
Determination (Environmental), of Sex in a Parthenogenetic Parasite (F. Wilson and L. T. Woolcock), 99
Determination (X-Ray), of Phillipsite in a Sediment Core from the Central Equatorial Pacific (F. Lippman), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 10, Special Investigations, No 3), 609
Determining the Rheological Properties of Dough made from Wheaten Flour : A Role for Thiol and Disulphide Groups in (R. Frater, Dr. F. J. R. Hird, H. J. Moss and J. R. Yates), 451
Detonations, Flammability and Ignition : Explosions, Part I (Prof. S. S. Penner) ; Part 2 (B. P. Mullins), *review* by Dr H F Coward, 666
Detoxication during Secondary Growth in Plants (C. M. Stewart), 374
Dettbarn, Dr. Wolf D. : Effect of Curare on Conduction in Myelinated, Isolated Nerve Fibres of the Frog, 891
Deuchar, Dr. D. C. : Cardiac Neuroses, *review*, 423
Deuterium-labelled Carbohydrates : Infra-red Spectra of (Dr S. A. Barker, R. H. Moore, Prof. M. Stacey and Dr. D H. Whiffen), 307
Deutsche Akademie der Naturforscher, Halle : Election of new Members, 766
Deutsche Geologische Vereinigung : Jubilee Meeting (Discussion on Orogens), 206, 689
  Steinmann Medal awarded to Prof H. H. Read, 206, 690
Development : A Bibliography on the Economic and Social Implications of Scientific Research and (United States National Science Foundation), 14
  Projects in Colleges and Universities on the Economic and other Impacts of Scientific Research and (United States National Science Foundation), 14
Development in Britain : Amenities and, 265
Development of Ballistic Missiles, 358
Development of Carrageenin Granuloma : Biological Significance of Peptide containing Hydroxyproline during the (Dr. M Chvapil and B. Cmuchalová), 806
Development of 5-Hydroxytryptophan Decarboxylase Activity in Rat Kidney (Dr. Irene Huang, Sheila Tannenbaum and Dr. David Yi-Yung Hsia), 717
Development of the Infective Larvae of *Oesophagostomum radiatum* (Rud. 1803) (Strongylidae : Nematoda) : Effect of X-Rays on the (R. F. Riek and R. K. Keith), 981
Development of Learning in the Rhesus Monkey (Harry F. Harlow and colleagues), 211
Development of Nuclear Energy in Britain, 1
Development of Resistance in Mice to Tumour Induction by *S E* Polyoma Virus (Sarah E. Stewart, Bernice E. Eddy, Marjean Irwin and Stephanie Lee), 615
Development of Science in South-East Asia (Unesco South-East Asia Science Co-operation Office and the Indonesian Council of Sciences Discussion on), 859
Development of the Teaching of Chemistry : Status and (Organization for European Economic Co-operation Seminar on the), 208
Develoment (Academic Research and) : United States Expenditure on, 1016
Development (Aeronautical Research and), Advisory Group for (NATO) : AGARDOgraph No 31, Explosions, Detonations, Flammability and Ignition, Part I (Prof. S. S. Penner) ; Part 2 (B. P. Mullins), *review* by Dr. H. F. Coward, 666
  Meeting on Ionospheric Research, 685
  Discussion on Boundary Layer Research, 1022
Development (The Future), of Management Education and of Business Studies—Revision of Joint Examination Schemes (Ministry of Education, Circular 1/60), 743
Development (Overseas) : Assistance from the United Kingdom for (White Paper on), 501
Development (Progressive), in *Habrobracon* Females : Divergence between Lethal Doses and Sterilizing Doses of X-Rays wtih (Dr. Howard E. Erdman), 254
Development (Research and), in Colleges and Universities in the Fiscal Year 1958 (United States National Science Foundation Report on), 1016
Development (Retarded) of *Ostertagia* Species in Sheep (J. D. Dunsmore), 986
Development Commissioners, and others : Postgraduate Training Grants in Fishery Research, 360
Development Expenditure : Industrial Research and, 1958 (Department of Scientific and Industrial Research), 997
Development Stages (Adult Male and Nymph), of *Triatoma infestans* : Non-Identity of Triosephosphate Dehydrogenase of (Prof. M. Agosin, A. Neghme and N. Scaramelli), 1052
Development and Productivity of Rice Plants : Stimulating Effects of Nuclear Radiations on (Dr. Maung Mya Thaung), 982
Developments in the Applications of Nuclear Science for Peaceful Purposes : Recent (CENTO Institute of Nuclear Science Symposium on), 685
Developments in the Propagation of Clones of *Hevea brasiliensis* by Cuttings (G. H. Tinley and R. J Garner), 407
Deverall, B. J. : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Deviants (Chromsomal) : Triploid Rat Embryos and other, after Colchicine Treatment and Polyspermy (L. Piko and O. Bomsel-Helmreich), 737
Devon (North) Countryside : Preservation of, 935
Dewar, Prof. M. J. S. : Elected a Fellow of the Royal Society, 11
  Appointed to the chair of organic chemistry in the University of Chicago, 762 ; work of, 762
Dewey, Dr. D. L. : Effect of Oxygen and Nitric Oxide on the Radiosensitivity of Human Cells in Tissue Culture, 780
Dewhirst, Dr. D. W. : The New Cosmography, *review*, 109
Dexter, R. R., and others (edited by) : Advances in Aeronautical Sciences—Proceedings of the First International Congress on the Aeronautical Sciences (Madrid 1958), *review* by Prof. A. R. Collar, 665
Dextranase (Bacterial) : Action of a, on Branched Dextrans (R W. Bailey, Dr. D. H. Hutson and Dr. H. Weigel), 553

Dextrans (Branched) · Action of a Bacterial Dextranase on (R W. Bailey, Dr. D H. Hutson and Dr. H. Weigel), 553
Diagnosis : Growth (Leona M. Bayer and Nancy Bayley), *review* by Dr. K. M. Hawkins, 45
Diagnosis of Human Growth, *review* by Dr. K. M. Hawkins, 45
Diamond, R., and Hirsch, P. B. . X-Ray Studies of some Carbonized Coals, 204
Diamond : Intrinsic Recombination Radiation in (J. C. Male and J. R. Prior), 1037
Diapause Eggs of *Acheta commodus* (Walk) : Effect of Sub-Zero Temperatures on (T W. Hogan), 98
Diaphragm (Isolated Rat) Accumulation of Substrate by—a Possible Mechanism for the Anti-Inflammatory Action of Corticosteroids (Prof. Ira G Wool), 728
Diaphragm (Rat) : Release of Acetylcholine in (K. Krnjević and J. F. Mitchell), 241
Diatomic Radicals containing Boron or Silicon : Absorption Spectra of (Dr. B. A. Thrush), 1044
2,6-Dichlorobenzonitrile, a New Herbicide (Dr. H. Koopman and J. Daams), 89
Dichotic Stimulation and Memory Disorder (Prof James Inglis), 181
Dickinson, H (Azam, M. N , and) Time-lags in the Intrinsic Electrical Breakdown of Glass, 146
Dictionary : Russian Machine Translation (H. S H. Massey), 852
Dictionary of Indian Raw Materials and Industrial Products : The Wealth of India, a— Raw Materials, Vol. 5, H–K, *review* by Dr F. N. Howes, 70
Dictionary of Nuclear Science, Engineering and Technology, in Four Languages (English–German–French–Italian) Atomic Terminology, a (compiled by Dr. Lore Lettenmeyer), *review* by Dr J B. Sykes, 67
Diczfalusy, E., and others : A New Class of Hormonally Active Steroids, 168
Dieldrin · Genetics of Resistance to, in *Lucilia cuprina* Wied. (G. J. Shanahan), 181
  Normal Susceptibility Levels of *Anopheles pharoensis* Theobald to DDT and (Dr. F. Kuhlow), 410
  Selection for High-Order Resistance to, in *Lucilia cuprina* Wied. (G. J. Shanahan), 100
Dieldrin Deposits : Determination of, on Sprayed Mud Surfaces (Dr. R. E. Ford), 994
Diet (British) : Strontium-90 Content of, 852
Dietary Intake of certain Insecticides : Influence of, on the Haemoglobin and Erythrocyte Contents of Chick Blood (Prof B. K. Srivastava, H. C. Saxena and J. C. Sharma), 172
Diethyl β-Acetamidoglutarate : Requirements for Stereospecificity in Hydrolysis by Chymotryptin— (Prof. Saul G. Cohen and Ezra Khedouri), 75
Diethylstilboestrol : Duration of Stimulation of Phagocytic Activity of the Reticulo-Endothelial System after Cessation of Treatment with (C. C. Ware and Prof. T Nicol), 974
Difference (Sex), in Accidental Mortality of Guppies exposed to Elevated Temperature (Prof John A. Freeman), 491
Differences in Numbers of Erythrocytes between Inbred Lines of Chickens (Dr. P. Jaffe), 978
Differences (Seasonal), in Ovulating Hormone in the Merino Ewe (Dr. D. R. Lamond), 971
Different Tensions of Oxygen : Some Effects of, on the Respiration and Growth of *L*-Strain Fibroplasts (A. R. Fisher), 315
Differential Analyser : The *Corsair*, a Digital (Royal Aircraft Establishment and Semiconductors, Ltd.), 201
Differential Geometry (Prof. Erwin Kreyszig), *review*, 70
Differential Test of Arts/Science Aptitude (L. Hudson), 413
Differentiation : Intraspecific—Biological and Social Aspects (Dr. Max Pettersson), 431
Differentiation (Sexual) : Evolutionary Origin of, and the Sex-Ratio (Dr. H. Kalmus and Dr. C. A. B. Smith), 1004
Differently Saturated Fats for Three Years : Essential Fatty Acids of Normal and Atherosclerotic Aortas from Chickens receiving (Prof. H. Fisher and A. S Feigenbaum), 85
Diffraction (Micro-) : A Technique for Sampling Oxide Layers and Brittle Materials for (A. M. Adams, M. A. Silva and Veronica M. Spiers), 147
Diffraction Study (X-Ray), of Denatured Ferritin and Apoferritin (Vladimir Kleinwächter), 313
Diffusion of Proteins through Lipophilic Agar Cells (Dr. Ch. Wunderly), 885
Digital Differential Analyser : The *Corsair*, a (Royal Aircraft Establishment and Semiconductors, Ltd), 201
1,4-Dihydrazinophthalazine · Effects of, on the Catechol Amines (M. Bygdeman and L. Stjarne), 82
Dihydrocodeine and Aminopyrine Analgesia (Morphine,) : Synergetic Action of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on (Dr. E. Fischer, J. L. J. Szabó and M. Stamburgo), 893
3,4-Dihydroxymandelic Acid : Condensation Product of Ethylenediamine with Noradrenaline or (Kunio Yagi, Toshiharu Nagatsu and Ikuko Nagatsu), 310
Dihydroxyphenylalanine and 5-Hydroxyindoles · Vanadium Catalysis of the Oxidation of Catechol Amines, (Dr. G. M Martin, E. P. Benditt and N. Eriksen), 884
Dijkstra, A. (Bokhoven, C , and) : Effect of Carrier Gas on the Sensitivity of Thermal Conductivity Detectors, 793
Dikshit, Mandakini B. (Chaudhury, Prof. Ranjit Roy, and) . Milk-ejecting Action of Ergot, 722
Dilemma of the Far East, *review* by Prof. W. D. Borrie, 664
Dilli, S., and Green, Dr. J. H. : Radiation Synthesis of Urea, 383
Dilute Aqueous Solution : Chemical Effects of Ionizing Radiation on Deoxyribonucleic Acid in (G. Hems), 710
Dimer (Pyrene) · Radiative Life-time of the, and the Possible Role of Excited Dimers in Energy Transfer Processes (Dr. B. Stevens and E. Hutton), 1045
Dimerization of the Benzyloxyl Free Radical in Solution : Disproportionation and (Dr. J. B. de Sousa and S. K. Ho), 776
Dimers (Excited), in Energy Transfer Processes : Radiative Life-time of the Pyrene Dimer and the Possible Role of (Dr. B. Stevens and E. Hutton), 1045
Dimers and Hexamers (Insulin) : Symmetry of (Prof. Barbara W. Low and J. Ralph Einstein), 470
αω-Dimethanesulphonoxyalkanes : Optical Properties of the (Dr. A. C. Bishop and Dr. R. D. Marshall), 74
Dimethyl Siloxane Polymers · Proton Magnetic Resonance in a Series of—a Specific Long-Chain ? (Dr. J. G. Powles and A Hartland), 26
Dimond, A. E. (edited by J. G Horsfall and) Plant Pathology, an Advanced Treatise, Vol. I, The Diseased Plant, *review* by W C. Moore, 47
Dinesen, A. (Brotzen, F , and) : On the Stratigraphy of some Bottom Sections from the Central Pacific (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 10, Special Investigations, No. 4), 609
Dingle, Prof. Herbert · Modern Philosophy of Science, *review*, 503
Dingle, J. T , and others : Synovial Proliferation induced by Polysaccharides, 251
2,4-Dinitrophenol : Effect of Thyroxine and, on Levels of Ubiquinone and Ubichromenol in the Rat (E. E. Edwin, J. Green, A. T. Diplock and J. Bunyan), 725
Dintenfass, L. : Visco-Elastic Systems (Rheological Classification of Suspensions), 943
Dinucleotide (Nicotinic Acid Adenine) Excretion of Nicotinic Acid and, by Biotin-deficient Yeast (Dr. Anthony H. Rose), 139
Dioscorea Saponin Smilagenone and *Epi*-Smilagenin from (D. Chakravarti, Prof. R N Chakravarti and M N Mitra), 236
Dioxide (Carbon), and in Carbon Monoxide Oxidation of Beryllium in (Dr S J. Gregg, Dr R J Hussey and Dr. W B Jepson), 468
Dioxide (Carbon) Gas . Formation of Beryllium Carbide during the Corrosion of Beryllium in Carbon Monoxide and in (V. D. Scott), 466
Dipeptidase Activity of Brain (L. Lahut Uzman, Marilynn K Rumley and Stanley van den Noort), 559
Diphenylamine Effect of, on the Synthesis of Carotene (Gy. Schneider, Dr. B. Matkovics, J Zsolt and Ó Kovács), 235
Diphenylphenylenediamine . Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by α-Tocopherol, a Tocopherol Metabolite, Menadione and (Dr Laurence M. Corwin and Dr. Klaus Schwarz), 1048
Diplock, A. T., and others : Ubiquinones and Ubichromenols in the Rat, 554
  Effect of Thyroxine and 2,4-Dinitrophenol on Levels of Ubiquinone and Ubichromenol in the Rat, 725
Diploid-like Meiotic Behaviour of Wheat : Position of the Gene determining the (Dr. Ralph Riley, Victor Chapman and Gordon Kimber), 259
Dirac's Cosmology and the Origin of the Solar System (Prof. L. Egyed), 621
Direct Current Signals : Transistor Modulators for Low-level (J. F. Evans), 626
Direct Entry into First Degree Courses in the Faculty of Science : Report of an Enquiry into the Suitability of the General Certificate of Education Advanced Level Syllabuses in Science as a Preparation for (University of Birmingham), 687
Direct Evidence for the Importance of Glutathione for the Enzyme Status in Intact Cells : Glutathione Stability and Pyrophosphatase Activity in Reticulocytes— (Prof. S. Rapoport and D. Scheuch), 967
Directory of Radioisotopes · International, Vol. I, Unprocessed and Processed Radioisotope Preparations and Special Radiation Sources ; Vol. 2, Compounds of Carbon-14, Hydrogen-3, Iodine-131, Phosphorus-32 and Sulphur-35 (International Atomic Energy Agency), 282
Discharge (Gas) : Reaction between Copper and Solid Oxygen condensed at Very Low Temperatures from a (Jerome Kruger and William J. Ambs), 794
Discharge (Gas) Harmonic Generator : Coherence and Band-width of a (N. R Bierrum, D. Walsh and J. C. Vokes), 626
Discharge (Linear Pinched) : Growth of Surface Instabilities in a (Dr. R. Latham, J. A. Nation, F. L. Curzon and Dr A Folkierski), 624
Discharge (Sewage Effluent) : Effect of a, on the Deposition of Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith), (R. W Edwards and J. Heywood), 492
Discrimination of Polarized Light by *Octopus* (The Visual System of *Octopus*), (M. F. Moody and J R Parriss), 839
Discrimination (Form) : Regularities in the Retina and Optic Lobes of *Octopus* in relation to (The Visual System of *Octopus*), (Prof. J Z. Young), 836
Discrimination (Shape), in *Octopus* : Theories of (The Visual System of *Octopus*), (Dr. N. S. Sutherland), 840
Disease : Monkeys and, *review* by Dr C. R. Coid, 506
  Nature and Exploitation of Crop Plant Resistance to (Association of Applied Biologists and the British Mycological Society Symposium on), 857
Disease (Foot-and-Mouth) : Influence of Route of Inoculation and Strain of Mouse on Infectivity Titrations of the Virus of (Wendy Heatley, H. H. Skinner and H. Subak-Sharpe), 909
Disease (Parabiotic) : Graft versus Host Reaction in (Dr. B. Nakič, Z. Nakič and V Silobrčič), 322
Diseased Plant : The (Plant Pathology, an Advanced Treatise, edited by J. G. Horsfall and A. E Dimond, Vol. I), *review* by W. C Moore, 47
Diseases of Farm Crops (A. Beaumont), *review* by J. M. Hirst, 65
Diseases of Laboratory Primates (Prof. Theodore C. Ruch), *review* by Dr. C. R. Coid, 506
Diseases (Infective) · The Aetiology of (Prof Reginald Lovell), *review* by Dr. G. Lapage, 581
  Factors and Causes of, *review* by Dr. G. Lapage, 581
Dislocations beneath a Surface Film : Piling-up of (A. R C. Westwood and L. J. Demer), 146
Disorder (Memory) : Dichotic Stimulation and (Prof. James Inglis), 181
Dispersal by Flight : A Basis for a General System of Insect Migration and (C. G. Johnson), 348
Disproportionation and Dimerization of the Benzyloxyl Free Radical in Solution (Dr J. B de Sousa and S. K. Ho), 776
Dissection (Micro-) : Collagenase Maceration of Kidney for (Nancy J. Hayward), 403
Dissociation of Two Types of Immunity : Non-Specific Tolerance of Graft and the (Dr. Milan Hašek and Dr. Jan Hort), 985
Dissociation (Flavin), and Inactivation of Cytochrome b_5 by Oxygen (A New Type of Autoxidation Reaction), (J McD. Armstrong, Dr. J. H. Coates and Prof. R. K. Morton), 1033
Dissociation Constant (Acidic), of Alcoholic Hydroxyls of Oxycarboxylic Acids—Mandelic Acid (Dr. M. T. Beck and M. Halmos), 388
Distance Scale : The Extragalactic (Paul W. Hodge), 622
Distant Nuclear Test Explosions : Radioactivity of the Atmosphere due to (D. H Peirson, R. N. Crooks and E. M. R. Fisher), 224
Distensible Vessels (Tapered), Reflexions, and the Hosie Phenomenon : Pulsatile Flow through (Robert L. Evans), 290

Distillation · Preparation of Tritiated Water Samples by (J. D. Simpson and Dr J. R Greening), 467
Distinct (Metabolically) Classes of Ribonucleic Acids in Animal Cells: Fractionation of Two, and its Bearings on Cancer (Prof A. Sibatani, K. Yamana, K. Kimura and T Takahashi), 215
Distribution of Chromactivating Hormones in the Pituitary of the Minnow (A. K Kent), 395
Distribution (Binomial) · The Meaning of (A. W. F. Edwards), 1074
Distribution (Size), of Tobacco Smoke Droplets by a Replica Method (W. J. Harris), 537
Distribution (World), of ABO Blood Groups, *review* by Dr. F. Stratton, 581
Distribution-Free Interpretation of Spray-Drop Data (John B. Opfell), 822
Distribution Space of Glucose in the Dog Abrupt and Delayed Effects of Insulin on the (Dr G. Hetenyi, jun, and Prof. G A. Wrenshall), 808
Distribution and Form of Sponges · Influence of Environment on the (Prof M. A. Ali), 177
Distribution and Prevalence of *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw) Wr) producing Substances with Gibberellin-like Biological Properties (Prof. W. L. Gordon), 698
Distributions (Intensity), in the N_2 Lyman–Birge–Hopfield and CO Fourth Positive Band Systems Interpretation of (Prof R W Nicholls), 958
Disulphide Groups: A Role for Thiol and, in Determining the Rheological Properties of Dough made from Wheaten Flour (R Frater, Dr. F. J R Hird, H J Moss and J R. Yates), 451
Ditchburn, Prof R. W. New Physics Laboratory of the University of Reading, 768
Dittmer, Dorothy S (edited by): Handbook of Toxicology, Vol 5, Fungicides (analysis and compilation by Everett F. Davis, Barbara L. Tuma and Lucy C. Lee), *review*, 64
Diurnal Temperature Variation in the Rhesus Monkey under Normal and Experimental Conditions (Dr Lloyd B. Erikson), 83
Divergence between Lethal Doses and Sterilizing Doses of X-Rays with Progressive Development in *Habrobracon* Females (Dr. Howard E. Erdman), 254
Diversity of Trends in Medicine, *review* by Prof L J. Witts, 42
Dixon, J M S · Fate of Bacteria in the Small Intestine, 521
Dixon, Dr Malcolm, and others: A New Type of Autoxidation Reaction—Cause of the Instability of Cytochrome *c* Reductase, 1032
Dlouhá, H. (Nováková, V, and): Effect of Severing the Olfactory Bulbs on the Intake and Excretion of Water in the Rat, 638
Dobzhansky, Prof. Th. (Wallace, Prof. Bruce, and): Radiation, Genes and Man, *review* by Dr. A. G Searle, 109
Document Micro-reproduction, 602
Documenta Ophthalmologica (Advances in Ophthalmology, Vol 13), (edited by G von Bahr, G. B. Bietti, J. ten Doesschate, H Fischer von Bunau, J François, H. Goldmann, H. K. Muller, Jean Nordmann, A J. Schaeffer and Arnold Sorsby), *review* by R. C. Davenport, 42
Documents · Preservation of (W. K. Wilson and B. W. Forshee), 124
Dodds, Sir Charles: Appointed chairman of the Advisory Committee on Poisonous Substances in Agriculture and Food Storage, 934
Dodé, Prof. Maurice: Bases Fondamentales et Applications de la Thermodynamique Chimique, Tome I, Les Principes, les Systèmes ideaux Gazeux, et avec Phases Condensées pures, *review* by Prof. A. R. Ubbelohde, 55
Dodge, R. P, and Schomaker, Dr V. · Crystal Structure of Tetraphenyl-*cyclo*butadiene Iron Tricarbonyl, 798
Dodgson, Dr. K. S: Biochemical Data, *review*, 50
Dog: Abrupt and Delayed Effects of Insulin in the Distribution Space of Glucose in the (Dr. G Hetenyi, jun, and Prof G A. Wrenshall), 808
  Erythropoietine Production in the (Dr. F. W. Kinard, F. F. Griffin, jun, and F. W Kinard, jun), 561
Dog Hip Joints (Normal). Clearance Rates of Sodium-24, Potassium-42 and Iodine-131 in (Prof. Patrick G. Laing and Dr. Ik Dong Kim), 898
Dolichol, a Naturally Occurring Isoprenoid Alcohol (J. F. Pennock, F. W. Hemming and Prof R. A. Morton), 470
Doling, Dr. D. A. · Nature and Exploitation of Crop Plant Resistance to Disease (Physiological Specialization in *Puccinia glumarum* and *Phytophthora infestans*), 858
Domaniewska-Sobczak, Kazimiera, and others: The ABO Blood Groups, *review* by Dr F. Stratton, 581
Domiciliary Medical Care (Ambulatory and): Role of Hospitals in—Second Report of the Expert Committee on Organization of Medical Care (United Nations, World Health Organization, Technical Report Series No. 176), 202
Domján, Gy, and others · Histochemical and Biochemical Studies of Rat Liver in Experimental Cirrhosis after Partial Hepatectomy, 397
Donahue, T. M., and Hushfar, F.: Detection of Negative Ions formed by Charge Transfer, 1038
Donald, H. J, and others · Structure of High-Rank Coals deduced from Helium Densities, 792
Doppler Radar (Pulsed): Meteorological Use of (J. R. Probert-Jones), 271
Doses (Lethal), and Sterilizing Doses of X-Rays: Divergence between, with Progressive Development in *Habrobracon* Females (Dr. Howard E. Erdman), 254
Doses (Sterilizing), of X-Rays: Divergence between Lethal Doses and, with Progressive Development in *Habrobracon* Females (Dr. Howard E. Erdman), 254
Dosimetry (Thyroid) · A Comparison of Iodine-124 and Iodine-131 (Dr. C. M. E. Matthews and Dr. J. F. Fowler), 983
Double Crossing-Over (Apparent), in a Short Genetic Interval in *Drosophila melanogaster* (Prof M. M. Green), 990
Double Layers involving Solid Metals: Determination of Adsorption in (Dr Erik A Blomgren and Dr John O'M. Bockris), 305
Dough Made from Wheaten Flour: A Role for Thiol and Disulphide Groups in Determining the Rheological Properties of (R. Frater, Dr. F. J. R. Hird, H J Moss and J. R. Yates), 451
Dougherty, Dr. Ellsworth C, and Solberg, Bjørn: Monoxenic Cultivation of an Enchytraeid Annelid, 1067
Dougherty, Marshall, and others: Spontaneous Potentials from Explants of Brain Tissue in Culture, 477
Douglas, R. H, and Hitschfeld, Dr. W.: Awarded jointly the first prize (Canadian Awards) of the Darton Prizes of the Royal Meteorological Society, 440
Dove, J E: Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Downs, Dr. W. G.. Medical Research in the British Caribbean (Virological Investigation of Human Yellow Fever Cases in Trinidad), 863
Dowsing—Fact or Fiction?, *review* by Prof. H. J Eysenck, 346
Doy, Dr. C. H Alkaline Conversion of 4-Hydroxyphenylpyruvic Acid to 4-Hydroxybenzaldehyde, 529
Drabkin, Dr. I. E. (Cohen, Prof Morris R. and) · A Source Book in Greek Science, second printing, with corrections, *review*, 63
Drahoš, V, and Delong, A: A Simple Method for Obtaining Perforated Supporting Membranes for Electron Microscopy, 104
Drahota, Dr. Z, and Hudlická, O.: Effect of Denervation on Potassium-42 Uptake by the Rat Muscle *in vitro*, 396
Drahota, Dr Z. (Zák, Dr. R, and) · Release of Methionine labelled with Sulphur-35 from Muscle Tissue and Mitochondria, 973
Drazin, Dr. P G.: Appointed lecturer in mathematics at the University of Bristol, 937
Drever, Prof J. Motivation, *review*, 39
Dried Cultures · Recovery of Adult *Amoeba lescherae* from (Monica Taylor), 329
Drinking Water Fluoridation of (Gerald H Leatherman and J A Ellis), 438
Driver, Dr Peter M: A Possible Fundamental in the Behaviour of Young Nidifugous Birds, 416
Driver Characteristics Traffic Accidents and (Sauli Hakkinen), 273
Drivers: Proneness of, to Road Accidents (Dr. R. J Smeed), 273
Dronamraju, K. R.: Selective Visits of Butterflies to Flowers—a Possible Factor in Sympatric Speciation, 178
Drop (Spray-) Data Distribution-Free Interpretation of (John B Opfell), 822
Droplets (Tobacco Smoke) Size Distribution of, by a Replica Method (W. J. Harris), 537
Drosophila · Homeostasis of the Sex Ratio in (Dr P. A. Parsons), 411
  A Mosaic of, consisting of 1X, 2X and 3X Tissue and its Probable Origin by Mitotic Non-disjunction (Prof. Curt Stern), 179
Drosophila melanogaster: Apparent Double Crossing-Over in a Short Genetic Interval in (Prof. M. M Green), 990
  Genetic Basis of Two Melanin Inhibitors in (Dr R. A. Kroman and Dr. P. A. Parsons), 411
Drucker, Philip, and others: Excavations at La Venta, Tabasco, 1955, 134
Drugs · Tolerance to, especially to Morphine (Dr. Guy Nadeau and Georges Sobolewski), 169
  The Use of Laboratory Animals in the Standardization of (Research Defence Society Pamphlet No. 10), 438
Drugs affecting Lipid Metabolism (Institute of Pharmacology of the University of Milan Symposium on), 127
Drugs and other Means: Treatment of Depression by (Dr. Linford Rees), 114
Drugs (Addiction-producing) · Tenth Report of the Committee on (World Health Organization, Technical Report Series No. 188), 1018
Drugs (Narcotic): International Control of, 21
Dry Cleaning · Solvents and, 764
Dry Enzyme · A Connexion between S–S Bond Breakage and Inactivation by Radiation of a (Dilip K. Ray, Dr. Franklin Hutchinson and H. J. Morowitz), 312
Dryden, H. L. and others (edited by): Advances in Aeronautical Sciences—Proceedings of the First International Congress on the Aeronautical Sciences (Madrid 1958) *review* by Prof. A. R. Collar, 665
Dual Nature of the Third Component of Complement: Further Evidence for the (Dr J. D Hawkins), 483
Ducks (Migratory) · Food Habits of (Harry G. Anderson), 17
Duckworth, Dr John. *Obituary* by Dr. D. P. Cuthbertson, 678
Dudel, Dr Josef, and Orkand, Richard K.: Spontaneous Potential Changes at Crayfish Neuromuscular Junctions, 476
Duffus, H. J, and others: Influence of Geological Features on Very Low Frequency Geomagnetic Fluctuations, 141
Dugué, Prof Daniel, et Girault, Prof. Maurice: Analyse de Variance et Plans d'Expérience, *review* by Dr. D. J. Finney, 68
Duke-Elder, Sir Stewart: Elected a Fellow of the Royal Society, 11
  The Eye in Evolution, *review* by R. C. Davenport, 42
Dumont, P., and others Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in Rats receiving an Acute Whole-Body Dose of X-Rays, 487
Duncan, Prof. W J · Honorary Fellowship of the Royal Aeronautical Society conferred on, 685
Dunham, Prof K. C · Chemical Analyses of Rocks, *review*, 56
Dunjic, A, and others Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in Rats receiving an Acute Whole-Body Dose of X-Rays, 487
Dunning, J E P: Rocket Propulsion, *review*, 186
Dunsmore, J. D.: Retarded Development of *Ostertagia* Species in Sheep, 986
Dupree, Prof. A. Hunter: Asa Gray, 1810-1888, *review* by Sir Edward Salisbury, 44
Duration of Stimulation of Phagocytic Activity of the Reticulo-Endothelial System after Cessation of Treatment with Diethylstilboestrol (C. C. Ware and Prof. T. Nicol), 974
Durham Colleges: Appointment of Prof. D. G. Christopherson as Warden, 604
Durban Museum and Art Gallery · Annual Report for 1958-59, 203
Dwyer, Dr F. P., and others: Rate of Ligand Exchange with its Metal Complex by a Polarimetric Method, 966
Dyers and Colourists, Society of: Appointment of Dr. M. Tordoff as editor of the *Journal*, 440
Dyes (Fluorescent) · Depolarization of the Fluorescence of Proteins labelled with various (C. S. Chadwick, Dr. P Johnson and E. G. Richards), 239
Dyestuffs (British), and Wider Co-operation in Europe, 829
Dyke, C. V.: What is Agronomy?, *review*, 1000
Dynamics: Fluid (Dr. D. E Rutherford), *review* by Dr. G K. Batchelor, 1000
  Fluid—a Mixed Bag, *review* by Dr G K. Batchelor, 1000
  Planetary, *review* by Dr. R. H Garstang, 60

EARLY Ethology, *review* by Dr. R. A. Hinde, 43
Early Medicine and Science : Parasites and Parasitic Infections in (Prof. R. Hoeppli), *review* by Dr. Ben Dawes, 46
Early Science in China, *review* by Prof. W. M. Smart, 36
Earnshaw, A. W., and Sproson, J C. : Rheological Properties of Barytes Suspensions, 378
Earth . Mathematics and the Sciences of the Heavens and the (Dr. Joseph Needham, with the collaboration of Dr Wang Ling), (Science and Civilization in China, Vol 3), *review* by Prof W. M. Smart, 36
  Paths Across the (Lorus and Margery Milne), *review* by Sir Lansborough Thomson, 64
Earth and Space · Between (Dr. Clyde Orr, Jr.), *review* by B R Leaton, 68
Earth Satellite 1960*ε*, 598
Earth Satellite (Artificial) : Secular and Periodic Motions of the Node of an (Prof. Leon Blitzer), 874 ; (D. G King-Hele), 875
Earth's Field at the Equator : Regular Micropulsations of the (Rosemary Hutton), 955
Earthquake of February 29 : The Agadir (Ernest Tillotson), 199
Earthquakes : Rock Pressure and, 936
Earthquakes and Uranus—Misuse of a Statistical Test of Significance (E. J. Burr), 336 ; (Prof. R Tomaschek), 337
Earthworm Giant-Fibre Reflex of the (Dr M. B. V. Roberts), 167
  Neuro-Muscular Transmission in the (Dr. G. A. Horridge and Dr. M B. V Roberts), 650
  Occurrence of a Non-Fibrillar Elastin in the (Dr. P. Van Gansen-Semal), 654
East (Far) : The Dilemma of the, *review* by Prof W. D. Borrie, 664
  Population and Progress in the (Prof Warren S. Thompson), *review* by Prof W. D. Borrie, 664
East Africa : Agricultural Insects of (compiled by R. H. Le Pelley), *review* by Dr Kenneth Mellanby, 65
East Africa High Commission : East African Agriculture and Forestry Research Organization—Record of Research for 1958, 133
East African Agriculture and Forestry (Dr. E. C. Humphries), 133
East African Agriculture and Forestry Research Organization : Record of Research for 1958 (East Africa High Commission), 133
East Africans : Glucose-6-Phosphate Dehydrogenase Deficiency in Red Blood Cells of (Dr. A. C. Allison), 531
East Anglia : Investigating Glacial and Interglacial Geology in (Dr. R. G. West), 771
East Anglian Butterflies : Some (S. Beaufoy), 771
East Anglian Mammals (Lord Cranbrook), 770
Eastwood, E , and others · Radar 'Ring Angels' and the Roosting Movements of Starlings, 112
Ebert, Dr. M., and others · Mechanism of the Radiation Effect on the Synthesis of Deoxyribonucleic Acid, 563
Eclipse Phase of Vaccinia Virus (Dr. R. Postlethwait and Prof. H. B. Maitland), 335
École Nationale des Sciences Géographiques : Theoretical and Technical Course on Aerial Photogrammetry, 127
Economic Research Committee (Colonial) : Report for 1958-59, 501
Economic Science (Political and), British Library of : Annual Report for 1958-59, 520
Economic Studies concerning Africa South of the Sahara : Inventory of—an Annotated Reading List of Books, Articles and Official Publications (edited by Peter Ady), (Commission for Technical Co-operation in Africa South of the Sahara, CSA/CCTA Publication No. 30, Joint Project No. 4), 202
Economic and other Impacts of Scientific Research and Development : Projects in Colleges and Universities on the (United States National Science Foundation), 14
Economic and Social Implications of Scientific Research and Development : A Bibliography on the (United States National Science Foundation), 14
Economic and Social Research, National Institute of : Economic and Social Studies, Vol. 18, British Industrialists—Steel and Hosiery, 1850-1950 (Charlotte Erickson), *review* by R. Brightman, 347
Economics (Science and), in the United States, 14
Ectromelia Virus-infected Cells : Filamentous Structures in (Dr. Benjamin V. Siegel), 820
Eczema (Facial) Toxin, Sporidesmin : Detection and Estimation of a (G. R. Russell), 788
Eddy, Bernice E., and others : Development of Resistance in Mice to Tumour Induction by *S E* Polyoma Virus, 615
Edetate (Manganese) : Effect of, on Blood Formation in Rats (T. J. Sullivan), 87
Edmunds, F. H. : *Obituary* by S. C. A. Holmes, 597
Education at Sheffield, 121
Education : The Social Purposes of (K. G. Collier), *review* by Prof. H. L. Elvin, 420
Education in Sociology, *review* by Prof. H. L. Elvin, 420
Education and the Youth of Great Britain, 577
Education, Ministry of : The Supply and Training of Teachers for Technical Colleges, 185
  Pamphlet No. 38, Science in Secondary Schools, 663
  Circular 1/60, The Future Development of Management Education and of Business Studies—Revision of Joint Examination Schemes, 743 ; Appendix to Circular 1/60, Report of the Working Party appointed to examine the Scheme of Management Studies, 743
Education (Adult), National Institute of : Residential Short Courses, 685
Education (Further) : Northern Advisory Council on : Training of Technical Teachers, 281
  Report for 1958-59, 281
Education (Further), Southern Regional Council for : Twelfth Annual Report, 123
Education (Management), and of Business Studies · The Future Development of—Revision of Joint Examination Schemes (Ministry of Education, Circular 1/60), 743
Education (University), 1960-1970 ; Memorandum to the University Grants Committee on the Expansion of (National Union of Students), 687
l'Education Populaire, Bureau Européen de : Notes et Études, No. 15, European Calendar of Short Summer Courses, 685
Education and Business Studies : Management, 743
Education and Industry Mathematics,—a Record of a Conference of Teachers, Research Scientists and Industrialists, held at the University of Liverpool (1959), 1017
Education and Training in Chemical Engineering (Supplement to Chemical Engineering, a Career), (Institution of Chemical Engineers), 125
Edwards, A W. F. : The Meaning of Binomial Distribution, 1074
Edwards, Sir George : Honorary Fellowship of the Royal Aeronautical Society conferred on, 685
Edwards, Dr George A. : *Obituary*, 201
Edwards, R. W , and Heywood, J. Effect of a Sewage Effluent Discharge on the Deposition of Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith), 492
Edwin, E. E., and others · Ubiquinones and Ubichromenols in the Rat, 554
  Effect of Thyroxine and 2,4-Dinitrophenol on Levels of Ubiquinone and Ubichromenol in the Rat, 725
Eelworm (Stem) : A Spring Oat Variety resistant to the (T. Glyn Davies), 813
Effect of 3-Amino-1,2,4-triazole on the Experimental Production of Liver Cancer (Munemitsu Hoshino), 174
Effect of S-β-Aminoethyl*iso*thiouronium Bromide Hydrobromide on X-Ray Damage to Guinea Pig Skin (Dr. J B Walter and Prof D. Slome), 177
Effect of Antibody and Complement on Volume Control in an Ascites Tumour Cell (Dr. H. Green and Dr. F. Silverblatt), 646
Effect of Carrier Gas on the Sensitivity of Thermal Conductivity Detectors (C Bokhoven and A Dijkstra), 793
Effect of Cathode Surface Roughness and Oxidation on Arc Movement (Dr. T. J. Lewis and Dr P. E. Secker), 30
Effect of Centrifugation on the Macronucleus of *Spirostomum* and *Blepharisma* (Prof. B. R Seshachar), 333
Effect of Curare on Conduction in Myelinated, Isolated Nerve Fibres of the Frog (Dr. Wolf D Dettbarn), 891
Effect of 'Degranol' on it : Heterogeneity of Tumour Ribonucleic Acid and the (F. Antoni, E. J Hidvégi and K. Lapis), 81
Effect of Denervation on Potassium-42 Uptake by the Rat Muscle *in vitro* (Dr. Z. Drahota and O. Hudlická), 396
Effect of Diphenylamine on the Synthesis of Carotene (Gy. Schneider, Dr. B. Matkovics, J Zsolt and O. Kovács), 235
Effect of Electrical Stimulation on a Muscle Fibre Model in the Presence of Adenosine Triphosphate (Prof. Masahiro Fujino, Tatsuaki Matsushima, Tomizo Muroya, Hideyo Yabu, Saburo Yamaguchi and Masaki Takahashi), 318
Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat · Histophotometrical Study of the (S. L Liu), 475
Effect of Manganese Edetate on Blood Formation in Rats (T. J Sullivan), 87
Effect of Methylpentynol on Acetylcholine in the Rat's Brain (Giancarlo Pepeu and Prof. Nicholas J. Giarman), 638
Effect of Moisture on Carboxylic Acid Adsorption to Steel (M. E. Schrader and J. L. Kalinsky), 710
Effect of Molecular Structure upon Concentration of Hydrocarbons in 'Painted' Mouse Skin (Mary Burnham and Fred G. Bock), 323
Effect of Oxygen on the Inactivation of Trypsin by Ionizing Radiation (Prof. J. A. V Butler and Dr. A. B. Robins), 697
Effect of Oxygen on the Radiosensitivity of Bacteriophage in the Presence of Sulphydryl Compounds (Dr P. Howard-Flanders), 485
Effect of Oxygen and Nitric Oxide on the Radiosensitivity of Human Cells in Tissue Culture (Dr. D. L Dewey), 780
Effect of pH on Biological Activity of Pregnant Mare Serum Gonadotropin (Bengt H. Persson and Stig E. J. Melander), 163
Effect of Pituitary Growth Hormone *in vivo* on the Phosphorus/Oxygen Ratios of Isolated Rat Liver Mitochondria (C. N. Graymore, A. H. Melhuish and A. L. Greenbaum), 392
Effect of Relative Humidity on Hatching and on Toxicity of Ovicides to Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina : Tetranychidae), (R. A Harrison and A. G. Smith), 409
Effect of a Second Crystalline Modification in Polyethylene on X-Ray Crystallinity Measurements (Dr C G. Vonk), 962
Effect of Severing the Olfactory Bulbs on the Intake and Excretion of Water in the Rat (V. Nováková and H Dlouhá), 638
Effect of a Sewage Effluent Discharge on the Deposition of Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith), (R. W. Edwards and J. Heywood), 492
Effect of Solvent Polarizability on the Ultra-violet Spectral Shifts of Aromatic Compounds (Dr. F. A. Bovey and S. S. Yanari), 1042
Effect of Sub-Zero Temperatures on Diapause Eggs of *Acheta commodus* (Walk.), (T. W. Hogan), 98
Effect of Supernatant Potassium-Level on Cardiac Activity in Quantitative Tissue Culture (Prof. A W. B. Cunningham, K. Kleutch and W. Herbst), 241
Effect of Temperature on Growth in Weight and Tail-length of Inbred and Hybrid Mice (Prof S. C. Harland), 446
Effect of Temperature on the Hibernation of the European Corn Borer (Stanley D. Beck), 774
Effect of Thyroxine and 2,4-Dinitrophenol on Levels of Ubiquinone and Ubichromenol in the Rat (E. E. Edwin, J. Green, A. T. Diplock and J. Bunyan), 725
Effect of Vitamin A on the Cystine Content in Skin of Rats (Prof. Tatsuo Koyanagi and Satoru Odagiri), 809
Effect of X-Rays on the Development of the Infective Larvae of *Oesophagostomum radiatum* (Rud. 1803) (Strongylidae : Nematoda), (R. F. Riek and R. K. Keith), 981
Effect (Antioxidative), of Amino-Acids (Dr. Reinhard Marcuse), 886
Effect (Blocking), of Tetrahydroaminacrin on a New Psychotomimetic Agent (Dr. Samuel Gershon), 1072
Effect (Faraday), in the Transmissions from Fast Spinning Satellites (R. S. Roger and J. H. Thomson), 622
Effect (Kirkendall) : Analogy to the, in the Gas Phase (L. Miller and P. C. Carman), 549
Effect (Long-Chain) ? : Proton Magnetic Resonance in a Series of Dimethyl Siloxane Polymers—a Specific (Dr. J. G. Powles and A. Hartland), 26
Effect (Radiation) : Mechanism of the, on the Synthesis of Deoxyribonucleic Acid (Dr. R. J. Berry, E. Hell, Dr. L. G. Lajtha and Dr. M. Ebert), 563
Effect (A Trace Element), in Alloys based on the Aluminium–Zinc–Magnesium System (I. J. Polmear), 303

Effects of Chloramphenicol on the Recovery of Ultra-violet-irradiated *Escherichia coli B* (H. Okagaki and Prof. A. Sibatani), 818
Effects of 1,4-Dihydrazinophthalazine on the Catechol Amines (M. Bygdeman and L. Stjarne), 82
Effects of Fatty Acids on the ^{32}P-Adenosine Triphosphate Exchange Reaction in Rat Liver Mitochondria (K. Ahmed and Dr. P G. Scholefield), 1046
Effects of *Gibberella fujikuroi* on Fungal Root-Infections of *Pinus* (Dr. Ida Levisohn), 987
Effects of Injection of Bovine Pineal Extract on the Nuclei of Rat Pineal Parenchymal Cells (Dr Uno Holmgren, Dr. Mark D. Altschule and Dr Richard J. Wurtman), 393
Effects of Non-Ionic Surfactants upon Animal Tissues (Helen Goldhammer and W R. McManus), 317
Effects of Radiation of Human Heredity, 125
Effects (Abrupt and Delayed), of Insulin on the Distribution Space of Glucose in the Dog (Dr G Hetenyi, jun., and Prof G. A. Wrenshall), 808
Effects (Cardiovascular), of Nicotine and of Smoking (New York Academy of Sciences Symposium on), 525
Effects (Catalytic), in the Alkaline Oxidation of Cellulose (Dr. W. A. Bell), 963
Effects (Chemical), of Ionizing Radiation on Deoxyribonucleic Acid in Dilute Aqueous Solution (G. Hems), 710
Effects (Ionospheric), associated with the Solar Flare of July 10, 1959 (V. A. H. Harrison), 228
Effects (Quantum), on a Macroscopic Scale, *review* by Dr. J G. Valatin, 345
Effects (Some), of Different Tensions of Oxygen on the Respiration and Growth of *L*-Strain Fibroblasts (A R. Fisher), 315
Effects (Stimulating), of Nuclear Radiations on Development and Productivity of Rice Plants (Dr. Maung Mya Thaung), 982
Efficiency (Anthelmintic), of Tetrachlorodifluoroethane against *Fasciola hepatica* in Sheep (J. C. Boray and I. G Pearson), 252
Effluent Discharge (Sewage): Effect of a, on the Deposition of Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith), (R. W. Edwards and J. Heywood), 492
Effluents (Trade): Water Pollution by, 210
Efford, I E.: Appointed by the Royal Society to a John Murray Travelling Studentship in Oceanography and Limnology, 127
Egelstaff, Dr. P. A.: Neutron Physics, *review*, 187
Egg-White Administration (Lysozyme and): Increase in 'Alkaline' Ribonuclease of Rat Kidney Cortex after (Dr. T. Maack, Dr. R. Brentani and Dr. M Rabinovitch), 158
Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina: Tetranychidae): Effect of Relative Humidity on Hatching and on Toxicity of Ovicides to (R. A. Harrison and A. G. Smith), 409
Eggs (Diapause), of *Acheta commodus* (Walk): Effect of Sub-Zero Temperatures on (T W Hogan), 98
Eggs (Hen's): Vitamin A_1 Aldehyde in (Dr. P. A. Plack), 234
Egyed, Prof. L.: Dirac's Cosmology and the Origin of the Solar System, 621
  Orogens, 690
Ehrlich Ascites Tumour Cells: Calcium Binding in Homogenates of (R. Schofield and D. Thomason), 656
Eibl, Dr. Karl: Lehrbuch der Rinderbesamung, *review* by Sir John Hammond, 667
'Eidophor' Television Technique (Dr C. A. Taylor), 773
Einstein, J. Ralph (Low, Prof. Barbara W., and): Symmetry of Insulin Dimers and Hexamers, 470
Ejecting (Milk-) Action of Ergot (Prof. Ranjit Roy Chaudhury and Mandakini B. Dikshit), 722
El Mofty, Dr. M, and Smyth, Prof. J D: Endocrine Control of Sexual Reproduction in *Opalina ranarum* Parasitic in *Rana temporaria*, 559
Elastin (Non-Fibrillar), in the Earthworm: Occurrence of a (Dr. P. Van Gansen-Semal), 654
Electric Charges (Net), on Stars: Existence of (Prof V. A Bailey), 508
Electrical Breakdown (Intrinsic), of Glass: Time-lags in the (M. N. Azam and H. Dickinson), 146
Electrical Energy: Fuel Cells—Will they soon Become a Major Source of? (F. T. Bacon), 589
Electrical Engineering at Cambridge, 680
Electrical Engineers, Institution of (Electronics and Communications Section), and the International Federation for Medical Electronics: International Conference on Medical Electronics, and associated Exhibition, 523
Electrical Stimulation: Effect of, on a Muscle Fibre Model in the Presence of Adenosine Triphosphate (Prof. Masahiro Fujino, Tatsuaki Matsushima, Tomizo Muroya, Hideyo Yabu, Saburo Yamaguchi and Masaki Takahashi), 318
Electrical and Magnetic Properties of β-Carotene Triiodide (Dr. Charles M. Huggins and Dr. Oliver H. LeBlanc, jun.), 552
Electroanalytical Chemistry, Journal of, 124
Electrode: A Reversible Nitrate (P. H T. Beckett), 879
Electrodes ('Weightless' Micro-), for Recording Extracellular Unit Action Potentials from the Central Nervous System (Prof. B. Delisle Burns and Dr. J. G. Robson), 246
Electrodialysis: Desalting of Urine by (Dr. T Wood), 634
Electrodynamics (Quantum): Principles of (Walter E. Thirring), translated from the German by J Bernstein, *review* by Prof. N. Kemmer, 999
Electrolysis (The Fusion), of Titanium (Dr. W J. Kroll), 685
Electromagnetic Phenomena in Cosmical Physics (edited by B. Lehnert), (International Astronomical Union Symposium No. 6, Stockholm 1956), *review* by Dr. R. H. Garstang, 67
Electromagnetic Radiation: Coherence Properties of (United States Air Force, the Optical Society of America and the University of Rochester Conference on), 127
Electromagnetic Radiation from Cylindrical Structures (James R. Wait), *review* by W. Brown, 583
Electron, Proton and Neutron: Comparison of the Charges of the (A. M. Hillas and T. E. Cranshaw), 459
Electron Density Measurements in the Upper Ionosphere using the Faraday Rotation of Radio Signals from Artificial Satellites (Dr. D. McL. A. Wilson), 623
Electron Microscope: Techniques and Applications of the (Cornell University Summer Laboratory Course in), 127
  Yolk Formation in Oocytes of *Patella coerulea* L. and *Aplysia depilans* L. as observed in the (A. Bolognani), 490
Electron Microscopy: Co-ordination of Light and (Royal Microscopical Society and the Electron Microscopy Group of the Institute of Physics Symposium on), 672
  A Method of Staining Sectioned Tissues with Lead for (Dr. J. D. Lever), 810
  A Simple Method for Obtaining Perforated Supporting Membranes for (V Drahoš and A Delong), 104
Electron Microscopy and the Crystal Structure of Indanthrene (Lewis T. Chadderton), 541
Electron Spin Resonance: Study of the Oxidation of Hindered Phenols by (Dr. J E Bennett), 385
Electron Spin Resonance in Hydrogen Peroxide–Water Solutions at 90° K. Irradiated with Ultra-Violet Light (Robert C. Smith and S. J. Wyard), 226
Electron Transfer Reactions involving *s*-Trinitrobenzene (Dr. R. E Miller and Prof W. F. K. Wynne-Jones), 149
Electronic Computers in Population Genetics (W F. Bodmer), 851; (J. L. Crosby), 851
Electronic Engineers: New Instruments for, 852
Electronic Structure of Molecules, *review* by Prof C. A. Coulson, 54
Electronics: Medical (Electronics and Communications Section of the Institution of Electrical Engineers and the International Federation for Medical Electronics International Conference on, and associated Exhibition), 523
  Nuclear—Proceedings of the International Symposium on Nuclear Electronics organized by the French Society of Radioelectricians, (Sessions 1-5), *review* by W Abson, 583
Electronics, Institute of: Annual Electronics and Instruments Exhibition and Convention, 685
Electronics (Medical), International Federation for (Electronics and Communications Section of the Institution of Electrical Engineers and the): International Conference on Medical Electronics, and associated Exhibition, 523
Electronics (Solid State), No 1, 850
Electronics and Control, Journal of, Vol. 4, 685
Electronics and Instruments Exhibition and Convention: Annual (Institution of Electronics), 685
Electrons (Self-trapped) ('Polarons'): Primary Processes in the Action of Ionizing Radiations on Water—Formation and Reactivity of (Prof. Joseph Weiss), 751
Electrophoresis (Agar-gel): Variations in Electrophoretic Position of Haptoglobin Mixtures in (Dr. Jan Hirschfeld), 894
Electrophoresis (Micro-) of Human White Cells and Platelets (Dr. William P. Creger and Phyllis Menna Thomas), 171
Electrophoresis (Starch-gel): Separation of the α- and β-Chains of Globins by means of (C. J. Muller), 643
Electrophoresis (Starch–Agar-Gel), of Tuberculoproteins from Heated Culture Filtrates (T. P. Dekker), 392
Electrophoretic Components of the Proteins in Honeybee Larval Food (N. G. Patel, M H. Haydak and T. A Gochnauer), 633
Electrophoretic Demonstration (Agar-gel), of Individual Variations in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_2-Globulin Region of Normal Human Sera (Dr. Jan Hirschfeld), 321
Electrophoretic Medium (A New), and its Application to the Resolution of Human Haemoglobin Variants (Dr. E. R. Huehns and Dr. A. O. Jakubovic), 729
Electrophoretic Position of Haptoglobin Mixtures: Variations in, in Agar-gel Electrophoresis (Dr. Jan Hirschfeld), 894
Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_2-Globulin Region of Normal Human Sera: Agar-gel Electrophoretic Demonstration of Individual Variations in (Dr. Jan Hirschfeld), 321
Electroreduction of the Complexes of the Type $[M(NH_3)_5X]^{n+}$: Mechanism of the (Prof George W. Watt and Joe W. Vaughn), 309
Element (The Human), in Research Management (Dr. B. E Noltingk), *review* by E. S. Hiscocks, 579
Element (Trace) Effect in Alloys based on the Aluminium–Zinc–Magnesium System (I. J. Polmear), 303
Elementary Particles: Mass of (Dr S. E. Hornig), 708
Elementary Statistics with Applications in Medicine and the Biological Sciences (Prof Frederick E. Croxton), *review* by R. M. Cormack, 746
Elements: Periodic Classification of (W. P. Thistlethwaite), 153; (L. M. Simmons), 154, (A. A. Clifford), 154
  Radiochemistry of the, 602
Elements (Genetic): Structure and Function of—Report of Symposium held June 1959 (Brookhaven Symposia in Biology, No. 12), *review* by Prof. S. C Harland, 63
Elements (Minor), in Nutrition (Nutrition Society Symposium on), 939
Elements (Rare-Earth), Lanthanum to Lutetium, in Chondritic Meteorites: Abundances of the (Dr. R. A. Schmitt, A. W. Mosen, C. S. Suffredini, J E. Lasch, Dr. R. A. Sharp and D. A. Olehy), 863
Elevated Temperature: Sex Difference in Accidental Mortality of Guppies exposed to (Prof. John A. Freeman), 491
Elevation of Serum Haptoglobin in Rabbits in Response to Experimental Inflammation (R. K. Murray and G. E. Connell), 86
Elimination (Selective), of Single Sense Cells with Methylene Blue (Dr. Ulrich Clever), 812
Elizabeth the Queen Mother, H.M. Queen: To open the Brunswick Square building of the School of Pharmacy, University of London, 284
Elkind, Dr. M. M, and others: The Sigmoid Survival Curve in Radiobiology, 1062
Elliot, Dr. H.: Cosmic Ray Intensity in Interplanetary Space, 299
Elliott, Daphne C, and others (edited by): Data for Biochemical Research, *review* by Dr. K. S. Dodgson, 50
Elliott, W. H., and others (edited by): Data for Biochemical Research, *review* by Dr. K S Dodgson, 50
Ellis, G. R. A.: Observations of Atmospheric Radio Noise, 229
Ellis, J. A. (Leatherman, Gerald H., and): Fluoridation of Drinking Water, 438
Ellis, J. R.: Appointed professor of automobile engineering and first director of the Advanced School of Automobile Engineering at Cranfield, 762; work of, 762
Ellison, Prof. M. A.: The Sun and its Influence, second edition, *review* by Prof. C. W. Allen, 69

Elminius modestus Darwin in South-West Scotland (H Barnes and Margaret Barnes), 989
Elmore, Dr. D T. : Sterols and Terpenes, *review*, 745
Elton, Dr. L. R B. : Introductory Nuclear Theory, *review* by Dr. T. E. Allibone, 917
Elvin, Prof H. L. . Education in Sociology, *review*, 420
Embedding Media for Preparation of Ultra-Thin Sections Water-Soluble Methacrylates as (Dr O Wichterle, Dr P. Bartl and Dr. M. Rosenberg), 494
Embryo (Chick) Loss of Specificity on Passage of Immunologically Competent Cells in the (Sir Macfarlane Burnet and Georgiana Boyer), 175
Embryo (X-Irradiated) Synthesis of Contractile Proteins in the (Dr. Yoshito Ogawa), 77
Embryos of the Australian Cattle Tick Sulphydryl Content of the (W. J. Roulston and C. A. Schuntner), 1069
Embryos (Triploid Rat), and other Chromosomal Deviants after Colchicine Treatment and Polyspermy (L. Piko and O. Bomsel-Helmreich), 737
Emerson, W. W : Complexes of Calcium–Montmorillonite with Polymers, 573
Emin, I. (edited by) Russian–English Glossary of Solid State Physics, *review* by Prof S I Tomkeieff, 347
Emission (Photo-stimulated), of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide (J Wawrzyniak and Dr B. Sujak), 467
Emission (Solar Radio), and Polar Cap Absorption of Cosmic Noise · A Relation between (Dr. M. R Kundu and Prof F T Haddock), 610
Emission (X-Ray) Solar Limb Surges accompanied by (Dr. J Kleczek and Dr L Křivsky), 1035
Emmelot, Dr P , and others · Swelling of Fresh and Aged Liver Mitochondria as affected by Succinate, Adenine Nucleotides and Thyroxine, 556
Empire · The End of (John Strachey), 501
Emplacement of Granites · Age of (Dr. W Compston, Dr. P. M. Jeffery and G H Riley), 702
Employment of Women in Britain, 365
Emulsion Mosaics (Photographic) : Spectroscopic Applications of (Prof R. W Nicholls), 715
Encapsulated *Staphylococcus aureus* . Isolation of a Phagocytosis-inhibiting Substance from Culture Filtrates of an (Dr. Stephen I Morse), 102
Encephalomyocarditis Virus Particles Crystallization of Purified Mouse (P. Faulkner, E M. Martin, S. Sved and Dr T Work), 908
Enchytraeid Annelid : Monoxenic Cultivation of an (Dr. Ellsworth C. Dougherty and Bjørn Solberg), 1067
End of Empire (John Strachey), 501
Endocrine Control of Sexual Reproduction in *Opalina ranarum* Parasitic in *Rana temporaria* (Dr. M El Mofty and Prof. J D Smyth), 559
Endocrinology : International Congress of, 523
Energy Band Interpolation Scheme, with Application to Body-centred Cubic Lithium (J F. Cornwell and Dr. E. P. Wohlfarth), 379
Energy Transfer Processes · Radiative Life-time of the Pyrene Dimer and the Possible Role of Excited Dimers in (Dr B. Stevens and E. Hutton), 1045
Energy (Low-) Nuclear Physics, *review* by Dr. E. Bretscher, 58
Engineering Textile, *review* by Prof C. S Whewell, 189
Engineering in American Industry Science and—Report of a 1956 Survey (United States National Science Foundation), 763
Engineering (Automobile), Advanced School of (Cranfield) : Appointment of J. R. Ellis as professor of automobile engineering and first director, 762
Engineering (Biological) Society : Inauguration of the, 1019
  Election of Officers, 1019
Engineering (Chemical), at Birmingham, 849
Engineering (Chemical), at Nottingham, 933
Engineering (Chemical) : Education and Training in (Supplement to Chemical Engineering, a Career), (Institution of Chemical Engineers), 125
  Scholarships in (John Brown, Ltd , and the Institution of Chemical Engineers), 522
Engineering (Electrical), at Cambridge, 680
Engineering (Illuminating) Society : Summer Meeting, 206
Engineering (Mechanical), at Manchester, 1015
Engineering (Textile) Processes (edited by Prof. A H. Nissan), *review* by Prof. C. S Whewell, 189
Engineers (Agricultural), Institution of : Bursaries and a Scholarship, 284
Engineers (Chemical), Institution of : Education and Training in Chemical Engineering (Supplement to Chemical Engineering, a Career), 125
Engineers (Chemical), Institution of (John Brown, Ltd , and the) · Scholarships in Chemical Engineering, 522
Engineers (Electrical), Institution of (Electronics and Communications Section), and the International Federation for Medical Electronics : International Conference on Medical Electronics, and associated Exhibition, 523
Engineers (Electronic) : New Instruments for, 852
Engineers (Mining), Institute of : Summer Meeting, 127
English Language : Letter Structure of the (A. D. Baddeley, R. Conrad and W. E Thomson), 414
Enhanced Resistance of Mice to Infection with *Pasteurella pestis* following Vaccination with Fractions of Phenol-killed Tubercle Bacilli (Prof. David W Weiss), 1060
Enhancement of Peroxidase Action by Polysaccharides (Dr. B. Z. Siegel and Dr. S. M Siegel), 391
Enhancement of Staphylococcal Virulence for Mice by Intraperitoneal Cortisone Acetate, Cholesterol and Lecithin (Dr. Daniel Amsterdam and Dr. S. Stanley Schneierson), 101
Enstatite Chondrites : Silicon in the Metal Phase of (A E. Ringwood), 465
Entomological Conference : Seventh Commonwealth (Commonwealth Institute of Entomology), 603
Entomology : International Congress of, 938
Entomology, Commonwealth Institute of : Seventh Commonwealth Entomological Conference, 603
Entropies (Heats and), of Reaction of Transition Metal Ions with Ethylenediamine (M. Ciampolini, P. Paoletti and Prof L Sacconi), 880
Environment : Influence of, on the Distribution and Form of Sponges (Prof M A. Ali), 177
Environmental Demands · Sensory Specialization in Response to (Zoological Society Symposium on), 688
Environmental Determination of Sex in a Parthenogenetic Parasite (F. Wilson and L. T. Woolcock), 99
Environmental Temperature Oxygen Consumption in Cattle in relation to Rate of Increase in (Prof. H. H. Kibler), 972
Enzymatic Deamination of 5-Deoxycytidylic Acid and of 5-Methyl-5'-deoxycytidylic Acid in Growing and in Non-growing Tissues (Dr. Eduardo Scarano, Massimo Talarico, Luisa Bonaduce and Benita De Petrocellis), 237
Enzyme (Dry) A Connexion between S–S Bond Breakage and Inactivation by Radiation of a (Dilip K Ray, Dr Franklin Hutchinson and H J. Morowitz), 312
Enzyme Status in Intact Cells : Glutathione Stability and Pyrophosphatase Activity in Reticulocytes—Direct Evidence for the Importance of Glutathione for the (Prof S Rapoport and D. Scheuch), 967
Enzymes—Lectures held at the Conference on Enzymes and their Action, Wageningen, 1959, *review* by Prof J Brachet, 267
Enzymic Basis for Pathogenic Specificity (Elizabeth M C Turner), 325
Enzymic Oxidation of Stilboestrol labelled with Carbon-14 (P H Jellinck), 157
Enzymic (Non-) Reactions of Indoles with Coenzyme I (Prof S G. A. Alivisatos, G A. Mourkides and A. Jibril), 718
Enzymology Modern Trends in, *review* by Prof. J Brachet, 267
Epi-Smilagenin from *Dioscorea* Saponin : Smilagenone and (D Chakravarti, Prof. R N Chakravarti and M N Mitra), 236
Epps, F. J : South-Eastern Union of Scientific Societies, 770
Equation of State (A Monte Carlo), for Mixtures of Hard-Sphere Molecules (E. B. Smith and K R. Lea), 714
Equator Regular Micropulsations of the Earth's Field at the (Rosemary Hutton), 955
Equatorial Pacific (Central) . X-Ray Determination of Phillipsite in a Sediment Core from the (F Lippman), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 10, Special Investigations, No. 3), 609
Equilibria (Biological), in Human Cancer (Dr. Kenneth W Starr), 1006
Equilibrium of Celestial Bodies Figures of, with Emphasis on Problems of Motion of Artificial Satellites (Prof. Zdenek Kopal), *review* by D G. King-Hele, 747
Equilibrium (Non-) Theory of Gas–Liquid Chromatography (Dr. M. A. Khan), 800
Equilibrium (Oxygen), of Haemoglobin from *Thunnus thynnus* (Prof A. Rossi-Fanelli and E Antonini), 895
Equilibrium (Oxygen), of Myoglobin from *Thunnus thynnus* (Prof A. Rossi-Fanelli, E. Antonini and R Giuffrè), 896
Equivalence of Light and Adenosine Triphosphate in Bacterial Photosynthesis (Dr. M. Losada, Dr. A. V. Trebst, S Ogata and Prof. Daniel I. Arnon), 753
'Equivalent Redox Potential' · Significance of the, in Aqueous Solutions under Ionizing Radiation (Dr G. H. Cartledge), 370
Era · The Pleistocene, *review* by D F. W. Baden-Powell, 833
Erdman, Dr Howard E. Divergence between Lethal Doses and Sterilizing Doses of X-Rays with Progressive Development in *Habrobracon* Females, 254
Ergot : Milk-ejecting Action of (Prof Ranjit Roy Chaudhury and Mandakini B. Dikshit), 722
Erickson, Charlotte · British Industrialists—Steel and Hosiery, 1850-1950, *review* by R. Brightman, 347
Eriksen, N , and others . Vanadium Catalysis of the Oxidation of Catechol Amines, Dihydroxyphenylalanine and 5-Hydroxyindoles, 884
Erikson, Dr. Lloyd B Diurnal Temperature Variation in the Rhesus Monkey under Normal and Experimental Conditions, 83
Error-correcting Group Codes A Systematic Method for the Construction of (Prof. R B. Banerji), 627
Erwinia amylovora . An Association between Capsulation and Phage Sensitivity in (Eve Billing), 819
Erythrocyte Contents of Chick Blood · Influence of Dietary Intake of certain Insecticides on the Haemoglobin and (Prof B K. Srivastava, H. C. Saxena and J C Sharma), 172
Erythrocytes : Differences in Numbers of, between Inbred Lines of Chickens (Dr. P. Jaffe), 978
Erythrocytes (Human) · Age Difference in Nicotinamide Mononucleotide Synthesis by (Dr. Vlastimil Habermann and Sona Habermannová), 389
Erythropoietine Production in the Dog (Dr. F. W. Kinard, F. F. Griffin, jun , and F. W Kinard, jun), 561
Esashi, —., and Nagao, —. : Factors affecting Tubers in *Begonia evansiana* Andr., 766
Escherichia coli T_1 and λ Phage Adsorption on Protoplast-like Bodies of (Dr P. H. Hofschneider), 568
Escherichia coli B · Effects of Chloramphenicol on the Recovery of Ultra-violet-irradiated (H Okagaki and Prof A. Sibatani), 818
Eskola, Dr P. : Orogens (Juvenile Granites produced by Intrusive Magmas), 690
Essay on Die Ruckkoppelung als Urprinzip der Lebensvorgange : Prize of 8,000 D. marks for an (Bayerische Akademie der Wissenschaften), 938
Essay Competition : Waverley Gold Medal (*Research*), 937
Essen, Dr. L. · Elected a Fellow of the Royal Society, 11
Essential Fatty Acids of Normal and Atherosclerotic Aortas from Chickens receiving Differently Saturated Fats for Three Years (Prof. H. Fisher and A. S. Feigenbaum), 85
Essigsaure : Die Aktivierte (Dr Karl Decker), *review* by Prof. D. C. Harrison, 66
Estimate of the Peak Sunspot Number in 1968 (C. M. Minnis), 462
Estimated United Kingdom Power Output 1960-65, 122
Estimates, Select Committee on : Fifth Report from the, Session 1958-59, United Kingdom Atomic Energy Authority (Production Group and Development and Engineering Group), 1
Estimation of 3-Deoxy Sugars by means of the Malonaldehyde–Thiobarbituric Acid Reaction (Dr. Morris A. Cynkin and Dr. Gilbert Ashwell), 155
Estimation of a Facial Eczema Toxin, Sporidesmin Detection and (G R. Russell), 788
Estimation of Mouse Tumour Blood Volumes employing a Radioactive Isotope Technique (F. S. Stewart and Dr. A. E. G. Pearson), 250
Estimation (Histochemical) . Localization of Amino-acids for (Helen M. Notovny and Robert G Owens), 1057

Estuary (Stour) : Mud Fauna of the (Frances Bull, Helen Honeyman and Susan Knott), 1018
Ethology : Early, *review* by Dr R A Hinde, 43
Ethyl Iodide : Use of Solvents containing, in the Investigation of Phosphorescence Spectra of Organic Compounds (Dr. I J. Graham-Bryce and J M. Corkill), 965
Ethylene Production by Tomato and Apple Fruits (D. F. Meigh, K. H. Norris, C. C. Craft and M. Lieberman), 902
Ethylenediamine : Heats and Entropies of Reaction of Transition Metal Ions with (M. Ciampolini, P. Paoletti and Prof L. Sacconi), 880
Ethylenediamine with Noradrenaline or 3,4-Dihydroxymandelic Acid : Condensation Product of (Kunio Yagi, Toshiharu Nagatsu and Ikuko Nagatsu), 310
Eton College Natural History Society : Report, 282
Ettlinger, Dr. G. (Burton, D., and) : Cross-Modal Transfer of Training in Monkeys, 1071
l'Étude Agronomique du Congo Belge, Institut National pour . Flore du Congo Belge et du Ruanda-Urundi, Vol 9, 764
Europe : British Dyestuffs and Wider Co-operation in, 829
  Co-operative Research in, 520
European Barley Convention Ninth Annual Report of the Barley Committee, 16
European Calendar of Short Summer Courses (Bureau Européen de l'Education Populaire), 685
European Co-operation for Science, 600
European Corn Borer : Effect of Temperature on the Hibernation of the (Stanley D Beck), 774
European Economic Co-operation, Organization for : Seminar on the Status and Development of the Teaching of Chemistry, 208
  Seminar on Policy for School Science, 850
  Co-operation in the Field of Scientific and Technical Research, 998
European Economic Co-operation, Organization for, and the Scientific Future, 520
European Economic Co-operation, Organization for, and the United States National Science Foundation Award of Senior Visiting Fellowships in Science, 1019
European Organization for Nuclear Research (CERN) : Appointment of J B Adams as interim director-general, 523
  Personal library of the late Prof. Wolfgang Pauli transferred to the, 1017
European Organizations (Political and Economic Planning), 830
Evaluation of the Antibacterial Activity of Surface-Active Compounds : Methods for the (Society for Applied Bacteriology and the Microbiology Group of the Society of Chemical Industry Symposium on), 131, *erratum*, 206
Evans, Dr. D. G. : Elected a Fellow of the Royal Society, 11
Evans, J F. Transistor Modulators for Low-level Direct Current Signals, 626
Evans, Dr. P. R. V. Awarded the Andrew Carnegie Silver Medal for 1959 of the Iron and Steel Institute, 13
Evans, Robert L Pulsatile Flow through Tapered Distensible Vessels, Reflexions, and the Hosie Phenomenon, 290
Evans, Dr S, and Thomas, Dr. G M. : Results of the Royal Society's International Geophysical Year Expedition (Visual Work on Aurora), 192
Event of Aerial Contamination of Agricultural Land : An Assessment of the Quantities of Fission Products likely to be found in Milk in the (Dr R J. Garner), 1063
Everett, Prof D. H An Introduction to the Study of Chemical Thermodynamics, *review* by Prof A. R Ubbelohde, 55
Evidence of Concurrent Translocation (C. D. Nelson, H. J Perkins and P R. Gorham), 205
Evidence for the Existence of an Inner Zone : Geometry of the Southern Auroral Zone and the (Dr T Hatherton), 288
Evidence for a New Allele in the Kidd Blood Group System in Indians of Northern Mato Grosso, Brazil (Dr. Richard T. Silver, Jane M. Haber and Dr Aaron Kellner), 481
Evidence (Direct), for the Importance of Glutathione for the Enzyme Status in Intact Cells : Glutathione Stability and Pyrophosphatase Activity in Reticulocytes— (Prof S Rapoport and D. Scheuch), 967
Evidence (Further), for the Dual Nature of the Third Component of Complement (Dr. J. D. Hawkins), 483
Evolution : The Eye in (Sir Stewart Duke-Elder), *review* by R C Davenport, 42
Evolution (Invertebrate) Exhibit of (Australian Museum), 438
Evolutionary Origin of Sexual Differentiation and the Sex-Ratio (Dr. H. Kalmus and Dr. C. A. B Smith), 1004
Ewe (Merino) Seasonal Differences in Ovulating Hormone in the (Dr. D. R Lamond), 971
Ewers, Wm H. Multiple Infections of Trematodes in a Snail, 990
Ewles, J, and Dawson, J B. Micromosaic Patterns in Single Crystals of Potassium Chloride containing Barium Chloride, 381
Examinations : The Lack of Thinking in (Dr. Margaret Sutherland), 607
Examinations of Core 72 and 723 (W. Dekeyser), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 10, Special Investigations, No. 2), 609
Excavations at La Venta, Tabasco, 1955 (Philip Drucker, Robert F. Heizer and Robert J Squier), 134
Exchange of Genetic Material—Mechanisms and Consequences (Cold Spring Harbor Symposia on Quantitative Biology, Vol. 23), *review* by Prof. Kenneth Mather, 832
Exchange (Ligand), with its Metal Complex : Rate of, by a Polarimetric Method (B Bosnich, Dr. F. P. Dwyer and Dr. A M Sargeson), 966
Exchange Reaction (^{32}P-Adenosine Triphosphate), in Rat Liver Mitochondria . Effects of Fatty Acids on the (K Ahmed and Dr. P. G. Scholefield), 1046
Exchanger (Anion) : Fractionation of Heparin on an (Dr. J. P. Green), 472
Excited Dimers in Energy Transfer Processes : Radiative Life-time of the Pyrene Dimer and the Possible Role of (Dr. B. Stevens and E. Hutton), 1045
Excretion of Nicotinic Acid and Nicotinic Acid Adenine Dinucleotide by Biotin-deficient Yeast (Dr. Anthony H. Rose), 139
Excretion (Intake and), of Water in the Rat : Effect of Severing the Olfactory Bulbs on the (V. Nováková and H. Dlouhá), 638
Excretion (Urinary), of a Ninhydrin-positive Compound, probably a Peptide, after Administration of β-Aminoisobutyric Acid to the Mouse (Dr. James B Gilbert and Dr. Yuoh Ku), 160
Executive Health of the (Diagnostic Clinic of the Graduate School of Medicine, University of Pennsylvania, Medical Affairs, Vol. 1, No. 3), 765
Exhalation (Methane), in Sheep (E. Cresswell), 560
Exhibit of Invertebrate Evolution (Australian Museum), 438
Exhibition : Annual Electronics and Instruments, and Convention (Institution of Electronics), 685
  Tercentenary (Royal Society), 1016
Existence of an Inner Zone : Geometry of the Southern Auroral Zone and the Evidence for the (Dr. T. Hatherton), 288
Existence of Net Electric Charges on Stars (Prof V A Bailey), 508
Exo-electrons : Photo-stimulated Emission of, from the Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide (J Wawrzyniak and Dr. B. Sujak), 467
Expansion of University Education, 1960-1970 Memorandum to the University Grants Committee on the (National Union of Students), 687
Expedition . The New Zealand Antarctic (Sir Edmund Hillary), 526
Expedition (International Geophysical Year) : Results of the Royal Society's (Royal Society Discussion on), 191
Expenditure Industrial Research and Development, 1958 (Department of Scientific and Industrial Research), 997
Expenditure (United States), on Academic Research and Development, 1016
d'Expérience (Plans) : Analyse de Variance et (Prof Daniel Dugué et Prof Maurice Girault), *review* by Dr. D J Finney, 68
Experimental Biology at Rehovoth, 681
Experimental Cirrhosis : Histochemical and Biochemical Studies of Rat Liver in after Partial Hepatectomy (I. Bartók, Gy Domján, E. Horváth and Prof. B. Korpássy), 397
Experimental Conditions (Normal and) . Diurnal Temperature Variation in the Rhesus Monkey under (Dr Lloyd B Erikson), 83
Experimental Inflammation : Elevation of Serum Haptoglobin in Rabbits in Response to (R. K Murray and G. E. Connell), 86
Experimental Physics at Cambridge, 762
Experimental Production of Liver Cancer : Effect of 3-Amino-1,2,4-triazole on the (Munemitsu Hoshino), 174
Experimentally Induced Inter-bivalent Redistribution of Chiasmata in *Delphinium* (H K Jain and A K. Bose), 260
Experiments in the Field of Parametric Amplification (B Bollée and G. de Vries), 1019
Experiments (Animal) : Combined Application of Hydrogen Peroxide and Ionizing Rays in (E Fleischmann, H. Werkgartner and K. Karrer), 324
Experiments (Long-range Clock Synchronization) : Preliminary Flight Tests of an Atomic Clock in Preparation of (Friedrich H Reder and Gernot M R Winkler), 593
Explants of Brain Tissue in Culture : Spontaneous Potentials from (Prof. A W B. Cunningham, Marshall Dougherty and B. J. Rylander), 477
Exploitation of Crop Plant Resistance to Disease : Nature and (Association of Applied Biologists and the British Mycological Society Symposium on), 857
Explorations of the Galápagos Islands (Dr. L Harrison Matthews), 365
Exploratory Behaviour in the Rat (Roger G A Stretch), 454
Explosion of Gases and Vapours : Flame and, *review* by Dr. H F. Coward, 666
Explosions : Radioactivity of the Atmosphere due to Distant Nuclear Test (D. H Peirson, R. N Crooks and E. M. R Fisher), 224
Explosions, Detonations, Flammability and Ignition Part 1 (Prof. S. S. Penner) ; Part 2 (B. P Mullins), *review* by Dr. H. F. Coward, 666
Explosives : Modern (the late Dr. Wilfrid Taylor), 204
Export : British Books for, 600
Exposure Ages for Iron Meteorites (Oliver A. Schaeffer and David E. Fisher), 1040
Extracellular χ-Phage of *Serratia* : Induction and Reversion of *c*-Mutations by Irradiation of the (Prof. R. W Kaplan, U. Winkler and H. Wolf-Ellmauer), 330
Extracellular Unit Action Potentials from the Central Nervous System : 'Weightless' Micro-electrodes for Recording (Prof. B. Delisle Burns and Dr. J. G. Robson), 246
Extract (Bovine Pineal) : Effects of Injection of, on the Nuclei of Rat Pineal Parenchymal Cells (Dr. Uno Holmgren, Dr. Mark D Altschule and Dr. Richard J. Wurtman), 393
Extraction of Metals : Principles of the (Dr D J. G. Ives), 765
Extracts of *Azotobacter vinelandii* : Nitrogen Fixation in (Dr. D. J. D. Nicholas and D J Fisher), 735
Extracts (Alcoholic Plant) : An Ion-Exchange Resin Method for the Fractionation of (Dr. Dalwon Wang), 326
Extracts (Cardioactive Acetone), of Ox Spleen : Absence of Catecholamines in (Dr. L. B. Cobbin and Prof. R. H Thorp), 473
Extracts (Plant) . Treatment of Injured and Regenerating Muscles with (S. Hoja and J. Vittek), 283
Extragalactic Distance Scale (Paul W. Hodge), 622
Extreme Ultra-violet Radiation (Solar), as a Source of Interplanetary Ionization (Dr Hans E. Hinteregger), 523
Extreme Ultra-violet and Soft X-Rays : A Self-supporting Metal Fresnel Zone-plate to focus (Dr. Albert V. Baez), 958
Eye : The Biochemistry of the (Dr Antoinette Pirie), 352
Eye in Evolution (Sir Stewart Duke-Elder), *review* by R. C Davenport, 42
Eye and Vision, *review* by R. C. Davenport, 42
Eyles, A. G. : Nitrogen in Tropical Agriculture, 941
Eyles, Dr V A : Glossary of Geological Terms, *review*, 57
Eysenck, Prof. H. J. Dowsing—Fact or Fiction?, *review*, 346

FACIAL Eczema Toxin, Sporidesmin : Detection and Estimation of a (G. R. Russell), 788
Factor (Possible), in Sympatric Speciation : Selective Visits of Butterflies to Flowers—a (K. R. Dronamraju), 178
Factories : Structural Loading in (Department of Scientific and Industrial Research), 851
Factories (Ionizing Radiations) Special Regulations : Second Preliminary Draft of Regulations (Ministry of Labour), 13
Factors affecting Tubers in *Begonia evansiana* Andr. (— Esashi and —. Nagao), 766 ; (—. Nagao and —. Mitsui), 766

Factors (Recovery), in Rats receiving an Acute Whole-body Dose of X-Rays : Yeast Ribonucleic Acid and its Nucleotides as (Prof. J Maisin, P. Dumont and A. Dunjic), 487
Factors and Causes of Infective Diseases, *review* by Dr. G. Lapage, 581
Fagg, William : Grooved Rocks at Apoje, Nigeria, 205
Fairbairn, W. M. Ionization of *n*-Paraffin Molecules, 151
Fairbrother, Dr. R. W. : A Text-Book of Bacteriology, eighth edition, *review* by Dr. R H. Gorrill, 111
Falcon, N. L. : Elected a Fellow of the Royal Society, 11
Falkenbergia rufolanosa on the West Coast of Scotland : Occurrence of (Dr. Elsie Conway), 566
Fall-out (Radioactive), during 1959 (W. Anderson, R. E. Bentley, L. K. Burton, J. O. Crookall and C. A. Greatorex), 925
Fall-out Radioactivity in Southern Sweden (Prof Pontus Ljunggren), 655
Fallow : Red, Roe and, *review* by R. S. R. Fitter, 45
False-Positive Reactions (Bacterially Mediated), in Lytic Blood-Typing Tests (Prof. Clyde Stormont, Yoshiko Suzuki and W. J. Miller), 247
Family : The Free (Paul and Jean Ritter), *review* by Prof. M. D. Vernon, 38
Far East : The Dilemma of the, *review* by Prof W D. Borrie, 664
  Population and Progress in the (Prof. Warren S. Thompson), *review* by Prof. W. D. Borrie, 664
Faraday Effect in the Transmissions from Fast Spinning Satellites (R. S. Roger and J. H Thomson), 622
Faraday Rotation of Radio Signals from Artificial Satellites : Electron Density Measurements in the Upper Ionosphere using the (Dr. D. McL. A. Wilson), 623
Farm Animals : Feeding Antibiotics to (Agricultural Research Council and the Medical Research Council Joint Committee on), 280
Farm Crops : Diseases of (A. Beaumont), *review* by J. M. Hirst, 65
Farming (Profitable) : Fertilizers and (Dr. G. V. Cooke), *review* by G. V. Jacks, 424
Fasciola hepatica in Sheep : Anthelmintic Efficiency of Tetrachlorodifluoroethane against (J. C. Boray and I G Pearson), 252
Fast Spinning Satellites : Faraday Effect in the Transmissions from (R. S. Roger and J. H. Thomson), 622
Fate of Bacteria in the Small Intestine (J. M. S. Dixon), 521
Father : Dependence of the Sex Ratio at Birth on the Age of the (Dr. Leo Szilard), 649 ; (Dr. A. Comfort), 1065
Father of Chemistry : Robert Boyle— (Dr. Roger Pilkington), *review* by Dr. W. A. Smeaton, 63
Fats (Differently Saturated) : Essential Fatty Acids of Normal and Atherosclerotic Aortas from Chickens receiving, for Three Years (Prof. H. Fisher and A. S. Feigenbaum), 85
Fatty Acids : Effects of, on the ^{32}P-Adenosine Triphosphate Exchange Reaction in Rat Liver Mitochondria (K. Ahmed and Dr. P. G. Scholefield), 1046
Fatty Acids (Essential), of Normal and Atherosclerotic Aortas from Chickens receiving Differently Saturated Fats for Three Years (Prof. H. Fisher and A. S. Feigenbaum), 85
Faulkner, P., and others . Crystallization of Purified Mouse Encephalomyocarditis Virus Particles, 908
Fauna Preservation Society : Annual Report for 1959, 1017
Fauna (Late Precambrian), in South Australia (M. F. Glaessner and B. Daily), 205
Fauna (Mud), of the Stour Estuary (Frances Bull, Helen Honeyman and Susan Knott), 1018
Favejee, J. Ch. L. : Mineralogical Composition of some <2 Micron Fractions in a Sediment Core from the Mindanao Trough (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No. 5), 609
Fazekas de St. Groth, Dr. S. : Elected a Fellow of the Australian Academy of Science, 519
Features (Geological) . Influence of, on Very Low Frequency Geomagnetic Fluctuations (H. J. Duffus, J. A. Shand and Sir Charles Wright), 141
Federation of British Industries : Handbook on the Technical Colleges and their Government, 769
Federation of Malaya, Government of the, and others : International Conference on Natural Rubber Research, 767
Federation for Medical Electronics, International (Electronics and Communications Section of the Institution of Electrical Engineers and the) : International Conference on Medical Electronics, and associated Exhibition, 523
Federation of Rhodesia and Nyasaland : Government Organizations and Statutory Bodies concerned with Scientific Research and Technical Services in the, 202
Feeding Antibiotics to Farm Animals (Agricultural Research Council and the Medical Research Council Joint Committee on), 280
Feeding with Goitrogenous and Non-goitrogenous Cabbage : Level of Sulphydryl Compounds in Rat Liver following (Jozef Sedlák), 892
Feeding (Thyroid-Powder), and Liver Nitrogen in Mice (Dr. A. N. Granitsas, M. Kukku and M. Konstantinidu), 890
Feigenbaum, A. S. (Fisher, Prof H., and) : Essential Fatty Acids of Normal and Atherosclerotic Aortas from Chickens receiving Differently Saturated Fats for Three Years, 85
Feldspar? : Do Meteorites exist Consisting Predominantly of (Prof. K. Przibram), 300
Fell, J. : Nuclear Reactor Physics, *review*, 78
Feller, Prof. W. : Elected a member of the United States National Academy of Sciences, 773
Fellowship : Research (Royal Geographical Society), 684
Fellowships (City and Guilds of London Institute), 13
  Carlsberg–Wellcome Travelling Research (Wellcome Trust), 283
  Lederle Medical Student Research (American Cyanamid Company), 283
  Senior Research (United States Public Health Service), 439
  Studentships and (Agricultural Research Council), 126
Fellowships for 1960 : André Mayer (Food and Agriculture Organization of the United Nations), 15
Fellowships for 1960-61 (Ciba Fellowship Trust Awards), 684
Fellowships in Animal Reproduction : Ford Research (Zoological Society of London), 519
Fellowships for Medical Research (Beit Memorial Trust Elections), 520
Fellowships (Graduate), for 1960-61 (United States National Science Foundation Awards), 684
Fellowships (Harkness), of the Commonwealth Fund (Elections for 1960), 15
Fellowships (Senior Visiting), in Science (Organization for European Economic Co-operation and the United States National Science Foundation Awards), 1019
Female (Unfertilized), of the Spider *Uloborus walckenaerius* Latrielle · Unusual Web Pattern made by an (Dr. Rasza Szlep), 94
Female *Glossina morsitans* : Determination of Physiological Age for (D. S. Saunders), 651
Females (*Habrobracon*) · Divergence between Lethal Doses and Sterilizing Doses of X-Rays with Progressive Development in (Dr Howard E. Erdman), 254
Fennah, R. G. : The Aradidae, *review*, 46
  Meyrick's Microlepidoptera, *review*, 188
Fensom, D. S. · Bio-electric Potentials of Plants, 853
Feral Goat Herd · Home Range in a (Thane Riney and Graeme Caughley), 125
Ferguson, Dr L. N. (Barnes, Dr. C. J , and) · Amino-Acid Composition of Proteins from Surface Tissue of the Tongue, 617
Fern (Male), in Pharmacognosy : Indian Substitutes of (Prof. P. N. Mehra and T. C. Mittal), 722
Fern Species : Purification of a Specific Inducer of the Male Sex Organ in certain (Ross B. Pringle, Ulrich Naf and Armin C. Braun), 1066
Ferrari, I. (Bottura, C., and) : A Simplified Method for the Study of Chromosomes in Man, 904
Ferritin and Apoferritin . X-Ray Diffraction Study of Denatured (Vladimír Kleinwächter), 313
Fertility of College Graduates (Population Reference Bureau, Inc., *Population Bulletin*, Vol 15, No. 6), 22
Fertility (Human) . Problems of, *review* by Dr. Kenneth Walker, 188
Fertility Problem (Human) . Modern Science and the (Dr. Richard L. Meier), *review* by Dr Kenneth Walker, 188
Fertilizers and Profitable Farming (Dr. G. W. Cooke), *review* by G. V. Jacks, 424
Feughelman, M. : Visco-Elastic Systems (Effect of Humidity on Stress Relaxation in Wool), 943
Feulgen Reaction : A New Technique for Studying the Quantitative Aspects of Cytochemical Reactions and its Application to the (P. van Duijn and J. -P. Persijn), 805
Fibre Model (Muscle), in the Presence of Adenosine Triphosphate : Effect of Electrical Stimulation on a (Prof. Masahiro Fujino, Tatsuaki Matsushima, Tomizo Muroya, Hideyo Yabu, Saburo Yamaguchi and Masaki Takahashi), 318
Fibre Science (Textile Institute Conference on), 360
Fibre (Giant-) Reflex of the Earthworm (Dr. M. B. V. Roberts), 167
Fibre (Nerve) Myelin Sheath : Neurokeratin Network of the Peripheral, as a Centre of Metabolic Activity (Dr. H. B Tewari and Prof. Geoffrey H. Bourne), 645
Fibres (Myelinated, Isolated Nerve), of the Frog: Effect of Curare on Conduction in (Dr. Wolf D Dettbarn), 891
Fibres (Spruce Sulphite) · Structure of the Outer Secondary Wall on Unbleached (O. Kallmes and J. A S. Newman), 566
Fibres (Wool) : Supercontraction in, and Creep in the Post-yield Region (Dr. K. J Whiteley), 473
Fibrinogenolysis in Joints (A. J. Harrold), 1057
Fibroblasts (*L*-Strain) · Some Effects of Different Tensions of Oxygen on the Respiration and Growth of (A. R. Fisher), 315
Field of Parametric Amplification · Experiments in the (B. Boillé and G. de Vries), 1019
Field of Scientific and Technical Research : Co-operation in the (Organization for European Economic Co-operation), 998
Field Lines (Geomagnetic) : Motion of (C. J. Loughnan), 33
Field Manual (Laboratory and), of Ornithology (Olin Sewall Pettingill, Jr.) third edition, *review* by J D Macdonald, 65
Field Studies Council : Report for 1958-59, 203
Field Techniques (Practical), in Physical and Cultural Geography (Geographical Association Course in), 1020
Field and Store · Food Losses in (Nutrition Society Symposium on), 685
Fields, Joseph, and others : Synthetic Polyelectrolytes as Tumour Inhibitors, 778
Fields of Learning : The Problem of Language in Publications of Works in Scientific and other (Prof D Keilin), 912
Fieser, Prof. Louis F., and Fieser, Mary : Steroids, *review* by Dr. W. Klyne, 668
Fieser, Mary (Fieser, Prof. Louis F., and) : Steroids, *review* by Dr. W. Klyne, 668
Fifoot, E R. S. · Appointed University Librarian at the University of Edinburgh, 767
Figures of Equilibrium of Celestial Bodies, with Emphasis on Problems of Motion of Artificial Satellites (Prof. Zdenek Kopal), *review* by D. G. King-Hele, 747
Filamentous Structures in Ectromelia Virus-Infected Cells (Dr. Benjamin V. Siegel), 820
Fillings for Geiger-Muller Tubes : Helium–Butane Gas Mixtures as (Dr. V. Moses and Dr. J. F. Fowler), 538
Film in Teaching and Research in British Universities, 1959 : The Use of (British Universities Film Council), 444
Film (Surface) : Piling-up of Dislocations beneath a (A. R C. Westwood and L J. Demer), 146
Film Council (British Universities) : The Use of Film in Teaching and Research in British Universities (1959), 444
Film Strips in Teaching : Films and, 360
Films and Film Strips in Teaching, 360
Films (Thin), of Silver–Cadmium Alloy (K. Bahadur and P. V. Sastry), 467
Filtrates (Culture), of an Encapsulated *Staphylococcus aureus* : Isolation of a Phagocytosis-Inhibiting Substance from (Dr. Stephen I. Morse), 102
Filtrates (Heated Culture) · Starch—Agar-Gel Electrophoresis of Tuberculoproteins from (T. P. Dekker), 392
Filtrates (Serum) : Presence of Protein in some (Dr. F. J. Scandrett), 558
Finland's Institute of Technology : Scientific Researches No. 13, Traffic Accidents and Driver Characteristics (Sauli Häkkinen), 273
Finlay-Freundlich, E. : Celestial Mechanics, *review* by Dr. R. H. Garstang, 60
Finney, Dr. D. J. : Analyse de Variance et Plans d'Expérience, *review*, 68
Firsoff, V. A. : The Lunar Surface, 826
First Month of Life : Interrelation of Tryptophan and Nicotinic Acid in Man during the (S. Auricchio, E. Quagliariello and A. Rubino), 639
First Stage of Work Hardening in Aluminium Single Crystals (N. A McKinnon), 148

Firth, J. N. M. : Cleaning of Fossils by Ultrasonic Waves, 684
Fischbach, Dr. D. B. : High-Temperature Creep of Graphite, 795
Fischer, Dr. E., and others : Synergetic Action of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia, 893
Fischer, Prof. G. : Orogens, 689
Fischer, G. W., and others (edited by) : Plant Pathology, Problems and Progress, 1908-1958, *review* by W. C. Moore, 47
Fish and Game, Department of (California) : Bulletin No. 107, Trout and Salmon Culture—Hatchery Methods (Earl Leitritz), 204
Fishel, Prof. C. W. : Mucopolysaccharides of Serum and Pleural Fluid, 804
Fisher, A R. : Some Effects of Different Tensions of Oxygen on the Respiration and Growth of *L*-Strain Fibroblasts, 315
Fisher, David E. (Schaeffer, Oliver A., and) · Exposure Ages for Iron Meteorites, 1040
Fisher, D. J. (Nicholas, Dr. D. J. D., and) : Nitrogen Fixation in Extracts of *Azotobacter vinelandii*, 735
Fisher, E. M. R., and others : Radioactivity of the Atmosphere due to Distant Nuclear Test Explosions, 224
Fisher, Prof. H., and Feigenbaum, A. S. Essential Fatty Acids of Normal and Atherosclerotic Aortas from Chickens receiving Differently Saturated Fats for Three Years, 85
Fisher, H. D. (Mansfield, A. W., and) . Age Determination in the Harbour Seal, *Phoca vitulina* L., 92
Fisheries Advisory Committee (Colonial) · Report for 1958-59, 501
Fisheries Research in Australia, 280
Fishery Research : Postgraduate Training Grants in (Development Commissioners, the Ministry of Agriculture, Fisheries and Food, and the Scottish Home Department), 360
Fishery Research Station (Inland), Sagana, Kenya (Dr. Vernon D. van Someren), 425
Fisica, Società Italiana di : International School of Physics, 17
Fission Products : An Assessment of the Quantities of, likely to be found in Milk in the Event of Aerial Contamination of Agricultural Land (Dr. R. J. Garner), 1063
Fission Products in the Atmosphere : Detection of Recently Produced (Dr. W. Anderson, Dr. R. E. Bentley, L. K. Burton and Dr. C. A. Greatorex), 223
Fitter, R. S. R. : Red, Roe and Fallow, *review*, 45
Fitzgerald, F. : Decomposition of Methyl Acetylene, 386
Fixation (Nitrogen), in Extracts of *Azotobacter vinelandii* (Dr. D. J. D. Nicholas and D. J Fisher), 735
Fixation (Nitrogen), by a Legume : Cobalt in (Prof. H. M. Reisenauer), 375
Flagellate Spermatozoa : Position of the Proximal Centriole in (Prof. Vishwa Nath, Brij L. Gupta and L. C. Mittal), 899 ; (Dr. J. Bronte Gatenby and R. S Mathur), 900
Flame and Explosion of Gases and Vapours, *review* by Dr. H. F. Coward, 666
Flammability and Ignition : Explosions, Detonations, Part I (Prof. S. S. Penner), Part 2 (B. P. Mullins,) *review* by Dr. H. F. Coward, 666
Flare (Solar), of July 10, 1959 : Ionospheric Effects associated with the (V. A. H. Harrison), 228
Flavin Dissociation and Inactivation of Cytochrome b_2 by Oxygen (A New Type of Autoxidation Reaction), (J. McD. Armstrong, Dr. J. H. Coates and Prof. R. K. Morton), 1033
Flavonoid Compounds in the Inflorescence of *Helichrysum arenarium* (Z. I. Jerzmanowska and J. T. Grzybowska), 807
Flavonoids : Biosynthesis of (W. E. Hillis), 635
Fleischmann, E., and others : Combined Application of Hydrogen Peroxide and Ionizing Rays in Animal Experiments, 324
Flexner, Dr. Abraham · *Obituary* by Dr A N. Richards, 278
Flight : A Basis for a General System of Insect Migration and Dispersal by (C. G. Johnson), 348
  Man-powered (Financial grants from the Royal Aeronautical Society Man Powered Aircraft Group, for promising projects designed to further the achievement of), 1020
Flight (Space) : Problems of, *review* by D. G. King-Hele, 59
Flight Tests (Preliminary), of an Atomic Clock in Preparation of Long-range Clock Synchronization Experiments (Friedrich H. Reder and Gernot M. R. Winkler), 592
Flood, Dr. A. E. (Kirkham, Dr. D. S., and) : Nature and Exploitation of Crop Plant Resistance to Disease (Apple and Pear Scab), 858
Flora of the Belgian Congo, 764
Flora (Bacterial), of Roots : Influence of Light on (J. W. Rouatt and Dr. H. Katznelson), 659
Flora (A Mesozoic Micro-), from South Africa (A. R. H. Martin), 95
Flora (Suffolk) : Changes in the, during the Past 100 Years (F. W. Simpson), 771
Floras (Miocene), of the Columbia Plateau, Part I, Composition and Interpretation (Ralph W. Chaney) ; Part 2, Systematic Considerations (Ralph W. Chaney and Daniel I. Axelrod), *review* by Prof. J. Walton, 66
Flore du Congo Belge et du Ruanda-Urundi (Institut National pour l'Étude Agronomique du Congo Belge), Vol 9, 764
Florkin, M., et autres : Traité de Biochimie Generale, Vol. I, Composition Chimique des Organismes, *review* by Prof. F. G. Young, 51
Flour (Wheaten) : A Role for Thiol and Disulphide Groups in Determining the Rheological Properties of Dough made from (R. Frater, Dr. F J. R. Hird, H. J. Moss and J. R. Yates), 451
Flour Millers (British), Research Association of—New Laboratories (Dr. T. Moran), 856
Flow (Compressible) : Introduction to the Theory of (Prof Shih-I Pai), *review* by Dr. G. K. Batchelor, 1000
Flow (Pulsatile), through Tapered Distensible Vessels, Reflexions, and the Hosie Phenomenon (Robert L. Evans), 290
Flow (Thermally Stratified) : Wind Profile in (W. C. Swinbank), 463
Flow (Unsteady Supersonic) : The Potential Theory of (Prof. John W. Miles), *review* by L. E. Fraenkel, 505
Flow of Blood through Narrow Tubes (Dr. G W. Scott Blair), 708
Flow of Blood (Intrahepatic Shunted), in Cirrhosis of the Liver : Measurement of the (T. Nakamura, S Nakamura and K. Tokita), 243
Flowers : Selective Visits of Butterflies to—a Possible Factor in Sympatric Speciation (K R. Dronamraju), 178
Flowers (West African) : A Handbook of (Harold N. Saunders), *review* by J. P. M Brenan, 65
Floyd, Dr. W. F. Appointed first head of the Department of Ergonomics and Cybernetics at Loughborough College of Technology, 523
Fluctuations (Geomagnetic) : Influence of Geological Features on Very Low Frequency (H. J. Duffus, J. A. Shand and Sir Charles Wright), 141
Fluid (Amniotic) · Ultra-Structure of Human Amnion and its Possible Relation to the Circulation of (Dr. Gordon L. Bourne and Dr. Dennis Lacy), 952
Fluid (Pleural) : Mucopolysaccharides of Serum and (Prof. C. W. Fishel), 804
Fluid Dynamics (Dr. D. E Rutherford), *review* by Dr. G. K. Batchelor, 1000
Fluid Dynamics—a Mixed Bag, *review* by Dr. G. K. Batchelor, 1000
Fluid Masses : Rotating, *review* by D. G. King-Hele, 747
Fluid Mechanics (L. D. Landau and E. M. Lifshitz), translated from the Russian by J. B. Sykes and W. H. Reid, *review* by Dr. G. K. Batchelor, 1000
Fluids : Boundary-Layer Research in (Dr. G. E Gadd), 1022
Fluids (Human Cerebrospinal) : 5-Hydroxyindoles in (G. W. Ashcroft and D. F. Sharman), 1050
Fluoborate (*p*-*n*-Decyloxybenzenediazonium) : Reaction of, with Sodium Iodide in Benzene (Prof. W. Bradley and J. D. Thompson), 631
Fluorescence of Proteins labelled with various Fluorescent Dyes : Depolarization of the (C. S. Chadwick, Dr. P. Johnson and E. G. Richards), 239
Fluorescence (X-Ray) : Trace Analysis by, using Ion Exchange Resins (J. N. van Niekerk and J F. de Wet), 380
Fluorescent Dyes : Depolarization of the Fluorescence of Proteins labelled with various (C. S. Chadwick, Dr. P. Johnson and E. G. Richards), 239
Fluoridation of Drinking Water (Gerald H. Leatherman and J A. Ellis), 438
Fluorochrome (Nucleic Acid) : Inactivation by Visible Light of Yeast sensitized by a (David Freifelder and Prof. Robert B Uretz), 731
Fly (Adult House-), *Musca domestica* . Mechanisms of Resistance of the, to 'Cyclodiene' Insecticides (Dr. G. T. Brooks), 96
Focus Extreme Ultra-violet and Soft X-Rays : A Self-supporting Metal Fresnel Zone-plate to (Dr. Albert V. Baez), 958
Foetal Haemoglobin in the Monkey (N. N. Sen, K. C. Das and B. K. Aikat), 977
Fogg, Dr. G. E. : Appointed to the University of London chair of botany in Westfield College, 440
Foliar Abnormalities, including Repeated Branching and Root Formation, induced by Kinetin in Attached Leaves of *Marsilea* (Dr. A. Allsopp and Alicja Szweykowska), 813
Folkierski, Dr. A , and others : Growth of Surface Instabilities in a Linear Pinched Discharge, 624
Follett, Dr. D. H. : Appointed director of the Science Museum, London, 206, 518 ; work of, 518
Fondamentales (Bases), et Applications de la Thermodynamique Chimique (Prof. Maurice Dodé), Tome I, Les Principes, les Systèmes ideaux Gazeux, et avec Phases Condensées pures, *review* by Prof. A. R. Ubbelohde, 55
Food (Honeybee Larval) : Electrophoretic Components of the Proteins in (N. G. Patel, M. H. Haydak and T. A. Gochnauer), 633
Food Habits of Migratory Ducks (Harry G. Anderson), 17
Food Losses in Field and Store (Nutrition Society Symposium on), 685
Food Research Advisory Committee, 519
Food Storage, Advisory Committee on Poisonous Substances in Agriculture and : Appointment of Sir Charles Dodds as chairman, 934
Food and Agriculture Organization (United Nations) : André Mayer Fellowships for 1960, 15
  Animal Health Yearbook 1959, 281
Food-borne Infections and Intoxications : Report of a European Technical Conference on (World Health Organization of the United Nations), 852
Foot of the 'Abominable Snowman' : A Reconstruction of the (W. Tschernezky), 496
Foot-and-Mouth Disease : Influence of Route of Inoculation and Strain of Mouse on Infectivity Titrations of the Virus of (Wendy Heatley, H. H. Skinner and H. Subak-Sharpe), 909
Foraminifera in a Sediment Core from the Mindanao Trough : A Note on the (R. A. Reyment), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No. 6), 609
Ford, Boris Appointed director of the Institute of Education and professor of education in the Institute, University of Sheffield, 121 ; work of, 121
Ford, Dr. R. E. : Determination of Dieldrin Deposits on Sprayed Mud Surfaces, 994
Ford Foundation : Grant of 550,000 dollars to the Zoological Society of London, to endow research fellowships in Animal Reproduction, 519
Ford Research Fellowships in Animal Reproduction (Zoological Society of London), 519
Foregut of *Schistocerca gregaria* Forsk. : Nervous Control of Movements in the (Dr. K U. Clarke and H. Grenville), 98
Forerunner of Twentieth Century Physics—a Re-view of Larmor's 'Aether and Matter' (Lancelot Law Whyte), 1010
Forest Products Research Laboratory : Appointment of A C. Copisarow as director, 934
Forestry (Agriculture and) · East African (Dr. E. C. Humphries), 133
Forestry Commission : Leaflet No. 1, The Large Pine Weevil (*Hylobius abietis*), revised edition, 521
  Leaflet No. 45, The Roe Deer, 936
Form of Sponges . Influence of Environment on the Distribution and (Prof. M. A Ali), 177
Form Discrimination · Regularities in the Retina and Optic Lobes of *Octopus* in relation to (The Visual System of *Octopus*), (Prof. J. Z. Young), 836
Formation of Beryllium Carbide during the Corrosion of Beryllium in Carbon Monoxide and in Carbon Dioxide Gas (V. D. Scott), 466
Formation (Blood), in Rats : Effect of Manganese Edetate on (T. J. Sullivan), 87
Formation (Cell Wall), in Spores of the Fungus *Allomyces* (J M. Aronson and Prof. R. D Preston), 95
Formation (Multiple Spot), by Pure Substances . Paper Chromatography—(Dr. A. H. Beckett, M A. Beaven and Dr Ann E. Robinson), 775
Formation (Polymer), in Irradiated *p*-Xylene (Francis van Hecke), 382
Formation (Yolk), in Oocytes of *Patella coerulea* L. and *Aplysia depilans* L. as observed in the Electron Microscope (A Bolognani), 490
Formation and Reactivity of Self-trapped Electrons ('Polarons') : Primary Processes in the Action of Ionizing Radiations on Water— (Prof. Joseph Weiss), 751

Forms of Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide irradiated with Ultra-Violet Light : Use of Nitrous Oxide to discriminate between various (Prof. F. S. Dainton and S. A. Sills), 879
Forms of Hydrogen Atoms (H· and H_2^+ ?) produced by γ-Irradiation of Aqueous Solutions : Use of Nitrous Oxide to discriminate between the (Prof. F. S Dainton and Dr D. B. Peterson), 878
Forsek, Dr. Zlatko, and others . An Indicator Plaque-forming System for Demonstration of Interference by Non-cytocidal Strains of Rabies Virus, 821
Forshee, B. W. (Wilson, W. K., and) · Preservation of Documents (United States National Bureau of Standards, Monograph No. 5), 124
40th Anniversary of the October Revolution Soviet Reviews of Nuclear Science on the, *review* by Dr. T. E Allibone, 917
Foskett, D. J. (Vickery, B. C., and) : Classification and Indexing in Science, second edition, *review* by R Brightman, 190
Fossil Plants of the Carboniferous Rocks of Great Britain (Dr. Robert Crookall), second edition, *review* by T. M. Harris, 66
Fossil (Living and) Unicellular Algae and Aplanospores (D. M. Churchill), 493
Fossils British Caenozoic (Tertiary and Quaternary), (British Museum (Natural History)), *review*, 669
  Cleaning of, by Ultrasonic Waves (J. N. M. Firth), 684
Fossils (Micro-) (Lower Tertiary), from McMurdo Sound, Antarctica (Dr. Lucy M. M. Cranwell (Mrs Watson Smith), Dr H J Harrington and I. G. Speden), 700
Fottrell, P. F. : Elected to a Beit Memorial Junior Fellowship for Medical Research, 520
Fourah Bay College (University College of Sierra Leone) : Appointment of Dr. Davidson Nicol as principal, 599
Fowden, Dr. L. : Degradation of γ-Methylene-glutamic Acid by Plants, 897
Fowell, R. R. · Biology Staining Schedules, sixth edition, 125
Fowler, Dr. J. F. (Matthews, Dr. C. M E., and) A Comparison of Iodine-124 and Iodine-131 Thyroid Dosimetry, 983
Fowler, Dr. J. F. (Moses, Dr. V., and) : Helium–Butane Gas Mixtures as Fillings for Geiger-Müller Tubes, 538
Fox, H. C., and Miller, D. S. : Ackee Toxin, a Riboflavin Antimetabolite ?, 561
Fox, J. A. : Appointed lecturer in civil engineering at the University of Leeds, 767
Fractionation of Alcholic Plant Extracts : An Ion-Exchange Resin Method for the (Dr. Dalton Wang), 326
Fractionation of Genes (Prof. R. Ruggles Gates), 739
Fractionation of Heparin on an Anion Exchanger (Dr. J P. Green), 472
Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in Animal Cells and its Bearings on Cancer (Prof A. Sibatani, K. Yamana, K. Kimura and T. Takahashi), 215
Fractions of Phenol-killed Tubercle Bacilli · Enhanced Resistance of Mice to Infection with *Pasteurella pestis* following Vaccination with (Prof. David W. Weiss), 1060
Fractions (Gas Chromatographic) · Microquantitative Infra-Red Analysis—Application to (J. E. Stewart, R. O. Brace, T Johns and W. F. Ulrich), 628
Fraenkel, L. E. : Unsteady Supersonic Flow, *review*, 505
Francium : The Radiochemistry of (Earl K. Hyde), 602
Francois, J., and others (edited by) : Documenta Ophthalmologica (Advances in Ophthalmology, Vol. 13), *review* by R. C. Davenport, 42
Franklin, Mary T., and Hopper, D. J. : Plants Recorded as Resistant to Root-Knot Nematodes (*Meloidogyne* spp.), 684
Frater, R , and others : A Role for Thiol and Disulphide Groups in Determining the Rheological Properties of Dough made from Wheaten Flour, 451
Frazer, Prof. A. C : Medical Research in the British Caribbean, 862
Fredriksson, H. : A Sediment Core from the Mindanao Trough (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No 4), 609
Free Family : The (Paul and Jean Ritter), *review* by Prof M. D. Vernon, 38
Free Radical (Benzyloxyl), in Solution : Disproportionation and Dimerization of the (Dr. J. B. de Sousa and S. K. Ho), 776
Free-Radical Reactions · A Model to account for the Production of Vibrationally Hot Molecules in (Dr. J. P. Simons), 551
Free Radicals from Solids': The Tesla-coil Method for producing (Dr. C. H. Bamford, A D. Jenkins and J. C. Ward), 712
Freedman, Daniel X., and others : Serotonin Content of the Pineal Glands of Man and Monkey, 480
Freeman, Prof. John A. : Sex Difference in Accidental Mortality of Guppies exposed to Elevated Temperature, 491
Freeman, W. A., and others : Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methylisothiazole), a New Antibacterial Sulphonamide, 221
Freezing-Point Depressions of Hoagland's 'Carbowax' Systems (Howard G. Applegate), 232
Freifelder, David, and Uretz, Prof. Robert B : Inactivation by Visible Light of Yeast sensitized by a Nucleic Acid Fluorochrome, 731
French National School of Geographical Sciences · Theoretical and Technical Course on Aerial Photogrammetry, 127
Frequencies of the Haptoglobin Serum Groups among Blood Donors from Austria and Germany (Dr H. Baitsch, G. Meier, L. Schoeller and D. M Kahlich-Koenner), 976
Frequencies (Metal-ligand Stretching), of some Metal Hydrazine Complexes: The 'Irving–Williams' Order in the (Prof, L Sacconi and A. Sabatini), 549
Frequency (High), of Spontaneous and Induced Somatic Segregation in *Aspergillus nidulans* (Dr. Etta Käfer), 619
Frequency (Very Low) Geomagnetic Fluctuations : Influence of Geological Featutes on (H. J. Duffus, J. A. Shand and Sir Charles Wright), 141
Fresh and Aged Liver Mitochondria : Swelling of, as affected by Succinate, Adenine Nucleotides and Thyroxine (Dr. P. Emmelot, C. J. Bos, P. J. Brombacher and I. H. M. Reyers), 556
Freshwater Invertebrate Animals : A Guide to (Dr T. T. Macan), *review* by Dr. J. P Harding, 345
Freshwater Invertebrates, *review* by Dr. J. P. Harding, 345
Freshwater Snail : Chromosomes of *Gyraulus circumstratus*, a (John B. Burch), 497
Fresnel Zone-plate to Focus Extreme Ultra-violet and Soft X-Rays : A Self-supporting Metal (Dr. Albert V. Baez), 958
Friction Constant : The Liquid (Dr. G. H. A. Cole), 301
Friedman, Dr. Herbert : Elected a member of the United States National Academy of Sciences, 773
Fripiat, Dr. J. J., and Toussaint, F. : Predehydroxylation State of Kaolinite, 627
Fritz-Niggli, Prof. Dr. Hedi : Strahlenbiologie—Grundlagen und Ergebnisse, *review*, 66
Frog : Effect of Curare on Conduction in Myelinated, Isolated Nerve Fibres of the (Dr. Wolf D. Dettbarn), 891
Frog (California Yellow-legged) A Blood Parasite from the (Donald L. Lehmann), 765
Frohwein, Y. Z., and Leibowitz, Prof. J. Synthesis of 6-O-Acetyl-α-Glucose, 153
Froome, Dr K. D. · Millimetre Waves from Mercury Arc Harmonic Generator, 959
Fruit (*Nipa*) : A New Specimen of, from Mohgaonkalan Cherts (Dr S. D. Chitaley), 495
Fruits (Adhering and Abscising), of Peach treated with N-1-Naphthyl Phthalamic Acid : A Comparison of (Prof. Loyd E. Powell and Charlotte Pratt), 814
Fruits (Tomato and Apple) . Ethylene Production by (D. F. Meigh, K H. Norris, C. C Craft and M. Lieberman), 902
α-L-Fucosidase : Mammalian (Dr. G. A Levvy), 472
Fuel, Institute of : Annual Report for 1959, 601
  Fuel Abstracts and Current Titles, 601
Fuel Abstracts and Current Titles (Institute of Fuel), 601
Fuel Cells—Will they soon Become a Major Source of Electrical Energy? (F. T. Bacon), 589
Fuel Element Technology : Reactor (Imperial College of Science and Technology Course of Lectures in), 1025
Fujino, Prof. Masahiro, and others : Effect of Electrical Stimulation on a Muscle Fibre Model in the Presence of Adenosine Triphosphate, 318
Fuller, M. D. : Anisotropy of Susceptibility and the Natural Remanent Magnetization of some Welsh Slates, 791
Fulton, R. W., and others (edited by) . Plant Pathology, Problems and Progress, 1908-1958, *review* by W. C Moore, 47
Function of Genetic Elements : Structure and—Report of Symposium held June 1959 (Brookhaven Symposia in Biology, No. 12), *review* by Prof S. C. Harland, 63
Function of a Salivary Mucoprotein · Correlation between Composition, Structure, Shape and (Dr. Alfred Gottschalk), 949
Function of the Two Cytochrome Components in Chloroplasts—a Working Hypothesis (Dr. R. Hill and Dr. Fay Bendall), 136
Function of Universities, 107
Function (Structure and) : Protein (Brookhaven National Laboratory Symposia in Biology, No 13), 361
Functions (Gaussian Wave), for the Hydrogen Molecule (J V. L. Longstaff and Dr. K. Singer), 799
Functions (Mathematical) : Tables of Physical and Chemical Constants and some (Dr. G. W. C. Kaye and Dr. T. M Laby), twelfth edition, *review* by T. M. Yarwood, 67
Fundamental (A Possible), in the Behaviour of Young Nidifugous Birds (Dr. Peter M. Driver), 416
Fundamental Aspects of Reactor Shielding (Dr. Herbert Goldstein), *review* by Dr. T. E Allibone, 917
Fundamental and Applied Research : The Balance of, 341
Fundamentals of Nuclear Energy and Power Reactors (Henry Jacobowitz), *review* by Dr. T. E. Allibone, 917
Fungal Root-Infections of *Pinus* : Effects of *Gibberella fujikuroi* on (Dr. Ida Levisohn), 987
Fungi : Decomposition of Humic Acid by (Prof. Alan Burges and Pamela Latter), 404
Fungicides (Handbook of Toxicology, Vol. 5), analysis and compilation by Everett F. Davis, Barbara L. Tuma and Lucy C. Lee (edited by Dorothy S. Dittmer), *review*, 64
Fungus *Allomyces* : Cell Wall Formation in Spores of the (J. M. Aronson and Prof R. D Preston), 95
Funk, Dr. J. A : Awarded second prize (Home Awards) of the Darton Prizes of the Royal Meteorological Society, 440
Further Education, Northern Advisory Council on . Training of Technical Teachers, 281
  Report for 1958-59, 281
Further Education, Southern Regional Council for : Twelfth Annual Report, 123
Furunculosis in Salmon Kelts (Dr. Isabel W. Smith), 733
Fusarium Species : Characterization of a New Purine Riboside isolated from (Dr. Alessandro Ballini, Dr. Carlo Delfini and Dr. Serena Russi), 968
Fusarium moniliforme Sheld. (*Gibberella fujikuroi* (Saw.) Wr.) producing Substances with Gibberellin-like Biological Properties : Distribution and Prevalence of (Prof. W L. Gordon), 698
Fusarium oxysporum Schl forma *pisi* (Lindf.) S. and H.? : Is *Nectria haematococca* Berk and Br. the Perfect Stage of (Prof. W. L. Gordon), 903
Fusion (High-Temperature), of Possible Parent· Materials for Tektites (Origin of Tektites), (J. F. Lovering), 1028
Fusion Electrolysis of Titanium (Dr. W. J. Kroll), 685
Future Development of Management Education and of Business Studies—Revision of Joint Examination Schemes (Ministry of Education, Circular 1/60), 743
Fylingdales Moor : Ballistic Missile Early Warning Station at, 357

GABOR, Joseph, and others · Polyvinyl Benzoate Monolayers, 883
Gadd, Prof. C J. : *Obituary* of Sir Leonard Woolley, 516
Gadd, Dr. G. E. : Boundary-Layer Research in Fluids, 1022
Gahan, P. B., and others : Life-like Preservation of Cytoplasmic Detail in Plant Cells, 1068
Gahne, Bo and others : Inheritance of β-Globulins in Serum and Milk from Cattle, 907
Gain of a Photomultiplier : Use of an Auxiliary Grid to stabilize the (Dr. C. F. G. Delaney and Dr. A. J. Walton), 625
Gaines, jun., George L. : Overturning of Stearic Acid Molecules in Monolayers, 384
Galactic Communities (Superior) : Communications from (Prof. R. N. Bracewell), 670
Galambos, Dr. R. : Elected a member of the United States National Academy of Sciences, 773

Galápagos Islands, a History of their Exploration (Joseph Richard Slevin), 365
Galston, Prof Arthur W. : Appointed chairman of the Department of Botany in Yale University, 1020
γ-Aminobutyric Acid in Brain Cortex Slices : Active Transport of, with special reference to Phosphorus-32 Turnover in Phospholipids in Cytoplasmic Particulates (Yasuzo Tsukada, Yutaka Nagata and Shusuke Hirano), 474
γ-Irradiation of Aqueous Solutions : Use of Nitrous Oxide to discriminate between the Forms of Hydrogen Atoms (H and H_2^+?) produced by (Prof. F S Dainton and Dr D. B. Peterson), 878
γ-Methyleneglutamic Acid : Degradation of, by Plants (Dr. L. Fowden), 897
γ-Ray Resonance (Ultra-High Resolution), in Zinc-67 (D. E. Nagle, P. P. Craig and W. E. Keller), 707
Gangolly, S. R., Gopalakrishnan, T. P , and co-workers : Recent Advances in Coconut Research in India, 861
Gansser-Burckhardt, Dr. August : *Obituary* by Prof. K. H. Gustavson, 597
Garner, Prof F. H. Retirement from the chair of chemical engineering in the University of Birmingham, 849 ; work of, 849
Garner, Dr. R. J. : An Assessment of the Quantities of Fission Products likely to be found in Milk in the Event of Aerial Contamination of Agricultural Land, 1063
Garner, R J. (Tinley, G. H., and) : Developments in the Propagation of Clones of *Hevea brasiliensis* by Cuttings, 407
Garner, Prof. W. E. *Obituary* by Prof. C. E. H Bawn, 760
Garnets Infra-Red Spectrum of (P. Tarte), 234
Garstang, Dr. R H. : Planetary Dynamics, *review*, 60
  Electromagnetic Phenomena in Cosmical Physics, *review*, 67
Gas (Carbon Dioxide) : Formation of Beryllium Carbide during the Corrosion of Beryllium in Carbon Monoxide and in (V. D. Scott), 466
Gas (Carrier) Effect of, on the Sensitivity of Thermal Conductivity Detectors (C. Bokhoven and A Dijkstra), 793
Gas Chromatograph : A Micro (Prof. Nobuji Sasaki, Kimimichi Tominaga and Masaya Aoyagi), 309
Gas Chromatographic Fractions : Microquantitative Infra-Red Analysis—Application to (J E Stewart, R. O Brace, T. Johns and W. F. Ulrich), 628
Gas Chromatography (Gas Chromatography Discussion Group of the Institute of Petroleum Hydrocarbon Research Group Symposium on), 127, 943
  Analysis of Anaesthetic Mixtures by (E R. Adlard and D. W. Hill), 1045
  Radioassay by, of Compounds labelled with Carbon-14 (Dr. Arthur Karmen and Harold R. Tritch), 150
  Sterol Analysis by (R. K Beerthuis and J H. Recourt), 372
Gas Content of Graphites (Dr. J P Redmond and Dr. P L Walker, jun.), 72
Gas Discharge . Reaction between Copper and Solid Oxygen condensed at Very Low Temperatures from a (Jerome Kruger and William J. Ambs), 794
Gas Discharge Harmonic Generator : Coherence and Band-width of a (N. R. Bierrum, D. Walsh and J C Vokes), 626
Gas Phase . Analogy to the Kirkendall Effect in the (L. Miller and P. C. Carman), 549
Gas–Liquid Chromatography : Non-Equilibrium Theory of (Dr. M. A. Khan), 800
Gases (Inert) . New Clathrate Compounds of the (J. G. Waller), 429
Gases (Permanent) . Self-Quenching Geiger Counters containing Mixtures of (Dr. Oswald Riedel), 876 ; (A J. L Collinson, I. C. Demetsopoullos, J. A. Dennis and J. M. Zarzycki), 876
Gases and Vapours : Flame and Explosion of, *review* by Dr. H F. Coward, 666
Gastric Instillation of 3-Monohydroxycholanic Acid Cirrhosis of the Liver induced in Rabbits by (Dr. Paul Holsti), 250
Gastric Secretion of Hydrogen Ions : Mechanism of the (Prof. Spyridon G A Alivisatos), 368
Gastro-intestinal Tract of the Infant Mouse : Passage of Insulin through the Wall of the (W. A Kelly), 971
Gastropod : A Bivalve (Robert Burn), 179 ; (Prof. A. Myra Keen), 406
Gatenby, Dr. J. Bronte, and Mathur, R S : Position of the Proximal Centriole in Flagellate Spermatozoa, 900
Gates, Prof R Ruggles : Fractionation of Genes, 739
Gaussian Wave Functions for the Hydrogen Molecule (J. V. L. Longstaff and Dr K. Singer), 799
Gee, Prof G. Industrial Chemistry of the Lower Olefines, 286
  Polymeric Progress, 441
Geiger Counters (Self-Quenching), containing Mixtures of Permanent Gases (Dr Oswald Riedel), 876 ; (A. J. L. Collinson, I. C. Demetsopoullos, J A. Dennis and J. M. Zarzycki), 876
Geiger-Muller Tubes : Helium–Butane Gas Mixtures as Fillings for (Dr. V. Moses and Dr. J. F Fowler), 538
Geissman, T. A. : Principles of Organic Chemistry (now available in England), 17
Gel (Agar-) Electrophoresis : Variations in Electrophoretic Position of Haptoglobin Mixtures in (Dr Jan Hirschfeld), 894
Gel (Agar-) Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an Indoxyl-Acetate Splitting Component in the α_1-Globulin Region of Normal Human Sera (Dr. Jan Hirschfeld), 321
Gel (Starch-) Electrophoresis : Separation of the α- and β-Chains of Globins by means of (C J. Muller), 643
Gel (Starch–Agar-) Electrophoresis of Tuberculoproteins from Heated Culture Filtrates (T. P Dekker), 392
Gelatin : Reversible Transformation of, to the Collagen Structure (Dr. Arthur Veis and Dr. Jerome Cohen), 720
Gell-Mann, Prof M. : Elected a member of the United States National Academy of Sciences, 773
Gellner, E. : Sociology—the New Hope, *review*, 504
Gels (Starch) : Broadening of the Water Proton Line in High-Resolution Nuclear Magnetic Resonance Spectra of (Dr. Roger Collison and Dr. M. P. McDonald), 548
Gene : Position of the, determining the Diploid-like Meiotic Behaviour of Wheat (Dr. Ralph Riley, Victor Chapman and Gordon Kimber), 259
General Biochemistry, *review* by Prof. F. G. Young, 51
General Certificate of Education Advanced Level Syllabuses in Science : Report of an Enquiry into the Suitability of the, as a Preparation for Direct Entry into First Degree Courses in the Faculty of Science (University of Birmingham), 687
General Electric Co., Ltd. : A Commercial Thermoelectric Cold Box, 439
General Electric Co., Ltd., and International Computers and Tabulators, Ltd. : A New British Transistorized Computer, 936
General Physiology, *review* by Prof. A St. G Huggett, 52, 284
  Principles of (W. M. Bayliss), fifth edition, by Dr. L E. Bayliss, *review* by Prof. A St. G. Huggett, 52, 284
  A Textbook of (Dr Hugh Davson), second edition, *review* by Prof. A. St. G. Huggett, 52
General Relativity : Gravitational Waves in (Dr. H. Bondi), 535
General System of Insect Migration and Dispersal by Flight : A Basis for a (C G. Johnson), 348
Generation (Spontaneous) : Thermodynamics and Kinetics of (Dr. D. E. Hull), 693 ; (Prof J. D Bernal), 694
Generator (Gas Discharge Harmonic) : Coherence and Band-width of a (N R Bierrum, D Walsh and J. C. Vokes), 626
Generator (Harmonic) : Millimetre Waves from Mercury Arc (Dr. K. D. Froome), 959
Genes : Fractionation of (Prof. R. Ruggles Gates), 739
Genes and Man . Radiation, (Prof. Bruce Wallace and Prof Th Dobzhansky), *review* by Dr A G. Searle, 109
Genetic Basis of Two Melanin Inhibitors in *Drosophila melanogaster* (Dr. R. A Kroman and Dr. P A Parsons), 411
Genetic Elements : Structure and Function of—Report of Symposium held June 1959 (Brookhaven Symposia in Biology, No. 12), *review* by Prof. S. C Harland, 63
Genetic Instability and Outcrossing in the Groundnut Variety Mani Pintar (J. Smartt), 1070
Genetic Interval (Short), in *Drosophila melanogaster* . Apparent Double Crossing-Over in a (Prof. M. M. Green), 990
Genetic Material : Exchange of—Mechanisms and Consequences (Cold Spring Harbor Symposia on Quantitative Biology, Vol. 23), *review* by Prof. Kenneth Mather, 832
Genetic Radiation Hazards, *review* by Dr A G. Searle, 109
Genetic Recombination, *review* by Prof. Kenneth Mather, 832
Genetical Research, No. 1, 16
Genetical and Biochemical Studies of the Immobilization Antigens of *Paramecium aurelia* (J. O. Bishop and Dr. G. H Beale), 734
Genetics, National Institute of (Japan) : Annual Report No. 9 (1959), 286
Genetics of Resistance to Dieldrin in *Lucilia cuprina* Wied. (G. J. Shanahan), 181
Genetics (Human) : Outline of (Prof. L. S Penrose), *review* by Prof. H. Gruneberg, 347
Genetics (Medical) : An Introduction to (Dr. J A Fraser Roberts), second edition, *review* by R. H. Mole, 1003
Genetics (Population) : Electronic Computers in (W F. Bodmer), 851 ; (J L Crosby), 851
Genetyka (Edmund Malinowski), *review* by Dr. P. S. Hudson, 507
Genus New to the Old World . *Stereobalanus*, a (C. Burdon-Jones and A. D McIntyre), 491
Geographical Association : Course in Practical Field Techniques in Physical and Cultural Geography, 1020
Geographical Society (American) : Grant of 2,500 dollars from the Asia Foundation, to aid Asian libraries and Asian scholars temporarily in the United States, 126
Geographical Society (Royal) : Research Fellowship for work on the geography and topography of the Roman Fenland awarded to Dr. P. Salway, 684
Geographical Society (Royal Scottish) . Seventy-fifth Anniversary Exhibition (Mapping Britain), 523
Geographical Union, International : Tenth General Assembly and nineteenth International Congress, 938
Geography : Physical (Philip Lake), fourth edition, revised by Prof. J. A. Steers, *review* by Prof. L. Dudley Stamp, 190
Geography (Physical and Cultural) : Practical Field Techniques in (Geographical Association Course in), 1020
Geological Association (German): Jubilee Meeting (Discussion on Orogens), 206, 689
  Steinmann Medal awarded to Prof H. H. Read, 206, 690
Geological Congress : International, 938
Geological Features : Influence of, on Very Low Frequency Geomagnetic Fluctuations (H J. Duffus, J. A Shand and Sir Charles Wright), 141
Geological Nomenclature (English–Dutch–French–German), (edited by A. A. G Schieferdecker), *review* by Dr V. A. Eyles, 57
Geological Reconnaissance of the Sor-Rondane Mountains (Queen Maud Land), (Prof E E. Picciotto), 740
Geological Society : The Liverpool, 1859-1959 (R. G C. Bathurst), 9
Geological Society of London : Election of Officers, 603
Geological Survey of Canada Bulletin No. 54, Helicopter Operations of the Geological Survey of Canada, 521
Geological Survey of Great Britain : Memoirs of the, Palaeontology, Vol 4, Part 2, Fossil Plants of the Carboniferous Rocks of Great Britain (Dr Robert Crookall), second edition, *review* by T. M. Harris, 66
Geological Survey (United States) : Publication by the *American Journal of Science* of a 'Festschrift' in appreciation of the work of Dr. W. H. Bradley, chief geologist (1944-59), 934
Geological Surveying by Helicopter, 521
Geological Terms : Glossary of, *review* by Dr. V. A Eyles, 57
Geological Ways and By-Ways, *review* by Dr. J. V. Harrison, 57, 440
Geological and Mining Society of the Netherlands (Royal) : Geological Nomenclature (English–Dutch–French–German), (edited by A. A. G. Schieferdecker), *review* by Dr V. A. Eyles, 57
Géologie des Pétroles (Prof Maurice Robert), *review* by H. B. Milner, 268
Geologische Vereinigung (Deutsche) : Jubilee Meeting (Discussion on Orogens), 206, 689
  Steinmann Medal awarded to Prof H. H Read, 206, 690
Geologiska Undersokning (Sveriges) : Ser. C, No. 560, The Measurement of Rock Pressure in Mines (Nils Hast), 936
Geology : Principles of (James Gilluly, A. C. Waters and A. O. Woodford), second edition, *review* by Dr. J. V. Harrison, 57, 440
  Scottish, 1019
Geology in the U S.S.R : The Progress of (Prof. S. I. Tomkeieff), 438
Geology of Petroleum, *review* by H. B. Milner, 268
Geology (Glacial and Interglacial), in East Anglia . Investigating (Dr. R. G. West), 771

Geomagnetic Activities : Correlation of Occurrence of Whistlers with (Atsushi Kimpara), 230
Geomagnetic Field Lines : Motion of (C. J. Loughnan), 33
Geomagnetic Fluctuations : Influence of Geological Features on Very Low Frequency (H. J. Duffus, J A. Shand and Sir Charles Wright), 141
Geometry : Differential (Prof. Erwin Kreyszig), review, 70
Geometry of the Southern Auroral Zone and the Evidence for the Existence of an Inner Zone (Dr. T. Hatherton), 288
Geophysical Observatory : Mundaring, 606
Geophysical Research Directorate (United States) : Guenter Loeser Memorial Lecture (Dr. Hans E. Hinteregger), 523
Geophysical Year, International : Ionospheric Observations over Belgium during the (Royal Meteorological Institute of Belgium), 203
  U.S S.R and the, 359
Geophysical Year (International) Expedition : Results of the Royal Society's (Royal Society Discussion on), 191
George, Dr E. P. : Action Potentials in Active Tissue with Delayed Potassium Permeability, 889
Gergen, Dr. John L , and Huch, Dr. William F : A Synoptic Study of Infra-red Radiation over the United States, 426, *erratum*, 604
Germain-Jones, Dr. D. T : *Obituary*, 21
German Academy of Science and the Austrian Academy of Science : Preparation of an edition of the letters of Alexander von Humboldt (1769-1859), 685
German Geological Association : Jubilee Meeting (Discussion on Orogens), 206, 689
  Steinmann Medal awarded to Prof H. H. Read, 206, 690
Germany (Austria and) : Frequencies of the Haptoglobin Serum Groups among Blood Donors from (Dr. H. Baitsch, G. Meier, L. Scoeller and D. M. Kahlich-Koenner), 976
Gershon, Dr. Samuel : Blocking Effect of Tetrahydroaminacrin on a New Psychotomimetic Agent, 1072
Giant-Fibre Reflex of the Earthworm (Dr M. B. V. Roberts), 167
Giarman, Prof Nicholas J , and others : Serotonin Content of the Pineal Glands of Man and Monkey, 480
Giarman, Prof Nicholas J. (Pepeu, Giancarlo, and) : Effect of Methylpentynol on Acetylcholine in the Rat's Brain, 638
Gibberella fujikuroi : Effects of, on Fungal Root-Infections of *Pinus* (Dr. Ida Levisohn), 987
Gibberellic Acid and Osmotic Pressure (J. van den Ende and P. Koornneef), 327
Gibberellin-like Biological Properties : Distribution and Prevalence of *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw) Wr.) producing Substances with (Prof. W. L. Gordon), 698
Gibberellin-like Substances in Lettuce Seed : Presence of (Dr. S. Blumenthal-Goldschmidt and Prof A. Lang), 815
Gibberellin-treated Wheat Seedlings : Chlorophyll Content of (Prof. Frederick T. Wolf and Dr. Alan H Haber), 217
Gibbons, Dr J. L. (Coppen, Dr. A. J., and) : Saliva–Serum Ratios of Tritium after the Administration of Tritiated Water, 724
Gibson, Dr. R E. : Presented with the Capt. Robert Dexter Conrad Award, 122 ; work of, 122
Gifkins, R. C. : Visco-Elastic Systems (Deformations in Crystals), 942
Gifted Children : Psychology of (Dr. W. D. Wall), 692
Gilbert, Dr. G. A. : Concentration-Dependent Sedimentation of Aggregating Proteins in the Ultracentrifuge, 882
Gilbert, Dr. James B , and Ku, Dr. Yuoh : Urinary Excretion of a Ninhydrin-positive Compound, probably a Peptide, after Administration of β-Amino*iso*butyric Acid to the Mouse, 160
Gilbert, L. A. : Reflectance of Coal Vitrains in the Visible and Ultra-Violet compared with that of Graphite, 143
Giles, Prof. Norman H. : Appointed acting chairman of the Department of Botany in Yale University, 1020
Gillies, D. K. A. : Awarded second prize (Canadian Awards) of the Darton Prizes of the Royal Meteorological Society, 440
Gillies, Dr. N E., and others : The Sigmoid Survival Curve in Radiobiology, 1062
Gillman, Prof. Theodore, and others : Aortic, Serum, Connective Tissue and Osseous Chemistry in Lathyritic Rats, 164
Gilluly, James, and others : Principles of Geology, second edition, *review* by Dr. J. V. Harrison, 57, 440
Gilman, D. J., and others : Pentafluoropyridine, 231
Gilmour, Darcy : Activity in relation to *p*H of Myosin-5'-Nucleotidase, 295
Giraffe : The Respiratory Dead Space of the (Prof. Eugene D. Robin, Dr. Joseph M. Corson and Prof. Gustave J. Dammin), 24
Girault, Prof Maurice (Dugué, Prof. Daniel, et) : Analyse de Variance et Plans d'Expérience, *review* by Dr. D. J Finney, 68
Girling, Dr. J. : Gas Chromatography (Studies on the Identification of the Primary Products of the Pyrolysis of Coal), 944
Giuffrè, R., and others : Oxygen Equilibrium of Myoglobin from *Thunnus thynnus*, 896
Glacial and Interglacial Geology in East Anglia : Investigating (Dr. R. G. West), 771
Glaessner, Dr M. F : West-Pacific Stratigraphic Correlation, 1039
Glaessner, Dr. M. F , and Daily, B. : Late Precambrian Fauna in South Australia, 205
Glands (Pineal), of Man and Monkey : Serotonin Content of the (Prof Nicholas J. Giarman, Daniel X. Freedman and Luis Picard-Ami), 480
Glass : Initiation of Clotting in Normal and Hageman Plasma by (Dr Preben Ollendorff), 173
  Solar Furnace (Origin of Tektites), (Dr. Gerald S. Hawkins and Dr. Sumner H. Wolfson), 1027
  Time-lags in the Intrinsic Electrical Breakdown of (M N. Azam and H. Dickinson), 146
Glass : Physics and Chemistry of, Vol. 1, No. 1, (Society of Glass Technology), 601
Glass Making : Journals and the Science of, 601
Glass Technology : Vol. 1, No. 1 (Society of Glass Technology), 601
Glass Technology, Society of : *Glass Technology*, Vol. 1, No. 1, 601
  Physics and Chemistry of Glass, Vol 1, No. 1, 601
Globin, Haemoglobin and Haptoglobin : Observations on, using a Rabbit Antiglobin Serum (D. S Rowe and J. F. Soothill), 975
Globins : Separation of the α- and β-Chains of, by means of Starch-gel Electrophoresis (C J Muller), 643
Globular Clusters (Dr. T D. Kinman), 608
β-Globulin : A Haemoglobin-binding, in Human Serum (Dr. M. P. Tombs), 1055
α_2-Globulin Region of Normal Human Sera : Agar-gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the (Dr. Jan Hirschfeld), 321
β-Globulin Polymorphism in the Serum Proteins of Pigs : Thread Protein and (G C. Ashton), 991
β-Globulins in Serum and Milk from Cattle : Inheritance of (Bo Gahne, Jan Rendel and Dr Ole Venge), 907
Glossary of Geological Terms, *review* by Dr. V. A. Eyles, 57
Glossary (Russian-English), of Optics and Spectroscopy, *review* by Prof. S. I. Tomkeieff, 347
Glossary (Russian–English), of Solid State Physics (edited by I. Emin), *review* by Prof. S I Tomkeieff, 347
Glossina morsitans : Determination of Physiological Age for Female (D. S. Saunders), 651
Glucose in the Dog : Abrupt and Delayed Effects of Insulin on the Distribution Space of (Dr. G Hetenyi, jun , and Prof G A. Wrenshall), 808
Glucose on Paper Chromatograms : Specific Detection of (Dr. M R. J. Salton), 966
Glucose Tolerance Test : Improvement of the Intravenous (Dr John C. Seed, Dr. Forman S. Acton and Dr. Albert J. Stunkard), 808
Glucose (Blood) in Crayfishes in relation to Moult and Handling (Dr J. A. Riegel), 727
Glucose-6-Phosphate Dehydrogenase Deficiency in Red Blood Cells of East Africans (Dr A C. Allison), 531
Gluesenkamp, Earl, and others : Synthetic Polyelectrolytes as Tumour Inhibitors, 778
Glutamic Acid in Tobacco Leaves inoculated with Tobacco Mosaic Virus : Decarboxylation of (M S. Gubanski), 657
D-Glutamic Acid : Isolation of Mutants of *Bacillus subtilis* requiring (Haruo Momose and Prof. Yonosuke Ikeda), 567
D-Glutamic Acid-requiring Mutants of *Bacillus subtilis* : Physiology of (Haruo Momose and Prof. Yonosuke Ikeda), 818
Glutathione (edited by E M. Crook), (Biochemical Society, Symposium No. 17, 1958), *review*, 669
Glutathione (Importance of), for the Enzyme Status in Intact Cells : Glutathione Stability and Pyrophosphatase Activity in Reticulocytes—Direct Evidence for the (Prof. S Rapoport and D. Scheuch), 967
Glutathione Stability and Pyrophosphatase Activity in Reticulocytes—Direct Evidence for the Importance of Glutathione for the Enzyme Status in Intact Cells (Prof S Rapoport and D. Scheuch), 967
Glycogen in the Liver : Changes in the Levels of Adenosine Triphosphate and, caused by Protein Administration (Dr. Catherine M. Clark, Dr G A. J. Goodlad, Dr. J. Chisholm and Dr H. N. Munro), 719
Glycolipids (Type-Specific), of *Mycobacteria* : Mycosides, a New Class of (Donald W Smith, H. M. Randall, A. P. MacLennan and E. Lederer), 887
Goat Herd (Feral) : Home Range in a (Thane Riney and Graeme Caughley), 125
Goats : Influence of Cervical Sympathectomy and Pituitary Stalk Section upon Milk Secretion in (G. B. Tverskoy), 782
Gochnauer, T. A., and others : Electrophoretic Components of the Proteins in Honeybee Larval Food, 633
Goddard, Prof L. S. : Mathematics and the Conduction of Heat in Solids, *review*, 421
Godel's Proof (Ernest Nagel and James R. Newman), *review* by F. I. G. Rawlins, 61
Godwin, Dr. H : Appointed professor of botany in the University of Cambridge, 356 ; work of, 356
Goitre : International Conference on, 523
Goitrogenous and Non-goitrogenous Cabbage : Level of Sulphydryl Compounds in Rat Liver following Feeding with (Jozef Sedlák), 892
Gold Medals of the Institute of Mining and Metallurgy awarded to E. D. McDermott and J. Kruttschnitt, 854
Gold Medals of the Linnean Society of London presented to Dr. Libbie Henrietta Hyman and Dr. H Hamshaw Thomas, 766
Goldacre, Dr R. J., and Bean, A. D : A Model for Morphogenesis, 294
Goldhammer, Helen, and McManus, W. R. : Effects of Non-ionic Surfactants upon Animal Tissues, 317
Golding, R. M. : Ultra-Violet Spectra of Water Solutions, 308
Goldmann, H , and others (edited by) : Documenta Ophthalmologica (Advances in Ophthalmology, Vol. 13), *review* by R. C. Davenport, 42
Goldstein, Dr. Herbert : Fundamental Aspects of Reactor Shielding, *review* by Dr. T. E. Allibone, 917
Golgi Bodies and Golgi Zones in Molluscan Oocytes (A. Bolognari), 565
Golgi Zones (Golgi Bodies and), in Molluscan Oocytes (A. Bolognari), 565
Gonadrotropin (Pregnant Mare Serum) : Effect of *p*H on Biological Activity of (Bengt H. Persson and Stig E J Melander), 163
Gonococcus Strains : Resistance of, to Penicillin (Alice Reyn and M. W. Bentzon), 608
Goodlad, Dr. G A. J., and others : Changes in the Levels of Adenosine Triphosphate and Glycogen in the Liver caused by Protein Administration, 719
Goodman, M. : Polymeric Progress (Recent Work by the Polymer Group at Brooklyn Polytechnic), 442
Goodwin, Prof. A. J. H. : *Obituary* by Dr. S. H Haughton, 761
Gopalakrishnan, T. P. (Gangolly, S. R.), and co-workers : Recent Advances in Coconut Research in India, 861
Gorbman, Dr. Aubrey (Oztan, Dr. Nezihe, and) : Responsiveness of the Neurosecretory System of Larval Lampreys (*Petromyzon marinus*) to Light, 167
Gordon, Prof W. L. : Distribution and Prevalence of *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw) Wr.) producing Substances with Gibberellin-like Biological Properties, 698
  Is *Nectria haematococca* Berk and Br. the Perfect Stage of *Fusarium oxysporum* Schl forma *pisi* (Lindf.) S. and H.?, 903
Gordon Research Conferences 1960, 283
Gorer, Dr P A : Elected a Fellow of the Royal Society, 11
  Cancer Research in the U S.S.R., *review*, 420
Gorham, P R , and others : Evidence of Concurrent Translocation, 205
Gorrill, Dr. R H. : Text-Book of Bacteriology, *review*, 111

Gosling, H. W. : Awarded a grant of £3,000 from the Paul Instrument Fund, for the construction of an instrument for checking the stability of the standard ampere, 520
Gossling, B. S. : Heritable Changes in Lactic Streptococci induced by Physical Treatments, 868
Gottschalk, Dr. Alfred : Correlation between Composition, Structure, Shape and Function of a Salivary Mucoprotein, 949
Gottstein, J. W. : Visco-Elastic Systems (Influence of Changes in Moisture Content), 943
Gould, G. N. : Advances in Veterinary Surgery, *review*, 667
Governing Technical Colleges, 769
Government : The Technical Colleges and their (Joint Federation of British Industries Technical Colleges Committee), 769
Government of the Federation of Malaya, and others : International Conference on Natural Rubber Research, 767
Government Organizations and Statutory Bodies concerned with Scientific Research and Technical Services in the Federation of Rhodesia and Nyasaland, 202
Gracie, J. J. : Fellowship of the City and Guilds of London Institute conferred on, 13
Graddon, Dr. D. P. : Nature of Cupric Alkanoate Solutions, 715
Graduate Fellowships for 1960-61 (United States National Science Foundation Awards), 684
Graduates (American College) : Marriage-Rate of, 22
Graduates (College) Fertility of (Population Reference Bureau, Inc., *Population Bulletin*, Vol. 15, No. 6), 22
Graft : Non-Specific Tolerance of, and the Dissociation of Two Types of Immunity (Dr. Milan Hašek and Dr. Jan Hort), 985
Graft versus Host Reaction in Parabiotic Disease (Dr. B. Nakić, Z. Nakić and V. Silobrčić), 322
Grafting : Biological Problems of—a Symposium, sponsored by the Commission Administrative du Patrimoine Universitaire de Liège and the Council for International Organizations of Medical Sciences), *review* by Dr. D. M. V. Parrott, 51
Graham-Bryce, Dr. I. J., and Corkill, J. M. : Use of Solvents containing Ethyl Iodide in the Investigation of Phosphorescence Spectra of Organic Compounds, 965
Grainer, Jr., Prof. Thomas H. : A Guide to the History of Bacteriology, *review* by Dr. R. H. Gorrill, 111
Grainger, L. : Reactor Fuel Element Technology, 1025
Grandison, A. G. C. : Poisonous Amphibians and Reptiles, *review*, 269
Granit, Prof. Ragnar A. : Elected a Foreign Member of the Royal Society, 435
Granites : Age of Emplacement of (Dr. W. Compston, Dr. P. M. Jeffery and G. H. Riley), 702
Granitsas, Dr. A. N., and others : Thyroid-Powder Feeding and Liver Nitrogen in Mice, 890
Grant, Dr. L. S. (Sigel, Dr. M. M., and) : Medical Research in the British Caribbean (Intra-dermal Inoculation against Asian Influenza), 863
Grant, Dr. R. A., and others : Aortic, Serum, Connective Tissue and Osseous Chemistry in Lathyritic Rats, 164
Grants from the Cheesman and Pethybridge funds, to enable students of mycology to attend the Spring or Autumn Foray, or the Plant Pathology Field Meeting (Applications invited from members of the British Mycological Society, and heads of departments, for), 440
Grants for Medical Research (Wellcome Trust), 439
Grants for Research in Marine Biology or Oceanography (Challenger Society), 854
Grants (Postgraduate Training), in Fishery Research (Development Commissioners, the Ministry of Agriculture, Fisheries and Food, and the Scottish Home Department), 360
Granules (Mast Cell) : A Specific Stain for (Dr. B. G. Radden), 400
Granuloma (Carrageenin) : Biological Significance of Peptide containing Hydroxyproline during the Development of (Dr. M. Chvapil and B. Cmuchalová), 806
Graphite : High-Temperature Creep of (Dr. D. B. Fischbach), 795
  Reflectance of Coal Vitrains in the Visible and Ultra-Violet compared with that of (L. A. Gilbert), 143
  Structure of, and the Kinetics of its Reactions (Société de Chimie Physique Conference on), 284
Graphite as a Lubricant : Action of (W. Bollmann and J. Spreadborough), 29
Graphite (Pyrolytic) : Tensile Behaviour of, at 2,750°C. (H. E. Martens and W. V. Kotlensky), 960
Graphites : Gas Content of (Dr. J. P. Redmond and Dr. P. L. Walker, jun.), 72
  Mosaic Texture of (E. G. Steward and B. P. Cook), 797
Gravitational Waves in General Relativity (Dr. H. Bondi), 535
Gray, Asa, 1810-1888 (Prof. A. Hunter Dupree), *review* by Sir Edward Salisbury, 44
Gray, A. R. : Precipitating Antibody in Trypanosomiasis of Cattle and other Animals, 1058
Gray, Sir James : How Animals Move (Royal Institution Christmas Lectures, 1951), *review* by Dr. N. B. Marshall, 921
Graymore, C. N., and others : Effect of Pituitary Growth Hormone *in vivo* on the Phosphorus/Oxygen Ratios of Isolated Rat Liver Mitochondria, 392
Great Britain : Dairying in, *review* by Dr. C. C. Balch, 504
  Education and the Youth of, 577
  Fossil Plants of the Carboniferous Rocks of (Dr. Robert Crookall), second edition, *review* T. M. Harris, 66
  University Entrance in, 14
  See also under Britain
Greatorex, Dr. C. A., and others : Detection of Recently Produced Fission Products in the Atmosphere, 223
  Radioactive Fallout during 1959, 925
Greek Science : A Source Book in (Prof. Morris R. Cohen and Dr. I. E. Drabkin), second printing, with corrections, *review*, 63
Green, Dr. H., and Silverblatt, Dr. F. : Effect of Antibody and Complement on Volume Control in an Ascites Tumour Cell, 646
Green, Prof. H. N. (Westrop, J. W., and) : Binding of a Hepatocarcinogen to the Structural Lipoprotein of Rat Liver—its Bearing on the Immunological Theory of Cancer, 350
Green, J., and others : Ubiquinones and Ubichromenols in the Rat, 554
  Effect of Thyroxine and 2,4-Dinitrophenol on Levels of Ubiquinone and Ubichromenol in the Rat, 725
Green, Dr. J. H. : Appointed reader in physiology at the Middlesex Hospital Medical School, London, 938
Green, Dr. J. H. (Dilli, S., and) : Radiation Synthesis of Urea, 383
Green, Dr. J. P. : Fractionation of Heparin on an Anion Exchanger, 472
Green, Prof. M. M. : Apparent Double Crossing-Over in a Short Genetic Interval in *Drosophila melanogaster*, 990
Green, Dr. R. A. : The Teaching of Veterinary Anatomy as a Branch of Biology—its Relationships to Human Anatomy, 192
Greenbaum, A. L., and others : Effect of Pituitary Growth Hormone *in vivo* on the Phosphorus/Oxygen Ratios of Isolated Rat Liver Mitochondria, 392
Greene, Dr. H. : Rice, *review*, 507
  Paddy Soils and Rice Production, 511
Greenham, G. C. : Mistletoe in Australia, 135
Greening, Dr. J. R. (Simpson, J. D., and) : Preparation of Tritiated Water Samples by Distillation, 467
Greenwood, Dr. A. D. : Co-ordination of Light and Electron Microscopy, 672
Gregg, Dr. S. J., and others : Oxidation of Beryllium in Carbon Dioxide and in Carbon Monoxide, 468
Gregory, Prof. F. G. : Elected to Fellowship of the Imperial College of Science and Technology, London, 522
Gregory, Hollingsworth F. (edited by, Morton Alperin and) : Vistas in Astronautics, Vol. 2 (Second Annual Astronautics Symposium sponsored by the United States Air Force Office of Scientific Research and the Institute of Aeronautical Sciences), *review* by D. G. King-Hele, 59
Grenville, H. (Clarke, Dr. K. U., and) : Nervous Control of Movements in the Foregut of *Schistocerca gregaria* Forsk., 98
Gresford, Guy B. : The Development of Science in South-East Asia, 859
Greville, Dr. G. D. : The Metabolism of Sulphur Compounds, *review*, 424
Grevillea robusta : Boron Deficiency in (A. N. Smith), 987
  Manganese Toxicity in (Dr. R. Child and A. N. Smith), 1067
Gribben, Dr. R. J. : Appointed a lecturer in mathematics at the University of Southampton, 284
Grid (Auxiliary) : Use of an, to stabilize the Gain of a Photomultiplier (Dr. C. F. G. Delaney and Dr. A. J. Walton), 625
Griew, Dr. S., and Lynn, Dr. R. : Construct 'Reactive Inhibition' in the Interpretation of Age Changes in Performance, 182
Griffin, Dr. D. M. : Perfect Stage of *Microsporum gypseum*, 94
Griffin, Prof. D. R. : Elected a member of the United States National Academy of Sciences, 773
Griffin, Jun., F. F., and others : Erythropoietine Production in the Dog, 561
Griffin and George, Ltd. : Appointment of R. C. Palmer as director of research, 206
Grinter, R. : Awarded a Ciba Fellowship for 1960-61, 684
Griseofulvin : Research into (Dr. P. W. Brian), 853
Grist, D. H. : Rice, third edition, *review* by Dr. H. Greene, 507
Grooved Rocks at Apoje, Nigeria (William Fagg), 205
Grossman, Dr. P. U. A. : Rheology in Australia, 941
  Visco-Elastic Systems (Continuum Theory), 943
Ground Water Hydrology (Prof. David Keith Todd), *review* by E. Miller, 423
Groundnut Variety Mani Pintar : Genetic Instability and Outcrossing in the (J. Smartt), 1070
Group Codes (Error-correcting) : A Systematic Method for the Construction of (Prof. R. B. Banerji), 627
Growing and in Non-growing Tissues : Enzymatic Deamination of 5-Deoxycytidylic Acid and of 5-Methyl-5'-deoxycytidylic Acid in (Dr. Eduardo Scarano, Massimo Talarico, Luisa Bonaduce and Benita De Petrocellis), 237
Growth : Human (Society for the Study of Human Biology Symposium on), 19
Growth of Plant Cell-Walls : Structure and, *review* by Prof. R. D. Preston, 920
Growth of Single Crystals of Copper (Rev. D. S. Kemsley), 33 ; (Prof. E. N. da C. Andrade), 540
Growth of Single Isolated Mammalian Cells : Are Macromolecules required for ? (Ralph B. Gwatkin), 984
Growth of *L*-Strain Fibroblasts : Some Effects of Different Tensions of Oxygen on the Respiration and (A. R. Fisher), 315
Growth of Surface Instabilities in a Linear Pinched Discharge (Dr. R. Latham, J. A. Nation, F. L. Curzon and Dr. A. Folkierski), 624
Growth in Weight and Tail Length of Inbred and Hybrid Mice reared at Two Different Temperatures (Prof. G. A. Harrison, R. J. Morton and Dr. J. S. Weiner), 446
Growth (Human) : Diagnosis of, *review* by Dr. K. M. Hawkins, 45
Growth (Pituitary) Hormone *in vivo* : Effect of, on the Phosphorus/Oxygen Ratios of Isolated Rat Liver Mitochondria (C. N. Graymore, A. H. Melhuish and A. L. Greenbaum), 392
Growth (Primary Neoplastic) : Chromosomes in (Dr. K. Bayreuther), 6
Growth (Secondary), in Plants : Detoxication during (C. M. Stewart), 374
Growth (Simplified Bulk), of *Vibrio foetus* (Dusan Jakovljevic and H. E. R. Beattie), 736
Growth Diagnosis (Leona M. Bayer and Nancy Bayley), *review* by Dr. K. M. Hawkins, 45
Growths (Crystal), and the Corrosion of Iron (Earl A. Gulbransen and Thomas P. Copan), 959
Grundlage (Äquivalenter) : Petrochemische Berechnungsmethoden auf (Prof. Conrad Burri), *review* by Prof. K. C. Dunham, 56
Grüneberg, Prof. H. : Outline of Human Genetics, *review*, 347
Grzybowska, J. T. (Jerzmanowska, Z. I., and) : Flavonoid Compounds in the Inflorescence of *Helichrysum arenarium*, 807
Guanidine Derivatives : Antimalarial Properties of some (Y. Ch. Chin, Y. Y. Wu, B. Skowrońska-Serafin, Prof. T. Urbański and J. Venulet), 170
Guarino, Angelo (Cacace, Fulvio, and) : Radiation Labelling with Carbon-14 of Aliphatic Hydrocarbons, 632
Gubanski, M. S. : Decarboxylation of Glutamic Acid in Tobacco Leaves inoculated with Tobacco Mosaic Virus, 657
Gugenberger, P. (presented by) : Proceedings of the International Conference on Nuclear Physics—Low-Energy Nuclear Interactions and Nuclear Structure (Paris 1958), *review* by Dr. E. Bretscher, 58
Guide to Freshwater Invertebrate Animals (Dr. T. T. Macan), *review* by Dr. J. P. Harding, 345
Guide to the History of Bacteriology (Prof. Thomas H. Grainger, Jr.), *review* by Dr. R. H. Gorrill, 111

Guide to Press Arrangements for Scientific, Medical and Technical Conferences (edited by Ronald Bedford), 437
Guide (An Easy), to Radio Astronomy, *review* by Dr. J S. Hey, 59
Guide-Book to Biochemistry (Kenneth Harrison), *review* by Prof. D. C. Harrison, 583
Guided Missiles : Use of Miniature Gyroscopes in Aircraft and (W. R. Simons), 522
Guidry, C. L. (Oró, Dr J , and) : A Novel Synthesis of Polypeptides, 156
Guinea Pig Lung (Chopped) · Inhibition of the Anaphylactic Release of Histamine from, by Chymotrypsin Substrates and Inhibitors (Dr. K. F. Austen and Dr. W. E Brocklehurst), 866
Guinea Pig Skin Effect of *S*-*β*-aminoethyl*iso*thiouronium Bromide Hydrobromide on X-Ray Damage to (Dr. J. B Walter and Prof. D Slome), 177
Guinea Pigs (Ovariectomized) · Normal Implantation in (Dr. Ruth Deanesly), 327
Gulbransen, Earl A , and Copan, Thomas P · Crystal Growths and the Corrosion of Iron, 959
Gum, Dr. C S. . *Obituary* by Dr. J L. Pawsey, 932
Gunlake, J H . Elected president of the Institute of Actuaries, 127
Guppies exposed to Elevated Temperature : Sex Difference in Accidental Mortality of (Prof. John A. Freeman), 491
Gupta, Brij L , and others : Position of the Proximal Centriole in Flagellate Spermatozoa, 899
Gurevitch, J , and others : Blood Groups in Rabbits, 321
Gustavson, Prof. K. H · *Obituary* of Dr. August Gansser-Burckhardt, 597
Gutenberg, Prof. B. *Obituary* by Dr. R Stoneley, 433
Gutowsky, Prof H S. · Elected a member of the United States National Academy of Sciences, 773
Gwatkin, Ralph B Are Macromolecules required for Growth of Single Isolated Mammalian Cells ?, 984
Gyraulus circumstratus, a Freshwater Snail · Chromosomes of (John B. Burch), 497
Gyroscopes (Miniature) : Use of, in Aircraft and Guided Missiles (W. R. Simons), 522

HAAS, Dr Paul · *Obituary* by Sir Edward Salisbury, 595
Haber, Dr Alan H. (Wolf, Prof. Frederick T., and) Chlorophyll Content of Gibberellin-treated Wheat Seedlings, 217
Haber, Jane M., and others · Evidence for a New Allele in the Kidd Blood Group System in Indians of Northern Mato Grosso, Brazil, 481
Habermann, Dr. Vlastimil, and Habermannová, Sona : Age Difference in Nicotinamide Mononucleotide Synthesis by Human Erythrocytes,, 389
Habermannová, Sona (Habermann, Dr. Vlastimil, and) . Age Difference in Nicotinamide Mononucleotide Synthesis by Human Erythrocytes, 389
Habib, Dr G. : Medical Research in the British Caribbean (Non-Addisonian Vitamin B_{12} Deficiency in the Adult), 863
Habits (Food), of Migratory Ducks (Harry G. Anderson), 17
Habrobracon Females · Divergence between Lethal Doses and Sterilizing Doses of X-Rays with Progressive Development in (Dr. Howard E. Erdman), 254
Hackmann, Dr. C. The Actinomycins and their Importance in the Treatment of Tumours in Animals and Man (Work of the Bayer Group in Germany with Actinomycin C and other Preparations), 772
Haddock, Prof. F. T (Kundu, Dr M. R , and) : A Relation between Solar Radio Emission and Polar Cap Absorption of Cosmic Noise, 610
Hadfield Medal for 1960 of the Iron and Steel Institute awarded to Dr J. C Hudson, 13
Haemoglobin in the Root Nodules of *Casuarina cunninghamiana* (Dr. H. E. Davenport), 653
Haemoglobin from *Thunnus thynnus* · Oxygen Equilibrium of (Prof. A Rossi-Fanelli and E Antonini), 895
Haemoglobin Content of the Larvae of *Tendipes f l plumosus* L. from Various Levels of Bed Sediment (B Czeczuga), 484
Haemoglobin Variants (Human) A New Electrophoretic Medium and its Application to the Resolution of (Dr. E. R Huehns and Dr. A. O. Jakubovic), 729
Haemoglobin-binding *β*-Globulin in Human Serum (Dr M P Tombs), 1055
Haemoglobin (Foetal), in the Monkey (N N. Sen, K C. Das and B. K. Aikat), 977
Haemoglobin and Erythrocyte Contents of Chick Blood . Influence of Dietary Intake of certain Insecticides on the (Prof. B K. Srivastava, H. C. Saxena and J. C. Sharma), 172
Haemoglobin and Haptoglobin (Globin,) : Observations on, using a Rabbit Antiglobin Serum (D. S Rowe and J. F Soothill), 975
Haemorrhagic Lipaemia in the Rat (Sven Punsar, Gottfried Hartel, Antti Louhija and Olli P. Heinonen), 888
Haemorrhagic Septicaemia : Mechanism of Immunity in (R. V. S. Bain), 734
Haffkine Institute, Bombay · Annual Report for 1958, 763
Hageman Plasma (Normal and) : Initiation of Clotting in, by Glass (Dr. Preben Ollendorff), 173
Hagihara, Prof Yusuke . Stability in Celestial Mechanics, *review* by Dr. R. H. Garstang, 60
  Awarded the James Craig Watson Medal of the United States National Academy of Sciences, 686 ; work of, 686
Hagiwara, Shin (Uetake, Hisao, and) Somatic Antigen 15 as a Precursor of Antigen 34 in *Salmonella*, 261
Haguenau, Fr., and others : Ultrastructure of the Clear Cells in Renal Carcinomas and its Importance for the Demonstration of their Renal Origin, 402
Hahn, Dr. F H. · Elected to an Official Fellowship of Churchill College, Cambridge, and College lecturer in economics, 440
Haigh, Dr. J. C. · Nature and Exploitation of Crop Plant Resistance to Disease (Breeding for Resistance to certain Diseases in Vegetable Crops), 857
Hailsham, Lord Teaching of Science, 850
Hakkinen, Dr. I. P. T. : A Modification for Washing the Benzidine Sulphate Precipitate in the Determination of Sulphate, 232
Hakkinen, Sauli : Traffic Accidents and Driver Characteristics, 273
Halimeda opuntia var. *minor* on Jamaican Shores : Occurrence of (P. F. James), 493
Hall, Dr. Gilbert . Memory and Learning, a Neurologist's Point of View, *review*, 39
Hall, G. R . Reactor Fuel Element Technology, 1025
Hall, Prof. K R. L. : 60 Years of Learning Theory, *review*, 40
Hall, R : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Halley Bay : The Royal Society's Expedition to, during the International Geophysical Year (Sir Graham Sutton), 191
Halliday, I M. D : Awarded the William Prize for 1959 of the Iron and Steel Institute, 13
Halmos, M. (Beck, Dr. M. T , and) : Acidic Dissociation Constant of Alcoholic Hydroxyls of Oxycarboxylic Acids—Mandelic Acid, 388
Halpern, Prof. J., and others . Mechanism of the Oxidation and Reduction of Metal Ions by Hydrogen Atoms, 629
Hamer, Dr. D : *Obituary* of Dr. C. J Still, 848
Hamilton, Dr H : Medical Research in the British Caribbean, 862
Hamilton, W D. · Awarded a Ciba Fellowship for 1960-61, 684
Hammond, Sir John : Tropical Animal Husbandry, *review*, 49
  Artificial Insemination in Cattle, *review*, 667
Hancock, Dr. R. Streptomycin-induced Lysis of Penicillin-treated *Staphylococci*, 658
Hand of Life—the Story of the Weizmann Institute (Ritchie Calder), *review*, 64
Handbook of Toxicology · Vol. 5, Fungicides (analysis and compilation by Everett F. Davis, Barbara L. Tuma and Lucy C Lee), edited by Dorothy S Dittmer, *review*, 64
Handbook of West African Flowers (Harold N Saunders), *review* by J. P M. Brenan, 65
Handling · Blood Glucose in Crayfishes in relation to Moult and (Dr. J. A. Riegel), 727
Hanley, Prof J A. : *Obituary* by Prof H. Cecil Pawson, 596
Haptoglobin Mixtures : Variations in Electrophoretic Position of, in Agar-gel Electrophoresis (Dr Jan Hirschfeld), 894
Haptoglobin Types in *Macaca irus* (Lars Beckman and Gunilla Cedermark), 643
Haptoglobin (Globin, Haemoglobin and) : Observations on, using a Rabbit Antiglobin Serum (D. S Rowe and J F Soothill), 975
Haptoglobin (Serum), in Rabbits Elevation of, in Response to Experimental Inflammation (R K Murray and G E. Connell), 86
Haptoglobin Serum Groups . Frequencies of the, among Blood Donors from Austria and Germany (Dr. H. Baitsch, G. Meier, L Schoeller and D. M. Kahlich-Koenner), 976
Haptoglobin Types in a Japanese Population (Prof E. Matsunaga and Kyoko Murai), 320
Haque, S. Q (Misra, Prof A P., and) · Perfect Stage of *Sclerotium rolfsii* Sacc , 567
Harbour Seal, *Phoca vitulina* L. Age Determination in the (A. W. Mansfield and H. D. Fisher), 92
Hard-Sphere Molecules : A Monte Carlo Equation of State for Mixtures of (E B Smith and K. R. Lea), 714
Hardening (Work) : First Stage of, in Aluminium Single Crystals (N. A McKinnon), 148
Harding, Dr. J. P . Freshwater Invertebrates, *review*, 345
Hardisty, M W : Sex Ratio of Ammocoetes, 988
Harland, Prof S C : Structure and Function of Genetic Elements, *review*, 63
  The National Institute of Genetics, Japan, 286
  Effect of Temperature on Growth in Weight and Tail-length of Inbred and Hybrid Mice, 446
  Nature and Exploitation of Crop Plant Resistance to Disease, 858
Harley, Dr. J L : The Biology of Mycorrhiza, *review* by Dr. J. Warren Wilson, 48
Harlow, Harry F , and colleagues . Development of Learning in the Rhesus Monkey, 211
Harmonic Generator : Millimetre Waves from Mercury Arc (Dr. K. D. Froome), 959
Harmonic Generator (Gas Discharge) : Coherence and Band-width of a (N. R. Bierrum, D. Walsh and J. C. Vokes), 626
Harper, J : Reactor Fuel Element Technology (Springfields Manufacturing Process from Ore to Machined Bars for Calder and Central Electricity Generating Board Fuel Elements), 1026
Harper, Dr K H., and Calcutt, Dr. G. · Conjugation of 3 4-Benzpyrenols in Mouse Skin, 80
Harkness Fellowships of the Commonwealth Fund (Elections for 1960), 15
Harrington, Dr. H. J , and others · Lower Tertiary Microfossils from McMurdo Sound, Antarctica, 700
Harris, Prof. G W. · At the Scientific Publications Council's Discussion on the Rapid Increase in the number of New Scientific Journals, 18
Harris, Dr. H. : Appointed to the University of London chair of biochemistry at King's College, 1020
Harris, T M : Fossil Plants of the Carboniferous Rocks of Great Britain, *review*, 66
Harris, W J. Size Distribution of Tobacco Smoke Droplets by a Replica Method, 537
Harrison, Prof D. C. : Die Aktivierte Essigsaure, *review*, 66
  Biochemistry and Medicine, *review*, 422
  A Guide-Book to Biochemistry, *review*, 583
  Steric Course of Microbiological Reactions, *review*, 835
Harrison, D. P. (Brenan, P. M., and) . Results of the Royal Society's International Geophysical Year Expedition (Work in Radio Astronomy), 191
Harrison, Dr. G. Ainsworth : Human Growth, 19
Harrison, Prof. G. A., and others : The Growth in Weight and Tail Length of Inbred and Hybrid Mice reared at Two Different Temperatures, 446
Harrison, Dr J V : Geological Ways and By-Ways, *review*, 57, 440
  Aspects of Orogens, 689
Harrison, Kennth : A Guide-Book to Biochemistry, *review* by Prof. D. C. Harrison, 583
Harrison, R A., and Smith, A. G. : Effect of Relative Humidity on Hatching and on Toxicity of Ovicides to Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina . Tetranychidae), 409
Harrison, V. A. H. : Ionospheric Effects associated with the Solar Flare of July 10, 1959, 228
Harrold, A. J. : Fibrinogenolysis in Joints, 1057
Hart, Helen, and others (edited by) · Plant Pathology, Problems and Progress, 1908-1958, *review* by W. C. Moore, 47

Hartland, A. (Powles, Dr. J. G., and) Proton Magnetic Resonance in a Series of Dimethyl Siloxane Polymers—a Specific Long-Chain Effect?, 26
Härtel, Gottfried, and others : Haemorrhagic Lipaemia in the Rat, 888
Hartland, S : Reactor Fuel Element Technology, 1025
Hašek, Dr. Milan, and Hort, Dr Jan Non-Specific Tolerance of Graft and the Dissociation of Two Types of Immunity, 985
Haskell, Dr. P. T : Sensory Specialization in Response to Environmental Demands (Sensory Equipment of the Migratory Locust), 688
Hast, Nils : The Measurement of Rock Pressure in Mines, 936
Hastie, A. C. : Nature and Exploitation of Crop Plant Resistance to Disease (Variation in *Verticillium albo-atrum* isolated from Hops), 858
Hastrup, Dr. J. : Awarded a Scholarship by the Tata Memorial Trust, for research on leukaemia and allied diseases, 1020
Haszeldine, Prof. R. N. : Light-Initiated Organic Synthesis, *review*, 53
  Industrial Chemistry of the Lower Olefines, 285
Hatching : Effect of Relative Humidity on, and on Toxicity of Ovicides to Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina : Tetranychidae), (R. A. Harrison and A G. Smith), 409
Hatherton, Dr. T. : Geometry of the Southern Auroral Zone and the Evidence for the Existence of an Inner Zone, 288
Hathorn, M., and others : Aortic, Serum, Connective Tissue and Osseous Chemistry in Lathyritic Rats, 164
Haughton, Dr. S. H. : *Obituary* of Prof A. J. H. Goodwin, 761
Haurwitz, Prof. B. : Elected a member of the United States National Academy of Sciences, 773
Hawes, C. G. : Fellowship of the City and Guilds of London Institute conferred on, 13
Hawkins, Dr. Gerald S., and Wolfson, Dr Sumner H. : Origin of Tektikes—Solar Furnace Glass, 1027
Hawkins, Dr J. D. Further Evidence for the Dual Nature of the Third Component of Complement, 483
Hawkins, Dr. K. M. : Diagnosis of Human Growth, *review*, 45
Hawkins, T H. : Health in Industry, *review*, 424
  Scientists and Administration, 446
Hayashi, Yoshiyuki : Xanthine Dehydrogenase in the Silkworm, *Bombyx mori* L., 1053
Haydak, M H., and others : Electrophoretic Components of the Proteins in Honeybee Larval Food, 633
Haynes, Prof —. Medical Research in the British Caribbean (Tropical Plants used for Medicinal Purposes), 863
Hayward, A. C. : A Method for Characterizing *Pseudomonas solanacearum*, 405
Hayward, Nancy J. Collagenase Maceration of Kidney for Microdissection, 403
Hazard of Tritium as a Deoxyribonucleic Acid Label in Man (R. Oliver and Dr. L. G. Lajtha), 91
Hazards : Genetic Radiation, *review* by Dr. A. G. Searle, 109
Health, United States Department of : Research Programmes in Ageing, 852
Health of the Executive (Diagnostic Clinic of the Graduate School of Medicine, University of Pennsylvania, Medical Affairs, Vol. I, No 3), 765
Health in Industry (Donald Hunter), *review* by T. H. Hawkins, 424
Health (Animal) Yearbook 1959 (Food and Agriculture Organization of the United Nations), 281
Health (Mental) Problems of Automation Study Group on the (World Health Organization, Report Series No. 183), 364
Health (Mental) Research Fund : Grant of £3,330 to the University of Oxford, for research on the physiology of drive, to be carried out in the Institute of Experimental Psychology, 126
Healy, W. B, and others : An Association between Dental Caries and certain Soil Conditions in New Zealand, 695
Heart : Korotkov's Sounds—Action of the (Wing-Comdr. J. E. Malcolm), 723
Heat in Solids : Conduction of (Prof. H S Carslaw and Prof J C. Jaeger), second edition, *review* by Prof. L. S. Goddard, 421
Heat in Solids : Mathematics and the Conduction of, *review* by Prof. L. S. Goddard, 421
Heat Shock : Blocking of Mitosis by (Per Bergan), 905
Heat Treatment Practice (British Iron and Steel Research Association Conference on), 523
Heated Culture Filtrates : Starch–Agar-Gel Electrophoresis of Tuberculoproteins from (T P. Dekker), 392
Heath, Prof. O. V. S. : Elected a Fellow of the Royal Society, 11
Heathcote, Dr. N. H de V. : Title of reader in the history and philosophy of science in the University of London (at University College) conferred on, 522
Heatley, Wendy, and others : Influence of Route of Inoculation and Strain of Mouse on Infectivity Titrations of the Virus of Foot-and-Mouth Disease, 909
Heats and Entropies of Reaction of Transition Metal Ions with Ethylenediamine (M. Ciampolini, P. Paoletti and Prof. L. Sacconi), 880
Heavenly Clockwork—the Great Astronomical Clocks of Medieval China (Dr. Joseph Needham, Dr. Wang Ling and Dr. Derek J. de Solla Price), *review* by Dr F. A. B. Ward, 834
Heavens and the Earth : Mathematics and the Sciences of the (Dr Joseph Needham, with the collaboration of Dr. Wang Ling), (Science and Civilization in China, Vol. 3), *review* by Prof. W. M Smart, 36
Hedberg, Prof. H D. : Elected a member of the United States National Academy of Sciences, 773
Hegarty, M P : Nitrogen in Tropical Agriculture (Nitrogen Uptake and Transformations), 941
Heinonen, Olli P., and others Haemorrhagic Lipaemia in the Rat, 888
Heisenberg, Prof. Werner : Physics and Philosophy, *review* by Prof L. Rosenfeld, 830
Heizer, Robert F., and others : Excavations at La Venta, Tabasco, 1955, 134
Helichrysum arenarium : Flavonoid Compounds in the Influorescence of (Z. I. Jerzmanowska and J. T. Grzybowska), 807
Helicopter Operations of the Geological Survey of Canada (Geological Survey of Canada, Bulletin No. 54), 521
Helium : A Supplement to (E. M. Lifshits and E. L. Andronikashvili), translated from the Russian, *review* by Prof. J. F. Allen, 835
  Liquid (Prof. K R. Atkins), *review* by Dr. J. G. Valatin, 345
Helium on Carbons : Adsorption of—Influence on Measurement of Density (Dr. F. A. P. Maggs, P. H. Schwabe and J H. Williams), 956
Helium Densities : Structure of High-Rank Coals deduced from (T. S. Polansky, H. J. Donald and Prof. C. R Kinney), 792
Helium–Butane Gas Mixtures as Fillings for Geiger-Muller Tubes (Dr. V. Moses and Dr. J. F. Fowler), 538
Hell, E., and others : Mechanism of the Radiation Effect on the Synthesis of Deoxyribonucleic Acid, 563
Helminthological Society of Washington : Fiftieth Anniversary, 206
Hemming, F W, and others : Dolichol, a Naturally Occurring Isoprenoid Alcohol, 470
Hemmings, W A. : Selection of Iodinated Protein in the Young Mouse, 399
Hems, G. Chemical Effects of Ionizing Radiation on Deoxyribonucleic Acid in Dilute Aqueous Solution, 710
Hen's Eggs : Vitamin A_1 Aldehyde in (Dr. P. A. Plack), 234
Henderson, J C. de C. : Appointed reader in reinforced concrete structures at the Imperial College of Science and Technology, London, 938
Hendrickse, R. G : Sickle-Cell Anaemia in Nigerian Children, 1027
Hendry, Dr. D P Appointed lecturer in psychology at the University of Durham, 937
Hens poisoned by Tri*para*ethylphenyl Phosphate : Ataxia in (Ann Silver), 766
Hentschel, Dr H. : Orogens (The Spilites of the Lahn-Dill Region), 690
Henzell, E. F. : Nitrogen in Tropical Agriculture (Use of Nitrogen Fertilizer on Pastures), 942
Henzell, E. F. (Norris, D O., and) : Nitrogen in Tropical Agriculture (Processes by which Nitrogen is added to the Soil/Plant System), 941
Heparin . Fractionation of, on an Anion Exchanger (Dr J P. Green), 472
Hepatectomy (Partial) : Histochemical and Biochemical Studies of Rat Liver in Experimental Cirrhosis after (I Bartók, Gy. Domján, E. Horváth and Prof B. Korpássy), 397
Hepatocarcinogen : Binding of a, to the Structural Lipoprotein of Rat Liver—its Bearing on the Immunological Theory of Cancer (J. W. Westrop and Prof. H. N. Green), 350
Herbert, J. D., and others : 'Prize', a Pre-ionized 'Theta' Pinch, 706
Herbert Spencerism, *review* by Dr. John Tucker, 37
Herbicide : 2,6-Dichlorobenzonitrile, a New (Dr. H. Koopman and J. Daams), 89
Herbst, W., and others : Effect of Supernatant Potassium-Level on Cardiac Activity in Quantitative Tissue Culture, 241
Heredity (Human) : Effects of Radiation on, 125
Herington, Dr E. F. G : Constants Galore, *review*, 918
Heritable Changes in Lactic Streptococci induced by Physical Treatments (B S Gossling), 868
Herskovits, Melville J. (edited by William R. Bascon and) : Continuity and Change in African Cultures, *review* by G. W. B. Huntingford, 38
Hertfordshire County Council Technical Information Service : Microtexts as Media for Publication, 602
Herzfeld, Prof. K F : Elected a member of the United States National Academy of Sciences, 773
Hetenyi, jun., Dr. G, and Wrenshall, Prof. G. A. : Abrupt and Delayed Effects of Insulin on the Distribution Space of Glucose in the Dog, 808
Heterogeneity of Lecithins labelled with Phosphorus-32 (Dr. F. D. Collins), 366
Heterogeneity of Tumour Ribonucleic Acid and the Effect of 'Degranol' on It (F. Antoni, E J. Hidvégi and K. Lapis), 81
Heterogeneous Labelling of Acid-soluble Nucleoside 5'-Monophosphates during Short *in vivo* Incubation with Phosphate-^{32}P (Dr. T. D. Price, K K. Tsuboi, H. A. Hinds and P. B. Hudson), 158
Hevea brasiliensis : Developments in the Propagation of Clones of, by Cuttings (G. H. Tinley and R. J Garner), 407
Hexamers (Insulin Dimers and) : Symmetry of (Prof. Barbara W. Low and J. Ralph Einstein), 470
Hexosamine and Hydroxyproline (Hexuronic Acid,) : Liberation of, from Steer Hide, by Stem Bromelain (E. A. Botan and T. B. Brother), 314
Hexuronic Acid, Hexosamine and Hydroxyproline from Steer Hide : Liberation of, by Stem Bromelain (E. A. Botan and T. B. Brother), 314
Hey, Dr J. S. : An Easy Guide to Radio Astronomy, *review*, 59
Heywood, J. (Edwards, R. W., and): Effect of a Sewage Effluent Discharge on the Deposition of Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith), 492
Hibernation of the European Corn Borer : Effect of Temperature on the (Stanley D. Beck), 774
Hide (Steer) : Liberation of Hexuronic Acid, Hexosamine and Hydroxyproline from, by Stem Bromelain (E. A Botan and T. B. Brother), 314
Hidvégi, E J, and others : Heterogeneity of Tumour Ribonucleic Acid and the Effect of 'Degranol' on it, 81
Hieger, Dr I. : Third Canadian Cancer Conference, *review*, 1001
Hieroglyphic Writing : Maya (J. Eric S. Thompson), second edition, *review* by Dr. G H S Bushnell, 580
Hieroglyphics : Maya, *review* by Dr. G. H. S. Bushnell, 580
Higgins, H. G : Visco-Elastic Systems (Behaviour of Hydrogen-bonded Materials), 942
Higgins, H. G. (De Yong, J, and) : Visco-Elastic Systems (Draining Studies on a Pad of Cellulose Fibres), 943
High Frequency of Spontaneous and Induced Somatic Segregation in *Aspergillus nidulans* (Dr. Etta Kafer), 619
High-Order Resistance to 'Dieldrin' in *Lucilia cuprina* Wied. : Selection for (G. J Shanahan), 100
High-Pressure Phase Transformations in Laboratory Mechanical Mixers and Mortars (Frank Dachille and Prof. Rustum Roy), 34
High-Rank Coals : Structure of, deduced from Helium Densities (T. S. Polansky, H. J Donald and Prof C R. Kinney), 792
High-Resolution Nuclear Magnetic Resonance Spectra of Starch Gels : Broadening of the Water Proton Line in (Dr. Roger Collison and Dr. M. P McDonald), 548
High-Temperature Creep of Graphite (Dr. D. B. Fischbach), 795
High-Temperature Fusion of Possible Parent Materials for Tektites (Origin of Tektites), (J F Lovering), 1028
High (Ultra-) Resolution γ-Ray Resonance in Zinc-67 (D. E. Nagle, P. P. Craig and W. E. Keller), 707
Higher National Certificates and Professional Status, 123
Higher Nervous Activity : *Pavlov Journal of* (translated from the Russian), 935
Hilgard, Prof. Ernest R. : Theories of Learning, second edition, *review* by Prof. K. R. L. Hall, 40

Hill, D. W. (Adlard, E. R , and) : Analysis of Anaesthetic Mixtures by Gas Chromatography, 1045
Hill, J. D. : Allotropic Transformations in Plutonium, 304
Hill, Dr. R., and Bendall, Dr. Fay : Function of the Two Cytochrome Components in Chloroplasts—a Working Hypothesis, 136
Hillary, Sir Edmund : The New Zealand Antarctic Expedition (Thomas Cawthron Memorial Lecture No. 33), 526
Hillas, A. M., and Cranshaw, T. E. : Comparison of the Charges of the Electron, Proton and Neutron, 459
Hillis, W. E : Biosynthesis of Flavonoids, 635
Hillman, Dr. William S. : Appointed assistant professor (plant physiology) in the Department of Botany in Yale University, 1020
Hills, Prof. T. L. : The St Lawrence Seaway, *review* by Prof. R. W. Steel, 110
Hinchley Medal of the British Association of Chemists awarded to Dr. C J. T. Cronshaw, 685
Hinde, Dr. R. A. : Early Ethology, *review*, 43
Hindered Phenols : Study of the Oxidation of, by Electron Spin Resonance (Dr. J. E. Bennett), 385
Hindle, Dr. Edward : Zoological Literature, *review*, 831
Hinds, H. A., and others · Heterogeneous Labelling of Acid-soluble Nucleoside 5'-Monophosphates during Short *in vivo* Incubation with Phosphate-^{32}P, 158
Hinshelwood, Sir Cyril : Results of the Royal Society's International Geophysical Year Expedition, 192
  Order of Merit conferred on, 361
Hinteregger, Dr. Hans E. : Solar Extreme Ultra-violet Radiation as a Source of Interplanetary Ionization (Guenter Loeser Memorial Lecture of the United States Geophysical Research Directorate), 523
Hip Joints (Normal Dog) · Clearance Rates of Sodium-24, Potassium-42 and Iodine-131 in (Prof. Patrick G. Laing and Dr. Ik Dong Kim), 898
Hirano, Shusuke, and others : Active Transport of γ-Aminobutyric Acid in Brain Cortex Slices, with special reference to Phosphorus-32 Turnover in Phospholipids in Cytoplasmic Particulates, 474
Hird, Dr. F. J R., and others · A Role for Thiol and Disulphide in Determining the Rheological Properties of Dough made from Wheaten Flour, 451
Hirono, Iwao : Non-Protein Sulphydryl Groups in the Original Strain and Sub-line of the Ascites Tumour resistant to Alkylating Reagents, 1059
Hirsch, P. B. (Diamond, R., and) X-Ray Studies of some Carbonized Coals, 204
Hirschfeld, Dr. Jan : Agar-gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_2-Globulin Region of Normal Human Sera, 321
  Variations in Electrophoretic Position of Haptoglobin Mixtures in Agar-gel Electrophoresis, 894
Hirst, Dr D. M. : Appointed lecturer in geochemistry at the University of Durham, 937
Hirst, J. M. : Diseases of Farm Crops, *review*, 65
Hirst, R. J. : The Problems of Perception, *review* by Prof M. D. Vernon, 919
Hiscocks, E S. : Organizaton and Methods, *review*, 62
  Management of Research Personnel, *review*, 579
Histamine from Chopped Guinea Pig Lung : Inhibition of the Anaphylactic Release of, by Chymotrypsin Substrates and Inhibitors (Dr. K. F Austen and Dr. W. E. Brocklehurst), 866
Histochemical Demonstration of Ascorbic Acid in the Locus Coeruleus of the Mammalian Brain (Dr. Nobuo Shimizu, Tomokazu Matsunami and Satoko Onishi), 479
Histochemical Estimation . Localization of Amino-acids for (Helen M. Notovny and Robert G. Owens), 1057
Histochemical and Biochemical Studies of Rat Liver in Experimental Cirrhosis after Partial Hepatectomy (I. Bartók, Gy. Domján, E. Horváth and Prof. B. Korpássy), 397
Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat (S. L. Liu), 475
History of Bacteriology . A Guide to the (Prof. Thomas H. Grainer, Jr.), *review* by Dr. R H. Gorrill, 111
History of Science · Tenth International Congress of the, 767
History of Scientific Ideas : Formation by the Nuffield Foundation of a Unit for the, 436
Hitschfeld, Dr. W. (Douglas, R. H , and) · Awarded jointly the first prize (Canadian Awards) of the Darton Prizes of the Royal Meteorological Society, 440
Hives, Lord : Awarded an honorary diploma in technology (engineering) by the National Council for Technological Awards, 767
Hlavka, Dr. Joseph J , and Buyske, Donald A. : Radioactive 7-Iodo-6-Deoxytetracycline in Tumour Tissue, 1064
Hnilicka, Dr. Milo P. : Appointed scientific assistant to the vice-president and director of research for the National Research Corporation of the United States, 604
Ho, S. K. (de Sousa, Dr. J. B., and) : Disproportionation and Dimerization of the Benzyloxyl Free Radical in Solution, 776
Hoagland's 'Carbowax' Systems : Freezing-Point Depressions of (Howard G. Applegate), 232
Hoare, A. M. : Appointed to a Research Fellowship in pure mathematics at the University of Birmingham, 937
Hobbs, Dr. Betty : Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds (Methods for Measuring the Practical Efficiency of Surface-Active Agents, with particular reference to the Catering Industry), 132, *erratum*, 206
Hodge, Paul W. : The Extragalactic Distance Scale, 622
Hoeppli, Prof. R : Parasites and Parasitic Infections in Early Medicine and Science, *review* by Dr. Ben Dawes, 46
Hofschneider, Dr. P H. · Plaque-forming Ability of Urea- or Plenol-treated T_2 Coli-Phage Preparations, 330
  T_1 and λ Phage Adsorption on Protoplast-like Bodies of *Escherichia coli*, 568
Hogan, T W. : Effect of Sub-Zero Temperatures on Diapause Eggs of *Acheta commodus* (Walk), 98
Hoja, S , and Vittek, J. Treatment of Injured and Regenerating Muscles with Plant Extracts, 283
Holder (Sample), for Radioactive Counting · An Inexpensive Castle and (Dr. Howard Boroughs), 145
Holland, A , and others · Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methylisothiazole), a New Antibacterial Sulphonamide, 221
Holliday, R. . Plant Population and Crop Yield, 22
Hollingworth, Prof. S. E. : Elected president of the Geological Society of London, 603
Holmes, I H., and others : Reactivation of Poxviruses by a Non-Genetic Mechanism, 902
Holmes, Dr. J. L : Appointed an I.C.I. Research Fellow in the University of Edinburgh, 767
Holmes, S. C A. : *Obituary* of F. H. Edmunds, 597
Holmgren, Dr. Uno, and others : Effects of Injection of Bovine Pineal Extract on the Nuclei of Rat Pineal Parenchymal Cells, 393
Holroyd, Dr. R. : Elected a Fellow of the Royal Society, 11
Holsti, Dr. Paul : Cirrhosis of the Liver Induced in Rabbits by Gastric Instillation of 3-Monohydroxycholanic Acid, 250
Holton, C. S., and others (edited by) : Plant Pathology, Problems and Progress, 1908–1958, *review* by W. C. Moore, 47
Holweck Medal and Prize (given jointly by the Société Française de Physique and the Physical Society) awarded to J. Brossel, 440
Home Range in a Feral Goat Herd (Thane Riney and Graeme Caughley), 125
Homeostasis of the Sex Ratio in *Drosophila* (Dr. P. A. Parsons), 411
Homogenates of Ehrlich Ascites Tumour Cells : Calcium Binding in (R. Schofield and D. Thomason), 656
Homogenates (E-Deficient Liver) : Maintenance of α-Ketoglutarate and Succinate Oxidation in, by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine (Dr. Laurence M. Corwin and Dr. Klaus Schwartz), 1048
Honeybee Larval Food : Electrophoretic Components of the Proteins in (N. G. Patel, M H. Haydak and T. A. Gochnauer), 633
Honeyman, Helen, and others : Mud Fauna of the Stour Estuary, 1018
Honours List : H.M. the Queen's Birthday, 933
Hooper, D. J. (Franklin, Mary T., and) : Plants Recorded as Resistant to Root-Knot Nematodes (*Meloidogyne* spp.), 684
Hopkins, Dr. B. : The Science Association of Nigeria, 442
Hopkins (Johns) Hospital, Baltimore · Grant of £15,000 from the Wellcome Trust, to adapt premises in the Department of Medicine as a research laboratory for studies of the heart and blood vessels in man, 439
Hormonally Active Steroids : A New Class of (Dr. E. H. Reerink, H F. L. Scholer, P. Westerhof, A. Querido, A. A. H. Kassenaar, E Diczfalusy and K. C. Tillinger), 168
Hormone (Interstitial Cell-stimulating) · Histophotometrical Study of the Effect of, on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat (S. L. Liu), 475
Hormone (Ovulating), in the Merino Ewe : Seasonal Differences in (Dr. D. R. Lamond), 971
Hormone (Pituitary Growth), *in vivo* : Effect of, on the Phosphorus/Oxygen Ratios of Isolated Rat Liver Mitochondria (C. N. Graymore, A. H. Melhursh and A. L. Greenbaum), 392
Hormones (Chromactivating), in the Pituitary of the Minnow : Distribution of (A. K. Kent), 395
Horn of Rantzien, H. : Fragments of Calcareous Algae in a Sediment Core from the Mindanao Trough (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No. 7), 609
Horning, Dr S. C : Mass of Elementary Particles, 708
Horology in Medieval China, *review* by Dr. F. A. B. Ward, 834
Horowitz, J., and others (edited by) : Physics and Mathematics, Vol. 3 (Progress in Nuclear Energy, Series 1), *review* by Dr. E. R. Rae, 68
Horridge, Dr. G. A , and Roberts, Dr. M. B. V : Neuro-Muscular Transmission in the Earthworm, 650
Horseshoe Crab, *Limulus polyphemus* : Visual Pigment of the (Dr. Ruth Hubbard and Prof. George Wald), 212
Horsfall, J. G., and Dimond, A. E. (edited by) : Plant Pathology, an Advanced Treatise, Vol. I, The Diseased Plant, *review* by W. C. Moore, 47
Hort, Dr. Jan (Hašek, Dr. Milan, and) : Non-Specific Tolerance of Graft and the Dissociation of Two Types of Immunity, 985
Horticultural Society (Royal) : Bowles Memorial Travel Scholarship, 206
Horváth, E., and others : Histochemical and Biochemical Studies of Rat Liver in Experimental Cirrhosis after Partial Hepatectomy, 397
Hoshino, Munemitsu : Effect of 3-Amino-1,2,4-triazole on the Experimental Production of Liver Cancer, 174
Hosie Phenomenon : Pulsatile Flow through Tapered Distensible Vessels, Reflexions, and the (Robert L. Evans), 290
Hospitals in Ambulatory and Domiciliary Medical Care : Role of—Second Report of the Expert Committee on Organization of Medical Care (United Nations, World Health Organization, Technical Report Series No. 176), 202
Hossack, D., and others : Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methyl*iso*thiazole), a New Antibacterial Sulphonamide, 221
Host Reaction · Graft versus, in Parabiotic Disease (Dr. B. Nakič, Z. Nakič and V. Silobrčič), 322
Hot Molecules (Vibrationally), in Free-Radical Reactions : A Model to account for the Production of (Dr. J P. Simons), 551
Hougen, Prof Olaf A , and others : Chemical Process Principles, Part 2, Thermodynamics, second edition, *review* by L. E. Marc de Chazal, 1003
House of Commons : Adjournment Debate on Marine Nuclear Propulsion, 122
  Debate on the Ballistic Missile Early Warning Station at Fylingdales Moor, 357
  Debate on the Crowther Report, 577
  Debate on the Supply of Teachers of Mathematics, 600
House of Lords : Debate on the Antarctic, 212
  Debate on the Crowther Report, 577
Housefly (Adult) ,*Musca domestica* : Mechanisms of Resistance of the, to 'Cyclodiene' Insecticides (Dr. G T. Brooks), 96
Housing and Local Government, Ministry of Final Report of the Trade Effluents Sub-Committee of the Central Advisory Water Committee, 210
Hovland, Prof C. I. : Elected a member of the United States National Academy of Sciences, 773
Howard, A M : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Howard, Dr. H. W , and Wainwright, J : Potato Virus *M* and Paracrinkle, 993
Howard-Flanders, Dr. P. · Effect of Oxygen on the Radiosensitivity of Bacteriophage in the Presence of Sulphydryl Compounds, 485

Howarth, F. : Dinner to be held in honour of, on his retirement from the Botany Department of the Imperial College of Science and Technology, London, 604
Howes, Dr F. N. : The Wealth of India, *review*, 70
Hsia, Dr. David Yi-Yung, and others : Development of 5-Hydroxytryptophan Decarboxylase Activity in Rat Kidney, 717
Hsiao, Dr. C. C. : Time-Dependent Tensile Strength of Solids, 535
Huang, Dr Irene, and others : Development of 5-Hydroxytryptophan Decarboxylase Activity in Rat Kidney, 717
Hubbard, Dr. Ruth, and Wald, Prof. George : Visual Pigment of the Horseshoe Crab, *Limulus polyphemus*, 212
Hubble, G. D., and Martin, A. E. : Nitrogen in Tropical Agriculture (Nitrogen Status of Queensland Soils), 941
Huch, Dr. William F (Gergen, Dr. John L., and) : A Synoptic Study of Infra-red Radiation over the United States, 426, *erratum*, 604
Hudlická, O. (Drahota, Dr. Z., and) : Effect of Denervation on Potassium-42 Uptake by the Rat Muscle *in vitro*, 396
Hudson, Dr J. C. : Awarded the Sir Robert Hadfield Medal for 1960 of the Iron and Steel Institute, 13
Hudson, L. : A Differential Test of Arts/Science Aptitude, 413
Hudson, P. B, and others : Heterogeneous Labelling of Acid-soluble Nucleoside 5'-Monophosphates during Short *In vivo* Incubation with Phosphate-^{32}P, 158
Hudson, Dr P. S. : Genetyka, *review*, 507
Huebner, Dr. R. J. Elected a member of the United States National Academy of Sciences, 773
Huehns, Dr. E. R., and Jakubovic, Dr. A. O. : A New Electrophoretic Medium and its Application to the Resolution of Human Haemoglobin Variants, 729
Huggett, Prof. A. St. G. : General Physiology, *review*, 52, 284
Huggins, Dr. Charles M., and Le Blanc, Jun, Dr. Oliver H. : Electrical and Magnetic Properties of β-Carotene Triiodide, 552
Hughes, Dr. Donald J. : *Obituary* by Dr. E. Bretscher, 848
Hughes, Dr. Donald J., and others (edited by) : Physics and Mathematics, Vol. 3 (Progress in Nuclear Energy, Series I), *review* by Dr. E. R. Rae, 68
Hughes, V. A. : Roughness of the Moon as a Radar Reflector, 873
Hughes, Dr. W. H., and Cardew, Dr. P. N. : An Apparatus for Panning in Ciné Micrography, 258
Hull, Dr. D. E. : Thermodynamics and Kinetics of Spontaneous Generation, 693
Human Amnion : Ultra-Structure of, and its Possible Relation to the Circulation of Amniotic Fluid (Dr. Gordon L Bourne and Dr. Dennis Lacy), 952
Human Anatomy : The Teaching of Veterinary Anatomy as a Branch of Biology—its Relationships to (Dr. R. A. Green), 192
Human Bile : Seromucoid Contents of (Dr. C. Mihaescu and Edith Mihaescu), 394
Human Biology, Society for the Study of : Symposium on Human Growth, 19
Human Blood-Group Antigen M : M_1, a Subdivision of the (J. A. Jack, Patricia Tippett, Jean Noades, Dr. Ruth Sanger and Dr. R. R. Race), 642
Human Cancer : Biological Equilibria in (Dr. Kenneth W. Starr), 1006
Human Cells in Tissue Culture : Effect of Oxygen and Nitric Oxide on the Radiosensitivity of (Dr. D. L. Dewey), 780
Human Cerebrospinal Fluid : Calcium and Magnesium in (Dr. G. Hunter and Honor V. Smith), 161
Human Cerebrospinal Fluids : 5-Hydroxyindoles in (G. W. Ashcroft and D. F. Sharman), 1050
Human Element in Research Management (Dr. B. E. Noltingk), *review* by E. S. Hiscocks, 579
Human Erythrocytes : Age Difference in Nicotinamide Mononucleotide Synthesis by (Dr. Vlastimil Habermann and Sona Habermannová), 389
Human Fertility : Problems of, *review* by Dr. Kenneth Walker, 188
Human Fertility Problem : Modern Science and the (Dr. Richard L. Meier), *review* by Dr. Kenneth Walker, 188
Human Genetics : Outline of (Prof. L. S. Penrose), *review* by Prof. H. Grüneberg, 347
Human Growth (Society for the Study of Human Biology Symposium on), 19
  Diagnosis of, *review* by Dr. K. M. Hawkins, 45
Human Haemoglobin Variants : A New Electrophoretic Medium and its Application to the Resolution of (Dr. E. R. Huehns and Dr. A. O. Jakubovic), 729
Human Heredity · Effects of Radiation on, 125
Human Knowledge : The Integration of (Prof. Oliver L. Reiser), *review* by Dr John Tucker, 37
Human Leucocytes · Culture of, on the Chorioallantoic Membrane of the Chick (Eugene Bell), 403
  Infra-Red Spectra of Deoxyribonucleic Acids from (G. Zerbi, P. A. Bianchi and E. E. Polli), 964
Human Problems of Innovation (Based on a Study of some Scottish Firms by Tom Burns and G M. Stalker), (Department of Scientific and Industrial Research, Problems of Progress in Industry No. 5), 419
Human Problems of Innovation in Industry, 419
Human Repercussions : Automation and its, 364
Human Rites, *review* by Dr Kenneth Walker, 37
Human Sera (Normal) · Agar-gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_2-Globulin Region of (Dr. Jan Hirschfeld), 321
Human Serum · A Haemoglobin-binding β-Globulin in (Dr. M. P. Tombs), 1055
Human Serum and Plasma · Antithromboplastin in (Dr. T. G. Scott, Dr. C. Symons and R L. Markham), 248
Human Spermatozoa Nuclear Morphology of (Dr Landrum B. Shettles), 648
Human White Cells and Platelets : Microelectrophoresis of (Dr. William P. Creger and Phyllis Menna Thomas), 171
Humboldt University, Berlin : 250th Anniversary of the Charité (Faculty of Medicine), 361
Humic Acid Decomposition of, by Fungi (Prof. Alan Burges and Pamela Latter), 404
Humidity (Relative) · Effect of, on Hatching and on Toxicity of Ovicides to Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina : Tetranychidae), (R. A. Harrison and A. G. Smith), 409
Humphreys, K. W., and Barry, H. D. : Cost of Scientific Periodical Publications, 124
Humphries, Dr. E C. : East African Agriculture and Forestry, 133
Hungarian Academy of Sciences : International Conference on Scientific Problems of Crop Protection, 523
Hunter, Donald : Health in Industry, *review* by T. H. Hawkins, 424
Hunter, Dr. G., and Smith, Honor V. : Calcium and Magnesium in Human Cerebrospinal Fluid, 161
Huntingford, G. W. B. : African Cultures, *review*, 38
Huntsman, Dr. R. G. (Anstall, Dr. H. B., and) · Influence of Temperature upon Blood Coagulation in a Cold- and a Warm-blooded Animal, 726
Hurst, Dr. E. Weston, and Reeve, P : Transmission of the Viruses of Trachoma, Inclusion Blennorrhoea and Lymphogranuloma to Mice, 336
Husbandry : Tropical Animal, *review* by Sir John Hammond, 49
Husbandry (Animal), in the Tropics : An Introduction to (G. Williamson and Dr. W. J. A Payne), *review* by Sir John Hammond, 49
Husbandry (Sheep), and Wool Technology at Pretoria, 280
Hushfar, F. (Donahue, T. M, and) : Detection of Negative Ions formed by Charge Transfer, 1038
Hussey, Dr. R. J., and others : Oxidation of Beryllium in Carbon Dioxide and in Carbon Monoxide, 468
Hutchinson, Dr. Franklin, and others : A Connexion between S–S Bond Breakage and Inactivation by Radiation of a Dry Enzyme, 312
Hutchinson, Prof. G. Evelyn : Elected a member of the Council of the United States National Academy of Sciences, 773
Hutchinson, Prof G. W. : Appointed to a newly established second chair of physics in the University of Southampton, 762 ; work of, 762
Hutson, Dr. D. H, and others . Action of a Bacterial Dextranase on Branched Dextrans, 553
Hutton, E. (Stevens, Dr. B., and) : Radiative Life-time of the Pyrene Dimer and the Possible Role of Excited Dimers in Energy Transfer Processes, 1045
Hutton, Prof. J. H. : *Obituary* of J. P. Mills, 1015
Hutton, Rosemary · Regular Micropulsations of the Earth's Field at the Equator, 955
Huxley, A. F. : Appointed to the University of London chair of physiology at University College, 1020
Huxley, Dr. H. E. : Elected a Fellow of the Royal Society, 11
Huygelen, Dr. C., and others · Isolation of a Cytopathogenic Agent from Skin Lesions of Cattle, 979
Hybrid Mice (Inbred and), reared at Two Different Temperatures : The Growth in Weight and Tail Length of (Prof. G. A. Harrison, R. J. Morton and Dr. J. S. Weiner), 446
Hybrids (Interspecific), of *Lycopersicum* (Dr. Donald Michie), 1071 ; (Helgi Nirk), 1071
Hyde, Earl K. : The Radiochemistry of Francium, 602
Hydrazine Complexes (Metal) : The 'Irving–Williams' Order in the Metal-ligand Stretching Frequencies of some (Prof. L. Sacconi and A. Sabatini), 549
Hydrobromide (S-β-aminoethylisothiouronium Bromide) : Effect of, on X-Ray Damage to Guinea Pig Skin (Dr. J. B. Walter and Prof. S. Slome), 177
Hydrocarbon Conversion : Hydrocarbon Synthesis and (Indian Institute of Science Symposium on), 691
Hydrocarbon Polymers : Mode of Radiation-Induced Cross-Linking in (T. F. Williams), 544
Hydrocarbon Synthesis and Hydrocarbon Conversion (Indian Institute of Science Symposium on), 691
Hydrocarbons in 'Painted' Mouse Skin : Effect of Molecular Structure upon Concentration of (Mary Burnham and Fred G. Bock), 323
Hydrocarbons (Aliphatic) : Radiation Labelling with Carbon-14 of (Fulvio Cacace and Angelo Guarino), 632
Hydrodynamics : Applied (H. R. Vallentine), *review* by E. P. Sutton, 669
Hydrogen Atoms : Mechanism of the Oxidation and Reduction of Metal Ions by (Prof. J. Halpern, G. Czapski, J. Jortner and Dr. G. Stein), 629
Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide irradiated with Ultra-violet Light : Use of Nitrous Oxide to discriminate between Various Forms of (Prof. F. S. Dainton and S. A. Sills), 879
Hydrogen Atoms ($H\cdot$ and H_2^+ ?) produced by γ-Irradiation of Aqueous Solutions · Use of Nitrous Oxide to discriminate between the Forms of (Prof. F. S. Dainton and Dr. D B. Peterson), 878
Hydrogen Ions : Mechanism of the Gastric Secretion of (Prof. Spyridon G. A. Alivisatos), 368
Hydrogen Molecule : Gaussian Wave Functions for the (J. Y. L. Longstaff and Dr. K. Singer), 799
Hydrogen Peroxide and Ionizing Rays : Combined Application of, in Animal Experiments (E. Fleischmann, H. Werkgartner and K. Karrer), 324
Hydrogen Peroxide–Water Solutions at 90°K. Irradiated with Ultra-Violet Light : Electron Spin Resonance in (Robert C. Smith and S. J. Wyatt), 226
Hydrology : Ground Water (Prof. David Keith Todd), *review* by E. Miller, 423
Hydrolysis by Chymotrypsin : Requirements for Stereospecificity in—Diethyl β-Acetamidoglutarate (Prof. Saul G. Cohen and Ezra Khedouri), 75
Hydroxide (Potassium) · Photo-stimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or (J. Wawrzyniak and Dr. B. Sujak), 467
11β-Hydroxy Dehydrogenation (Microbiological), of Corticosterone (M. Shirasaka, R. Takasaki and M. Tsuruta), 390
4-Hydroxybenzaldehyde : Alkaline Conversion of 4-Hydroxyphenylpyruvic Acid to (Dr. C. H. Doy), 529
5-Hydroxyindoles : Vanadium Catalysis of the Oxidation of Catechol Amines, Dihydroxyphenylalanine and (Dr. G. M. Martin, E. P. Benditt and N. Eriksen), 884
5-Hydroxyindoles in Human Cerebrospinal Fluids (G. W. Ashcroft and D. F. Sharman), 1050
Hydroxyls (Alcoholic), of Oxycarboxylic Acids : Acidic Dissociation Constant of—Mandelic Acid (Dr. M. T. Beck and M. Halmos), 388
4-Hydroxyphenylpyruvic Acid : Alkaline Conversion of, to 4-Hydroxybenzaldehyde (Dr. C. H. Doy), 529
Hydroxyproline : Biological Significance of Peptide containing, during the Development of Carrageenin Granuloma (Dr. M. Chvapil and B. Cmuchalová), 806

Hydroxyproline from Steer Hide : Liberation of Hexuronic Acid, Hexosamine and, by Stem Bromelain (E A. Botan and T B Brother), 314
5-Hydroxytryptamine in Coelenterates (Prof. J H Welsh), 811
5-Hydroxytryptophan Decarboxylase Activity · Development of, in Rat Kidney (Dr. Irene Huang, Sheila Tannenbaum and Dr. David Yi-Yung Hsia), 717
Hylobius abietis : The Large Pine Weevil (Forestry Commission, Leaflet No. 1), revised edition, 521
Hyman, Dr Libbie Henrietta : Presented with a Gold Medal of the Linnean Society of London, 766
Hyman, Ray (Vogt, Evon Z., and) : Water-Witching U.S A., *review* by Prof. H. J Eysenck, 346
Hyperstatic Structures (Prof. J. A. L. Matheson), Vol 1, *review* by Prof. A. J. S. Pippard, 582
Hypothermia (Chlorpromazine) : Postural Changes in (Dr D. Svorad), 240

IDENTIFICATION of Isomeric Chondroitin Sulphates (J. B Adams), 555
Ignition . Explosions, Detonations, Flammability and, Part 1 (Prof. S S. Penner) ; Part 2 (B. P. Mullins), *review* by Dr. H. F. Coward, 666
Ikeda, Prof. Yônosuke (Momose, Haruo, and) : Isolation of Mutants of *Bacillus subtilis* requiring D-Glutamic Acid, 567
  Physiology of D-Glutamic Acid-requiring Mutants of *Bacillus subtilis*, 818
Illiac II (a copy of) to be installed in the Computation Centre of the University of Toronto, 682
Illinois Natural History Survey : Bulletin, Vol. 27, Article 4, Food Habits of Migratory Ducks (Harry G. Anderson), 17
Illuminating Engineering Society Summer Meeting, 206
Imagination · The Sociological (Prof. C Wright Mills), *review* by E. Gellner, 504
Immobilization Antigens of *Paramecium aurelia* · Genetical and Biochemical Studies of the (J. O. Bishop and Dr. G. H. Beale), 734
Immunity : Non-Specific Tolerance of Graft and the Dissociation of Two Types of (Dr Milan Hašek and Dr. Jan Hort), 985
Immunity in Haemorrhagic Septicaemia . Mechanism of (R V. S Bain), 734
Immunological Theory of Cancer : Binding of a Hepatocarcinogen to the Structural Lipoprotein of Rat Liver—its Bearing on the (H. W. Westrop and Prof. H. N. Green), 350
Immunological Tolerance A Possible Basis for (Dr. D T. Denhardt), 728
Immunologically Competent Cells in the Chick Embryo . Loss of Specificity on Passage of (Sir Macfarlane Burnet and Georgiana Boyer), 175
Immunology of Tumours . Pathogenesis and (edited by G. V. Vygodchikov), translated from the Russian by R. Crawford, *review* by Dr. P. A. Gorer, 420
Impacts of Scientific Research and Development : Projects in Colleges and Universities on the Economic and other (United States National Science Foundation), 14
Impedance (Total Acoustic Radiation), of Rigid Pistons in an Array Measurements of the (J. S. M Rusby), 144
Imperfections (Solid) : Superficial Chemistry and (Prof. F. C Tompkins), 3
Imperial Chemical Industries, Ltd. New Ammonia Plant at Severnside, 202
Imperial College of Science and Technology, London : Fifty-second Annual Report of the Governing Body (1958-59), 123
  Research Report of the Royal College of Science (1956-59), 123
  New Nematology Laboratory to be built and equipped at the Field Station at Silwood Park, 205
  Booklet on Postgraduate Courses (1960-61), 206
  Appointment of Dr. D. V. Ager to the University of London readership in geology, 522
  Election of Sir Harold Roxbee Cox, Prof. C W. Dannatt, Prof F. G. Gregory, G. C. Lowry and Sir William Pugh to Fellowships, 522
  Dinner to be held in honour of F Howarth, on his retirement from the Botany Department, 604
  Optical Design group to be set up under the direction of Dr. C. G. Wynne, with the support of a grant of £9,400 a year from the Department of Scientific and Industrial Research, 934
  Appointment of J. C de C. Henderson as reader in reinforced concrete structures, 938
  Course of Lectures in Reactor Fuel Element Technology, 1025
Implantation (Normal), in Ovariectomized Guinea Pigs (Dr. Ruth Deanesly), 327
Implications (Economic and Social), of Scientific Research and Development : A Bibliography on the (United States National Science Foundation), 14
Importance for the Demonstration of their Renal Origin Ultrastructure of the Clear Cells in Renal Carcinomas and its (Prof Ch. Oberling. M. Rivière and Fr. Haguenau), 402
Importance of Glutathione for the Enzyme Status in Intact Cells Glutathione Stability and Purophosphatase Activity in Reticulocytes—Direct Evidence for the (Prof S. Rapoport and D. Scheuch), 967
Importance in the Treatment of Tumours in Animals and Man : Actinomycins and their (New York Academy of Sciences Conference on), 771
Improvement of the Intravenous Glucose Tolerance Test (Dr. John C. Seed, Dr. Forman S. Acton and Dr. Albert J Stunkard), 808
nability of Methionine to affect Lethality in Mice and Rats exposed to X-Rays (Prof Zenon M. Bacq and Dr. Marie L Beaumariage), 1064
Inability of Thiotaurine to protect Mice against Ionizing Radiation (Dr. D. Cavallini and L. Tentori), 254
Inactivation of Cytochrome b_2 by Oxygen : Flavin Dissociation and (A New Type of Autoxidation Reaction), (J McD. Armstrong, Dr. J. H. Coates and Prof. R. K. Morton), 1033
Inactivation by Radiation of a Dry Enzyme · A Connexion between S–S Bond Breakage and (Dilip K. Ray, Dr. Franklin Hutchinson and H. J. Morowitz), 312
Inactivation of Trypsin by Ionizing Radiation · Effect of Oxygen on the (Prof. J. A. V. Butler and Dr. A. B. Robins), 697
Inactivation by Visible Light of Yeast sensitized by a Nucleic Acid Fluorochrome (David Freifelder and Prof Robert B. Uretz), 731
Inbred Lines of Chickens Differences in Numbers of Erythrocytes between (Dr. P. Jaffe), 978
Inbred and Hybrid Mice reared at Two Different Temperatures : The Growth in Weight and Tail Length of (Prof. G. A. Harrison, R. J. Morton and Dr J. S. Weiner), 446
Inception of Agriculture · Increase of Settlement Size and Population since the (Dr. Max Pettersson), 870
Inclusion Blennorrhoea and Lymphogranuloma (Trachoma,) : Transmission of the Viruses of, to Mice (Dr. E. Weston Hurst and P. Reeve), 336
Inclusions (Cytoplasmic), of the Ageing Neurons of some Teleosts (Prof. A. Stolk), 332
Increase in 'Alkaline' Ribonuclease of Rat Kidney Cortex after Lysozyme and Egg-White Administration (Dr. T. Maack, Dr. R. Brentani and Dr. M. Rabinovitch), 158
Increase in Environmental Temperature : Oxygen Consumption in Cattle in relation to Rate of (Prof. H. H. Kibler), 972
Increase of Settlement Size and Population since the Inception of Agriculture (Dr. Max Pettersson), 870
Increased Capillary Permeability in Injury by Monoamine Oxidase Inhibitors · Suppression of (W. G Spector and D. A Willoughby), 162
Increased Oxygen Consumption in Rats during Irradiation : Significance of Adrenals for (Dr. A. Vacek), 90
Incubation (Short *in vivo*), with Phosphate-^{32}P . Heterogeneous Labelling of Acid-soluble Nucleoside 5'-Monophosphates during (Dr. T. D. Price, K K. Tsuboi, H. A. Hinds and P. B. Hudson), 158
Indanthrene : Electron Microscopy and the Crystal Structure of (Lewis T. Chadderton), 541
Indeterminate Structures (Statically) : A Treatise on, *review* by Prof. A. J. S. Pippard, 582
Index of Crystallographic Supplies (edited by Dr. A. J. Rose), second edition (Société Française de Minéralogie et de Cristallographie), 1019
Indexing in Science : Classification and (B. C. Vickery and D. J. Foskett), second edition, *review* by R. Brightman, 190
India : Recent Advances in Coconut Research in (Indian Central Coconut Committee Conference on), 860
  The Wealth of, a Dictionary of Indian Raw Materials and Industrial Products—Raw Materials, Vol. 5, H–K, *review* by Dr. F. N. Howes, 70
Indian Central Coconut Committee : Conference on Recent Advances in Coconut Research in India, 860
Indian Council of Scientific and Industrial Research (Chemical Research Committee) · Symposium on Proteins, 767
Indian Institute of Science, Bangalore : Golden Jubilee Symposia (Prof. R. L Datta), 691
  Symposium on Hydrocarbon Synthesis and Hydrocarbon Conversion, 691
  Symposium on Mass Transfer, 691
Indian Mineralogist, No. 1 (Mineralogical Society of India), 683
Indian Substitutes of Male Fern in Pharmacognosy (Prof. P N. Mehra and T. C Mittal), 722
Indians of Northern Mato Grosso, Brazil : Evidence for a New Allele in the Kidd Blood Group System in (Dr. Richard T. Silver, Jane M. Haber and Dr. Aaron Kellner), 481
Indicator Plaque-forming System for Demonstration of Interference by Non-cytocidal Strains of Rabies Virus (Dr. Martin M. Kaplan, Dr. Eberhard Wecker, Dr. Zlatko Forsek and Dr. Hilary Koprowski), 821
Individual Variations in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_2-Globulin Region of Normal Human Sera Agar-gel Electrophoretic Demonstration of (Dr. Jan Hirschfeld), 321
Indoles · Non-Enzymic Reactions of, with Coenzyme I (Prof. S G A. Alivisatos, G. A. Mourkides and A. Jibril), 718
Indonesian Council of Sciences (Unesco South-East Asia Science Co-operation Office and the) : Discussion on the Development of Science in South-East Asia, 859
Indoxyl-acetate Splitting Component in the α_2-Globulin Region of Normal Human Sera · Agar-gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an (Dr. Jan Hirschfeld), 321
Induced Somatic Segregation of *Aspergillus nidulans* : High Frequency of Spontaneous and (Dr. Etta Käfer), 619
Induced (Experimentally), Inter-bivalent Redistribution of Chiasmata in *Delphinium* (H. K. Jain and A. K. Bose), 260
Inducer (Specific) of the Male Sex Organ in certain Fern Species Purification of a (Ross B. Pringle, Ulrich Näf and Armin C. Braun), 1066
Induction of a Chorion-epitheliomatous Tumour in the Rat (R. Stein-Werblowsky), 980
Induction (Tumour), by *S E* Polyoma Virus : Development of Resistance in Mice to (Sarah E. Stewart, Bernice E. Eddy, Marjean Irwin and Stephanie Lee), 615
Induction and Reversion of *c*-Mutations by Irradiation of the Extracellular χ-Phage of *Serratia* (Prof. R. W. Kaplan, U. Winkler and H. Wolf-Ellmauer), 330
Induction Phenomena in Photosynthesis of Isolated Spinach Chloroplasts (Dr. Knud Vejlby), 652
Industrial Chemistry of the Lower Olefines (Chemical Society, the Institute of Petroleum, the Royal Institute of Chemistry and the Society of Chemical Industry Symposium on), 285
Industrial Property, International Association for the Protection of : Twenty-fourth Congress, 440
Industrial Psychology, National Institute of : Vernon Prize for 1960 awarded to Dr. R B Buzzard, 938
Industrial Research in the United States, 763
Industrial Research (Scientific and) : The Balance of, 997
Industrial Research and Development Expenditure, 1958 (Department of Scientific and Industrial Research), 997
Industrial Training Council : First Report (1958-59), 15
  Training Services in Industry, 123
Industrialists : British—Steel and Hosiery, 1850-1950 (Charlotte Erickson), *review* by R Brightman, 347
Industries (British), and their Organization (Prof. G. C. Allen), fourth edition, *review* by R Brightman, 70
Industries (British), Federation of : Handbook on the Technical Colleges and their Government, 769
Industries (British) Technical Colleges Committee, Joint Federation of : The Technical Colleges and their Government, 769

Industry : Health in (Donald Hunter), *review* by T. H Hawkins, 424
  Human Problems of Innovation in, 419
  Mathematics, Education and—a Record of a Conference of Teachers, Research Scientists and Industrialists, held at the University of Liverpool (1959), 1017
  Problems of Progress in, No 5, Human Problems of Innovation (Based on a Study of some Scottish Firms by Tom Burns and G M. Stalker), (Department of Scientific and Industrial Research), 419
  Training Services in (Industrial Training Council), 123
Industry (American) : Science and Engineering in—Report of a 1956 Survey (United States National Science Foundation), 763
Industry (Physical Sciences and) : Use of Radioisotopes in the (International Atomic Energy Agency Conference on), 284
Industry (Soviet) : Automatic Control in (Department of Scientific and Industrial Research), 287
Industry and Commerce : Appointments in, 682
Inert Gases : New Clathrate Compounds of the (J. G Waller), 429
Inexpensive Castle and Sample Holder for Radioactive Counting (Dr. Howard Boroughs), 145
Infant Mouse : Passage of Insulin through the Wall of the Gastro-intestinal Tract of the (W. A Kelly), 971
Infection with *Pasteurella pestis* : Enhanced Resistance of Mice to, following Vaccination with Fractions of Phenol-killed Tubercle Bacilli (Prof. David W Weiss), 1060
Infections (Food-borne), and Intoxications : Report of a European Technical Conference on (World Health Organization of the United Nations), 852
Infections (Fungal Root-), of *Pinus* : Effects of *Gibberella fujikuroi* on (Dr. Ida Levisohn), 987
Infections (Multiple), of Trematodes in a Snail (Wm H. Ewers), 990
Infections (Parasitic), in Early Medicine and Science : Parasites and (Prof. R. Hoeppli), *review* by Dr Ben Dawes, 46
Infective Diseases : The Aetiology of (Prof. Reginald Lovell), *review* by Dr G. Lapage, 581
  Factors and Causes of, *review* by Dr. G. Lapage, 581
Infective Larvae of *Oesophagostomum radiatum* (Rud 1803) (Strongylidae : Nematoda) : Effect of X-Rays on the Development of the (R F. Riek and R. K Keith), 981
Infectivity Titrations of the Virus of Foot-and-Mouth Disease : Influence of Route of Inoculation and Strain of Mouse on (Wendy Heatley, H. H Skinner and H. Subak-Sharpe), 909
Infestation Control Laboratory : Appointment of an Advisory Committee on the experimental and research work of the (Ministry of Agriculture, Fisheries and Food), 361
Inflammation (Experimental) : Elevation of Serum Haptoglobin in Rabbits in Response to (R. K Murray and G E. Connell), 86
Inflorescence of *Helichrysum arenarium* : Flavonoid Compounds in the (Z I. Jerzmanowska and J T. Grzybowska), 807
Influence : The Sun and its (Prof. M A. Ellison), second edition, *review* by Prof C. W. Allen, 69
Influence of Cervical Sympathectomy and Pituitary Stalk Section upon Milk Secretion in Goats (G. B Tverskoy), 782
Influence of Dietary Intake of certain Insecticides on the Haemoglobin and Erythrocyte Contents of Chick Blood (Prof B. K. Srivastava, H C. Saxena and J. C Sharma), 172
Influence of Environment on the Distribution and Form of Sponges (Prof. M A Ali), 177
Influence of Geological Features on Very Low Frequency Geomagnetic Fluctuations (H. J Duffus, J A Shand and Sir Charles Wright), 141
Influence of Light on Bacterial Flora of Roots (J W. Rouatt and Dr. H. Katznelson), 659
Influence on Measurement of Density : Adsorption of Helium on Carbons—(Dr. F. A P. Maggs, P. H. Schwabe and J. H. Williams), 956
Influence of Route of Inoculation and Strain of Mouse on Infectivity Titrations of the Virus of Foot-and-Mouth Disease (Wendy Heatley, H H. Skinner and H Subak-Sharpe), 909
Influence of Temperature upon Blood Coagulation in a Cold- and a Warm-blooded Animal (Dr H B. Anstall and Dr. R G Huntsman), 726
Information : The Measurement of, *review* by Prof. Colin Cherry, 506
Information (Scientific) : Abstracting, 358
Information Theory and Statistics (Prof. Solomon Kullback), *review* by Prof. Colin Cherry, 506
Infra-Red Analysis : Microquantitative—Application to Gas Chromatographic Fractions (J E. Stewart, R. O. Brace, T Johns and W F. Ulrich), 628
Infra-Red Radiation over the United States : A Synoptic Study of (Dr. John L. Gergen and Dr. William F. Huch), 426, *erratum*, 604
Infra-Red Spectra of Ammonia adsorbed on Silica–Alumina Catalysts (D. E. Nicholson), 630
Infra-Red Spectra of Deoxyribonucleic Acids from Human Leucocytes (G. Zerbi, P A Bianchi and E E. Polli), 964
Infra-Red Spectra of Deuterium-labelled Carbohydrates (Dr. S. A. Barker, R. H. Moore, Prof. M. Stacey and Dr. D. H. Whiffen), 307
Infra-Red Spectrum of Garnets (P Tarte), 234
Ingénieurs Électriciens, Association des (sortis de l'Institut Electrotechnique Montefiore) : International Information Day about Nuclear Energy, 440
Inglis, Prof. James : Dichotic Stimulation and Memory Disorder, 181
Inglis, J., and others : Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methyl*iso*thiazole), a New Bacterial Sulphonamide, 221
Ingold, Prof. C. T. : Nature and Exploitation of Crop Plant Resistance to Disease, 859
Inhaled Particles and Vapours (British Occupational Hygiene Society International Symposium on), 524
Inheritance of Asymmetry in a Water-boatman (*Krizousacorixa femorata*), (Dr. Walter Peters), 737
Inheritance of β-Globulins in Serum and Milk from Cattle (Bo Gahne, Jan Rendel and Dr. Ole Venge), 907
Inhibition of the Anaphylactic Release of Histamine from Chopped Guinea Pig Lung by Chymotrypsin Substrates and Inhibitors (Dr. K. F. Austen and Dr W E Brocklehurst), 866
Inhibition of Monoamine Oxidase by Benactyzine *in vitro* and *in vivo* (Dr. V Vítek and K. Ryšánek), 244
Inhibition' (Construct 'Reactive), in the Interpretation of Age Changes in Performance (Dr. S Griew and Dr. R. Lynn), 182
Inhibition (Specific), of Obligate Anaerobes (Dr. Herbert N. Prince), 816
Inhibitor of Aspartic Acid Utilization in *Leuconostoc mesenteroides* : (+) S-Methyl-L-Cysteine Sulphoxide, an (Wilfred N. Arnold, Clayton J Morris and John F. Thompson), 1051
Inhibitors (Chymotrypsin Substrates and) : Inhibition of the Anaphylactic Release of Histamine from Chopped Guinea Pig Lung by (Dr K F. Austen and Dr. W. E Brocklehurst), 866
Inhibitors (Melanin), in *Drosophila melanogaster* : Genetic Basis of Two (Dr. R A. Kroman and Dr P. A Parsons), 411
Inhibitors (Monoamine Oxidase) : Suppression of Increased Capillary Permeability in Injury by (W. G. Spector and D. A. Willoughby), 162
Inhibitors (Tumour) : Synthetic Polyelectrolytes as (Dr. William Regelson, Stephan Kuhar, Marvin Tunis, Joseph Fields, John Johnson and Earl Gluesenkamp), 778
Initiation of Clotting in Normal and Hageman Plasma by Glass (Dr. Preben Ollendorff), 173
Injection of Bovine Pineal Extract : Effects of, on the Nuclei of Rat Pineal Parenchymal Cells (Dr. Uno Holmgren, Dr Mark D Altschule and Dr. Richard J Wurtman), 393
Injured and Regenerating Muscles : Treatment of, with Plant Extracts (S. Hoja and J. Vittek), 283
Injury by Monoamine Oxidase Inhibitors : Suppression of Increased Capillary Permeability in (W. G Spector and D. A. Willoughby), 162
Inland Fishery Research Station, Sagana, Kenya (Dr. Vernon D. van Someren), 425
Inner Metagalaxy : The (Prof. Harlow Shapley), *review* by Dr D. W. Dewhirst, 109
Inner Zone : Geometry of the Southern Auroral Zone and the Evidence for the Existence of an (Dr. T. Hatherton), 288
Innovation : Human Problems of (Based on a Study of some Scottish Firms by Tom Burns and G. M. Stalker), (Department of Scientflic and Industrial Research, Problems of Progress in Industry, No 5), 419
Innovation in Industry : Human Problems of, 419
Inoculation (Route of), and Strain of Mouse : Influence of, on Infectivity Titrations of the Virus of Foot-and-Mouth Disease (Wendy Heatley, H. H. Skinner and H. Subak-Sharpe), 909
Inorganic Salts : Specific Interaction of Native Protein and (Folke Ronnike), 88
Insect Cuticle : Wetting Properties of (J W. L Beament), 408
Insect Migrants High in the Air : Mortality and Viability of (L. R. Taylor), 410
Insect Migration and Dispersal by Flight : A Basis for a General System of (C G Johnson), 348
Insect Photography, *review* by H. Oldroyd, 187
Insectes : Les Plus Beaux (Textes de A Villiers), *review* by H. Oldroyd 187
Insecticides : Influence of Dietary Intake of certain, on the Haemoglobin and Erythrocyte Contents of Chick Blood (Prof. B. K Srivastava, H C. Saxena and J C. Sharma), 172
Insecticides ('Cyclodiene') : Mechanisms of Resistance of the Adult House-fly (*Musca domestica*) to (Dr G. T Brooks), 96
Insects and Length of Day, 774
Insects (Agricultural), of East Africa (compiled by R. H. Le Pelley), *review* by Dr. Kenneth Mellanby, 65
Insemination (Artificial), in Cattle, *review* by Sir John Hammond, 667
Instabilities (Surface), in a Linear Pinched Discharge : Growth of (Dr R. Latham, J. A. Nation, F. L. Curzon and Dr. A. Folkierski), 624
Instability of Cytochrome c Reductase : Cause of the (A New Type of Autoxidation Reaction), (Dr Malcolm Dixon, J. M Maynard and P F. W. Morrow), 1032
Instability (Genetic), and Outcrossing in the Groundnut Variety Mani Pintar (J. Smartt), 1070
Instillation (Gastric), of 3-Monohydroxycholanic Acid : Cirrhosis of the Liver induced in Rabbits by (Dr. Paul Holsti), 250
Instinctive Behaviour, the Development of a Modern Concept (translated and edited by Claire H. Schiller), *review* by Dr R. A. Hinde, 43
Institut Électrotechnique Montefiore (Association des Ingénieurs Électriciens sortis de) : International Information Day about Nuclear Energy, 440
Institut National pour l'Étude Agronomique du Congo Belge : Flore du Congo Belge et du Ruanda-Urundi, Vol. 9, 764
Institutions concerned with Atomic Energy : World List of (International Atomic Energy Agency), 361
Instrument Abstracts (British Scientific Instrument Research Association), Vol. 15, No 1, 359, *erratum*, 685
Instruments (New), for Electronic Engineers, 852
Instruments (Electronics and) Exhibition and Convention : Annual (Institution of Electronics), 685
Insulin : Abrupt and Delayed Effects of, on the Distribution Space of Glucose in the Dog (Dr G Hetenyi, jun., and Prof. G. A. Wrenshall), 808
  Passage of, through the Wall of the Gastro-intestinal Tract of the Infant Mouse (W A. Kelly), 971
Insulin Dimers and Hexamers : Symmetry of (Prof. Barbara W. Low and J. Ralph Einstein), 470
Insulin (Œstrogen–) Interaction on the Uterus of the Rat (Dr. R. Michel Zilberstein), 635
Intact Cells : Glutathione Stability and Pyrophosphatase Activity in Reticulocytes—Direct Evidence for the Importance of Glutathione for the Enzyme Status in (Prof S Rapoport and D. Scheuch), 967
Intake (Dietary), of certain Insecticides : Influence of, on the Haemoglobin and Erythrocyte Contents of Chick Blood (Prof B. K. Srivastava, H. C Saxena and J. C. Sharma), 172
Intake and Excretion of Water in the Rat : Effect of Severing the Olfactory Bulbs on the (V Nováková and H. Dlouhá), 638
Integration of Human Knowledge (Prof. Oliver L. Reiser), *review* by Dr. John Tucker, 37
Intelligent Machines : Symbolic Logic and (Edmund C. Berkeley), *review* by Dr A D. Booth, 422
Intensity (Cosmic Ray), in Interplanetary Space (Dr H. Elliot), 299
Intensity Distributions in the N_2 Lyman–Birge–Hopfield and CO Fourth Positive Band Systems : Interpretation of (Prof R. W. Nicholls, 958
Interaction between Albumin, Lecithin and Cephalin (Dr Eric Ponder and Ruth V. Ponder), 235
Interaction (Œstrogen–Insulin), on the Uterus of the Rat (Dr R. Michel Zilberstein), 635

Interaction (Specific), of Native Protein and Inorganic Salts (Folke Rønnike), 88
Inter-bivalent Redistribution of Chiasmata in *Delphinium* : Experimentally Induced (H. K Jain and A. K. Bose), 260
Interbreeding Sub-species : The Redpoll in New Zealand— (David Stenhouse), 488
Interference by Non-cytocidal Strains of Rabies Virus An Indicator Plaque-forming System for Demonstration of (Dr. Martin M. Kaplan, Dr Eberhard Wecker, Dr. Zlatko Forsek and Dr. Hilary Koprowski), 821
Interglacial Geology (Glacial and), in East Anglia : Investigating (Dr. R. G. West), 771
International Association for the Protection of Industrial Property : Twenty-fourth Congress, 440
International Astronautical Congress (Swedish Interplanetary Society), 523
International Astronomical Union Symposium No. 6, Electromagnetic Phenomena in Cosmical Physics (Stockholm 1956), (edited by B Lehnert), *review* by Dr. R. H. Garstang, 67
International Atomic Energy Agency : Appointment of Prof. C. Salvetti as director of the Division of Research and Laboratories, 17
  International Directory of Radioisotopes, Vol. I, Unprocessed and Processed Radioisotope Preparations and Special Radiation Sources , Vol. 2, Compounds of Carbon-14, Hydrogen-3, Iodine-131, Phosphorus-32 and Sulphur-35, 282
  Scientific Conference (Use of Radioisotopes in the Physical Sciences and Industry), 284
  General Publication No 3, World List of Institutions concerned with Atomic Energy, 361
  Appointment of Dr. Gerald B. Cook as chief chemist, 854
  Assistance Programme, 855
International Basimetric Society (Society for Biological Rhythm and the) : Seventh International Conference, 604
International Colloquium on Sub-aquatic Medicine (Club Alpin Sous-Marin), 440
International Committee on Photobiology : International Congress on Photobiology, 523
International Communications and Scientific Journals, 358
International Computation Centre (Provisional) : *Bulletin*, No. 8, 764
International Computers and Tabulators, Ltd. (General Electric Co., and) A New British Transistorized Computer, 936
International Conference on Congenital Malformations (International Medical Congress, Ltd.), 685
International Conference on Goitre, 523
International Conference on Medical Electronics, and associated Exhibition (Electronics and Communications Section of the Institution of Electrical Engineers and the International Federation for Medical Electronics), 523
International Conference on Nuclear Physics : Proceedings of the—Low-Energy Nuclear Interactions and Nuclear Structure, Paris 1958 (presented by P. Gugenberger), *review* by Dr E. Bretscher, 58
International Conference on the Peaceful Uses of Atomic Energy . Proceedings of the United Nations Second, held in Geneva, 1958, Vol. 2, Survey of Raw Material Resources, *review* by Prof. C. F. Davidson, 921
International Conference on Powder Metallurgy (Metal Powder Industries Federation), 361
International Conference on Science in the Advancement of New States (Weizmann Institute of Science), 604
International Conference on Scientific Problems of Crop Protection (Hungarian Academy of Sciences), 523
International Congress on the Aeronautical Sciences : Proceedings of the First—Advances in Aeronautical Sciences (edited by Th. von Kármán, A. M. Ballantyne, R. R. Dexter, H Blenk, H. L. Dryden and M. Roy), *review* by Prof. A R. Collar, 665
International Congress on Automatic Control . First, 439
International Congress on Biophysics, 1020
International Congress of Endocrinology, 523
International Congress of Entomology, 938
International Congress of the History of Science : Tenth, 767
International Congress on Photobiology (International Committee of Photobiology), 523
International Congress of Zoology, 604
International Control of Narcotic Drugs, 21
International Co-operation and the Production of Calcium-47, 1018
International Council of Scientific Unions : Work of the Abstracting Board (Prof. E. A. Boutry), 358
International Council of Scientific Unions (Committee on Space Research) : First International Space Science Symposium, 749
International Directory of Radioisotopes, Vol. I, Unprocessed and Processed Radioisotope Preparations and Special Radiation Sources ; Vol. 2, Compounds of Carbon-14, Hydrogen-3, Iodine-131, Phosphorus-32 and Sulphur-35 (International Atomic Energy Agency), 282
International Federation for Medical Electronics (Electronics and Communications Section of the Institution of Electrical Engineers and the) : International Conference on Medical Electronics, and associated Exhibition, 523
International Geographical Union : Tenth General Assembly and nineteenth International Congress, 938
International Geological Congress, 938
International Geophysical Year : Ionospheric Observations over Belgium during the (Royal Meteorological Institute of Belgium), 203
  U.S S.R. and the, 359
International Geophysical Year Expedition : Results of the Royal Society's (Royal Society Discussion on), 191
International Medical Congress, Ltd. : International Conference on Congenital Malformations, 685
International Organizations of Medical Sciences, Council for (Commission Administrative du Patrimoine Universitaire de Liège and the) : Symposium on Biological Problems of Grafting, *review* by Dr. D. M. V Parrott, 51
International School of Physics (Società Italiana di Fisica), 17
International Scientific Film Association : Fourteenth Congress, 767
International Space Science Symposium : First (Committee on Space Research of the International Council of Scientific Unions), 749
International Summer Course on Plasma Physics (Danish Atomic Energy Commission), 938
International Symposium on Combustion, 938
International Symposium on Inhaled Particles and Vapours (British Occupational Hygiene Society), 524
International Symposium on Nuclear Electronics : Proceedings of the (organized by the French Society of Radioelectricians), (Sessions 1-5), *review* by W. Abson, 583
International Union for Conservation of Nature and Natural Resources : Seventh General Assembly, jointly with the eighth Technical Meeting, 206
International Union of Crystallography : Fifth General Assembly, 1020
  Symposium on Thermal Motion in Crystals and Molecules, 1020
  Symposium on Lattice Defects and the Mechanical Properties of Solids, 1020
International Union of Crystallography (Commission on Crystallographic Apparatus) : Index of Crystallographic Supplies (edited by Dr. A. J. Rose), second edition, 1019
Interpersonal Behaviour : Person Perception and (edited by Renato Tagiuri and Luigi Petrullo), *review* by Prof. M. D Vernon, 919
Interplanetary Ionization : Solar Extreme Ultra-violet Radiation as a Source of (Dr. Hans E. Hinteregger), 523
Interplanetary Society (Swedish) : Eleventh International Astronautical Congress, 523
Interplanetary Space : Cosmic Ray Intensity in (Dr. H. Elliot), 299
Interpolation Scheme : An Energy Band, with Application to Body-centred Cubic Lithium (J F. Cornwell and Dr. E. P. Wohlfarth), 379
Interpretation of Age Changes in Performance : Construct 'Reactive Inhibition' in the (Dr S Griew and Dr R. Lynn), 182
Interpretation of Cosmology (Prof. W. H McCrea), 1035
Interpretation of Intensity Distributions in the N_2 Lyman–Birge–Hopfield and CO Fourth Positive Band Systems (Prof R W. Nicholls), 958
Interpretation (Distribution-Free), of Spray-Drop Data (John B. Opfell), 822
Interpretation (A New), of the Mullite Problem (J H Welch), 545
Interrelation of Tryptophan and Nicotinic Acid in Man during the First Month of Life (S. Auricchio, E. Quagliariello and A. Rubino), 639
Interspecific Hybrids of *Lycopersicum* (Dr. Donald Michie), 1071 ; (Helgi Nirk), 1071
Interstitial Cell Nucleus (Testicular), in the Adult Rat : Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the (S L. Liu), 475
Interstitial Cell-stimulating Hormone : Histophotometrical Study of the Effect of, on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat (S. L. Liu), 475
Intestine (Small) : Fate of Bacteria in the (J. M. S. Dixon), 521
Intoxications (Food-borne Infections and) : Report of a European Technical Conference on (World Health Organization of the United Nations), 852
Intracellular Potentials in Rat Atria during and after Vagal Stimulation or Acetylcholine Administration (P. A. Bierstaker, J. Th. F. Boeles and L. N. Bouman), 637
Intrahepatic Shunted Flow of Blood in Cirrhosis of the Liver : Measurement of the (T. Nakamura, S. Nakamura and K. Tokita), 243
Intraperitoneal Cortisone Acetate, Cholesterol and Lecithin : Enhancement of Staphyloccal Virulence for Mice by (Dr. Daniel Amsterdam and Dr. S. Stanley Schneierson), 101
Intraspecific Differentiation—Biological and Social Aspects (Dr. Max Pettersson), 431
Intravenous Glucose Tolerance Test : Improvement of the (Dr. John C. Seed, Dr Forman S. Acton and Dr Albert J. Stunkard), 808
Intrinsic Electrical Breakdown of Glass : Time-lags in the (M. N. Azam and H Dickinson), 146
Intrinsic Recombination Radiation in Diamond (J C. Male and J. R Prior), 1037
Invention : National Reference Library of Science and, 934
Inventory of Economic Studies concerning Africa South of the Sahara—an Annotated Reading List of Books, Articles and Official Publications (edited by Peter Ady), (Commission for Technical Co-operation in Africa South of the Sahara, CSA/CCTA Publication No. 30, Joint Project No 4), 202
Invertebrate Animals (Freshwater) : A Guide to (Dr T. T. Macan), *review* by Dr. J. P. Harding, 345
Invertebrate Evolution : Exhibit of (Australian Museum), 438
Invertebrates : Freshwater, *review* by Dr. J. P. Harding, 345
  These are (Exhibit at the Australian Museum), 438
Investigating Glacial and Interglacial Geology in East Anglia (Dr. R. G. West), 771
Investigation of Phosphorescence Spectra of Organic Compounds : Use of Solvents containing Ethyl Iodide in the (Dr. I. J. Graham-Bryce and J M. Corkill), 965
Iodide (Ethyl) : Use of Solvents containing, in the Investigation of Phosphorescence Spectra of Organic Compounds (Dr. I. J. Graham-Bryce and J. M. Corkill), 965
Iodide (Potassium), irradiated with Ultra-violet Light : Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of (Prof. F. S. Dainton and S. A. Sills), 879
Iodide (Sodium), in Benzene : Reaction of *p*-*n*-Decyloxybenzenediazonium Fluoborate with (Prof. W. Bradley and J. D. Thompson), 631
Iodinated Protein in the Young Mouse : Selection of (W. A. Hemmings), 399
Iodination of Specific Sites on Bovine Serum Albumin (Dr. David Pressman and Dr. Gerald Radzimski), 1049
Iodine-124 and Iodine-131 Thyroid Dosimetry : A Comparison of (Dr. C. M. E. Matthews and Dr. J. F. Fowler), 983
Iodine-131 Thyroid Dosimetry : A Comparison of Iodine-124 and (Dr. C. M. E. Matthews and Dr. J. F. Fowler), 983
Iodine-131 (Sodium-24, Potassium-42 and) : Clearance Rates of, in Normal Dog Hip Joints (Prof. Patrick G. Laing and Dr. Ik Dong Kim), 898
7-Iodo-6-Deoxytetracycline (Radioactive), in Tumour Tissue (Dr Joseph J. Hlavka and Donald A Buyske), 1064
Ion-Exchange Resin Method for the Fractionation of Alcoholic Plant Extracts (Dr. Dalton Wang), 326
Ion Exchange Resins : Trace Analysis by X-Ray Fluorescence using (J. N. van Niekerk and J. F. de Wet), 380
Ionization of *n*-Paraffin Molecules (W. M. Fairbairn), 151
Ionization (Interplanetary) : Solar Extreme Ultra-violet Radiation as a Source of (Dr. Hans E. Hinteregger), 523

Ionizing Radiation : Chemical Effects of, on Deoxyribonucleic Acid in Dilute Aqueous Solution (G. Hems), 710
  Effect of Oxygen on the Inactivation of Trypsin by (Prof. J. A. V. Butler and Dr. A. B Robins), 697
  Inability of Thiotaurine to protect Mice against (Dr. D. Cavallini and L. Tentori), 254
  Significance of the 'Equivalent Redox Potential' in Aqueous Solutions under (Dr. G. H. Cartledge), 370
  Use of, in Spot Tests for Nitrogenous Compounds (H. J. M. Bowen, E. Arter and P. A. Cawse), 383
Ionizing Radiations on Water : Primary Processes in the Action of—Formation and Reactivity of Self-trapped Electrons ('Polarons'), (Prof. Joseph Weiss), 751
Ionizing Rays : Combined Application of Hydrogen Peroxide and, in Animal Experiments (E. Fleischmann, H. Werkgartner and K. Karrer), 324
Ionosphere · The Mesopause Region of the (Dr J. D. Whitehead), 461
Ionosphere (Magneto-) Disturbances (Academy of Sciences of the U.S.S.R), 359
Ionosphere (Upper) : Electron Density Measurements in the, using the Faraday Rotation of Radio Signals from Artificial Satellites (Dr. D. McL. A. Wilson), 623
Ionospheric Effects associated with the Solar Flare of July 10, 1959 (V. A. H. Harrison), 228
Ionospheric Observations over Belgium during the International Geophysical Year (Royal Meteorological Institute of Belgium), 203
Ionospheric Research (NATO Meeting on), 685
Ions (Hydrogen) : Mechanism of the Gastric Secretion of (Prof. Spyridon G. A. Alivisatos), 368
Ions (Metal) Mechanism of the Oxidation and Reduction of, by Hydrogen Atoms (Prof. J. Halpern, G. Czapski, J. Jortner and Dr. G. Stein), 629
Ions (Negative), formed by Charge Transfer : Detection of (T. M. Donahue and F Hushfar), 1038
Ions (Transition Metal) : Heats and Entropies of Reaction of, with Ethylenediamine (M. Ciampolini, P. Paoletti and Prof. L. Sacconi), 880
Ireland : Occurrence of the Slipper Limpet, *Crepidula fornicata* L., in (D. C. Arnold), 95
Iridium–Platinum Alloys : Constitution and Properties of the (Dr. A. S. Darling), 211
Iron : Crystal Growths and the Corrosion of (Earl A. Gulbransen and Thomas P Copan), 959
Iron Bacteria in Mine-waters (Dr L. G. M. Baas Becking and Dr. D. Moore), 670
Iron Meteorites : Exposure Ages for (Oliver A. Schaeffer and David E. Fisher), 1040
Iron Tricarbonyl (Tetraphenyl*cyclo*butadiene) : Crystal Structure of (R. P. Dodge and Dr. V. Schomaker), 798
Iron and Steel Institute : Bessemer Gold Medal for 1960 awarded to Prof. Hermann Schenck, 13
  Sir Robert Hadfield Medal for 1960 awarded to Dr. J. C. Hudson, 13
  Andrew Carnegie Silver Medal for 1959 awarded to Dr. P. R. V. Evans, 13
  William Prize for 1959 awarded to I. M. D. Halliday, 13
  Election of W. F. Cartwright as president for 1960-61, 13
Iron and Steel Research Association (British) . Grant of £1,000 to the University of Oxford for the continuation of research on the melting- and freezing-points of alloys, being carried out in the Department of Metallurgy, 126
  Conference on Heat Treatment Practice, 523
Irradiated with Ultra-Violet Light : Electron Spin Resonance in Hydrogen Peroxide–Water Solutions at 90°K. (Robert C. Smith and S. J. Wyatt), 226
Irradiated *p*-Xylene · Polymer Formation in (Francis van Hecke), 382
Irradiation : Significance of Adrenals for Increased Oxygen Consumption in Rats during (Dr. A. Vacek), 90
Irradiation Conference : Australian, 126
Irradiation of the Extracellular χ-Phage of *Serratia* · Induction and Reversion of c-Mutations by (Prof R. W. Kaplan, U. Winkler and H. Wolf-Ellmauer), 330
γ-Irradiation of Aqueous Solutions : Use of Nitrous Oxide to discriminate between the Forms of Hydrogen Atoms ($H\cdot$ and H_2^+ ?) produced by (Prof. F. S. Dainton and Dr. D. B. Peterson), 878
Irradiation (Serial) : Changes in the Deoxyribonucleic Acid Content of Mouse Sarcoma 37 Cells following (Dr. A. E. G. Pearson and N. B. Atkin), 647
Irvine, Dr. R. A. : Medical Research in the British Caribbean (Clinical Occurrence of Encephalitis in Jamaica), 863
'Irving–Williams' Order in the Metal-ligand Stretching Frequencies of some Metal Hydrazine Complexes (Prof. L. Sacconi and A. Sabatini), 549
Irwin, Marjean, and others : Development of Resistance in Mice to Tumour Induction by S E Polyoma Virus, 615
Is *Nectria haemotococca* Berk. and Br. the Perfect Stage of *Fusarium oxysporum* Schl. forma *pisi* (Lindf.) S. and H ? (W L. Gordon), 903
Ishida, Takeo (Okada, Hideya, and) · Brighteners for Nickel Plating and Polarographic Maxima, 152
Islands (The Galápagos), a History of their Exploration (Joseph Richard Slevin), 365
Isolated Mammalian Cells Are Macromolecules required for Growth of Single ? (Ralph B. Gwatkin), 984
Isolated Nerve Fibres (Myelinated), of the Frog : Effect of Curare on Conduction in (Dr. Wolf D. Dettbarn), 891
Isolated Rat Diaphragm · Accumulation of Substrate by—a Possible Mechanism for the Anti-inflammatory Action of Corticosteroids (Prof Ira G. Wool), 728
Isolated Rat Liver Mitochondria : Effect of Pituitary Growth Hormone *in vivo* on the Phosphorus/Oxygen Ratios of (C. N. Graymore, A. H. Melhuish and A. L. Greenbaum), 392
Isolated Sensitized Mast Cells : Antigen-induced Damage to (Dr. I. Mota and W. Dias da Silva), 245
Isolated Spinach Chloroplasts : Induction Phenomena in Photosynthesis of (Dr Knud Vejlby), 652
Isolation of a Cytopathogenic Agent from Skin Lesions of Cattle (Dr. C. Huygelen, D. Thienpont and M. Vandervelden), 979
Isolation of Mutants of *Bacillus subtilis* requiring D-Glutamic Acid (Haruo Momose and Prof. Yônosuke Ikeda), 567
Isolation of a Phagocytosis-inhibiting Substance from Culture Filtrates of an Encapsulated *Staphylococcus aureus* (Dr. Stephen I. Morse), 102
Isomeric Chondroitin Sulphates : Identification of (J. B. Adams), 555
Isomers (Vitamin A), in the Liver of Rats and Chicks (O. R. Braekkan, H. Myklestad, L. R. Njaa and F. Utne), 312
Isoprenoid Alcohol : Dolichol, a Naturally Occurring (J. F. Pennock, F. W. Hemming and Prof. R. A. Morton), 470
Isotope Information Bureau : Opened by Sir Roger Makins, 1017
Isotope Technique (Radioactive) : Estimation of Mouse Tumour Blood Volumes employing a (F. S. Stewart and Dr. A. E. G. Pearson), 250
Isotopic Composition of Potassium (B R. F. Kendall), 225
Israelsohn, Dr. Wilma · Human Growth (Modes of Analysis of Human Growth Data), 19
Isted, G. A , and others · Radar 'Ring Angels' and the Roosting Movements of Starlings, 112
Ives, Dr. D J. G. : Principles for the Extraction of Metals (Royal Institute of Chemistry, Monographs for Teachers No. 3), 765
Iyengar, M. S., and others : Alkylation of Coal by Benzyl Chloride–Aluminium Chloride, 387

JACK, J. A., and others . An Rh Antibody Specific for V and R's, 171
  M_1, a Subdivision of the Human Blood-Group Antigen M, 642
Jacks, G. V. : Fertilizers and Profitable Farming, *review*, 424
Jackson, Sir Willis : Fellowship of the City and Guilds of London Institute, *honoris causa*, conferred on, 13
Jacob, K. (John, C. M., and) : Recent Advances in Coconut Research in India, 860
Jacobowitz, Henry : Fundamentals of Nuclear Energy and Power Reactors, *review* by Dr T. E. Allibone, 917
Jaeger, Prof. J. C (Carslaw, Prof. H. S., and) · Condution of Heat in Solids, second edition, *review* by Prof. L. S. Goddard, 421
Jaffe, Dr. P. : Differences in Numbers of Erythrocytes between Inbred Lines of Chickens, 978
Jain, H. K., and Bose, A. K. : Experimentally Induced Inter-bivalent Redistribution of Chiasmata in *Delphinium*, 260
Jakovljevic, Dusan, and Beattie, H. E. R. : Simplified Bulk Growth of *Vibrio foetus*, 736
Jakubovic, Dr. A. O. (Huehns, Dr. E. R., and) : A New Electrophoretic Medium and its Application to the Resolution of Human Haemoglobin Variants, 729
Jamaican Shores : Occurrence of *Halimeda opuntia* var. *minor* on (P. F. James), 493
James, Dr. I. M. : *Obituary* of Prof. J. H. C. Whitehead, 932
James, J. L. (Chrones, J., and) . Industrial Chemistry of the Lower Olefines (The Economics of Ethylene Production from Light Naphtha), 285
James, P. F. : Occurrence of *Halimeda opuntia* var. *minor* on Jamaican Shores, 493
Japanese Population : Haptoglobin Types in a (Prof. E. Matsunaga and Kyoko Murai), 320
Jaumotte, Prof. André, and others : Rocket Propulsion, *review* by J. E. P. Dunning, 186
Javillier, M., et autres : Traité de Biochimie Générale, Vol. I, Composition Chimique des Organismes, *review* by Prof F. G. Young, 51
Jeffery, Dr P. M., and others : Age of Emplacement of Granites, 702
Jellinck, P. H. · Enzymic Oxidation of Stilboestrol labelled with Carbon-14, 157
Jenkins, A. D , and others : The Tesla-coil Method for Producing Free Radicals from Solids, 712
  Polymerization of Crystalline Methacrylic Acid Initiated by Ultra-violet Radiation, 713
Jenkins, G. C., and others : Role of C'_4 in the Antiglobulin Reaction, 482
Jenkinson, David S : Scintillation Counting of Carbon-14, 613
Jennings, Dr. K. R. · Appointed an I.C.I. Research Fellow in the University of Edinburgh, 767
Jensen, Dr. David (Kelly, Dr. Arthur L., and) : Chronic Aortitis in the California Sea-lion, *Zalophus californianus*, 731
Jensen, L. H. (Kraut, J., and) : Crystal Structure of Adenosine-5'-phosphate, 798
Jensen, Per Gert : Caesium-137 in Spray-dried Danish Milk, 562
Jepson, Dr. W. B., and others : Oxidation of Beryllium in Carbon Dioxide and in Carbon Monoxide, 468
Jerrard, Dr. H. G. : Title of senior lecturer in physics in the University of Southampton conferred on, 284
Jerzmanowska, Z. I., and Grzybowska, J. T. : Flavonoid Compounds in the Inflorescence of *Helichrysum arenarium*, 807
Jewell, Dr. P. : 1959 Supplement to British Veterinary Codex 1953, *review*, 507
Jibril, A., and others : Non-Enzymic Reactions of Indoles with Coenzyme I, 718
Jodrell Bank : Cost of the Radio Telescope at, 13
John, C. M , and Jacob, K. . Recent Advances in Coconut Research in India, 860
John, P. C. : Recent Advances in Coconut Research in India, 861
Johns, T., and others : Microquantitative Infra-Red Analysis—Application to Gas Chromatographic Fractions, 628
Johnson, Prof A. W : The Actinomycins and their Importance in the Treatment of Tumours in Animals and Man (Chemistry of the Actinomycins), 772
Johnson, C. G. · A Basis for a General System of Insect Migration and Dispersal by Flight, 348
Johnson, John, and others : Synthetic Polyelectrolytes as Tumour Inhibitors, 778
Johnson, Dr. P., and others : Depolarization of the Fluorescence of Proteins labelled with various Fluorescent Dyes, 239
Johnson, W. : Appointed to the chair of mechanical engineering in the University of Manchester, 1015 ; work of, 1015
Johnston, Dr A. R. : Appointed lecturer in physics at the Queen's University, Belfast, 767
Johnstone, Dr. R. Edgeworth : Appointed first Lady Trent professor of chemical engineering in the University of Nottingham, 933 ; work of, 933
Joints · Fibrinogenolysis in (A. J Harrold), 1057
Joints (Normal Dog Hip) : Clearance Rates of Sodium-24, Potassium-42 and Iodine-131 in (Prof. Patrick G. Laing and Dr. Ik Dong Kim), 898
Joklik, Dr. W. K., and others : Reactivation of Poxviruses by a Non-Genetic Mechanism, 992

Jones, D. H. P : Astronomy, *review*, 69
  Man's Conquest of the Stars, *review*, 69
  Astronomical Photography at the Telescope, *review*, 190
Jones, Dr. Francis : *Obituary* by D. J. Shearman, 596
Jones, Dr. G. R. H. : Appointed an I.C I Research Fellow in the University of Edinburgh, 767
Jones, Dr. K. : Awarded a Ciba Fellowship for 1960-61, 684
Jones, K M , and others (edited by) Data for Biochemical Research, *review* by Dr. K. S. Dodgson, 50
Jones, Robert T . Analysis of Accelerated Motion in the Theory of Relativity, 790
Jones, Prof R V : Velocity of Light in a Magnetic Field, 706
Jordan, C. L. : New Record Low Sea-Level Air Pressure, 283
Jørgensen, C. Barker, and Larsen, Lis Olesen : Control of Colour Change in Amphibians, 641
Jortner, J., and others Mechanism of the Oxidation and Reduction of Metal Ions by Hydrogen Atoms, 629
Joseph, Josy . Recent Advances in Coconut Research in India, 861
Joseph, K V. . Recent Advances in Coconut Research in India, 862
Joubert, Dr. D M : Appointed to the chair of sheep husbandry and wool technology in the University of Pretoria, 280 , work of, 280
Journal of Child Psychology and Psychiatry and Allied Disciplines, Vol. 1, No 1, 935
Journal of Electroanalytical Chemistry, 124
Journal of Electronics and Control, Vol. 4, 685
Journal of the Society of Dyers and Colourists : Appointment of Dr. M. Tordoff as editor, 440
Journals and the Science of Glass Making, 601
Journals (New Scientific) : Rapid Increase in the number of (Scientific Publications Council Discussion on), 18
Journals (Scientific) : International Communications and, 358

KAFER, Dr. Etta : High Frequency of Spontaneous and Induced Somatic Segregation in *Aspergillus nidulans*, 619
Kahlich-Koenner, D M , and others · Frequencies of the Haptoglobin Serum Groups among Blood Donors from Austria and Germany, 976
Kalinsky, J L. (Schrader, M E , and) : Effect of Moisture on Carboxylic Acid Adsorption to Steel, 710
Kallmann, Dr. H., and Pope, Dr M. : Bulk Conductivity in Organic Crystals, 31
Kallmes, O., and Newman, J. A S Structure of the Outer Secondary Wall on Unbleached Spruce Sulphite Fibres, 566
Kalmus, Dr. H. : Sensory Specialization in Response to Environmental Demands (Colour Vision and Odour Discrimination in the Honey Bee), 688
Kalmus, Dr. H., and Smith, Dr. C. A. B. : Evolutionary Origin of Sexual Differentiation and the Sex-Ratio, 1004
Kamp, A. F., and others (edited by) : Albert Jan Kluyver—His Life and Work, *review* by Prof. B. C J G. Knight, 44
Kanematsu Memorial Institute of Pathology, Sydney Hospital · Appointment of Dr. H. M. Whyte as director of the Department of Medical Research, 849
  Appointment of Dr. A A. Palmer as director of the Department of Clinical Pathology, 850
Kaolinite : Predehydroxylation State of (Dr J. J Fripiat and F. Toussaint), 627
Kaper, Dr. J. M : Protein Components from Turnip Yellow Mosaic Virus, 219
Kaplan, Dr. Martin M., and others : An Indicator Plaque-forming System for Demonstration of Interference by Non-cytocidal Strains of Rabies Virus, 821
Kaplan, Prof. R. W., and others : Induction and Reversion of *c*-Mutations by Irradiation of the Extracellular χ-Phage of *Serratia*, 330
χ-Phage of *Serratia* Induction and Reversion of *c*-Mutations by Irradiation of the Extracellular (Prof R. W. Kaplan, U. Winkler and H. Wolf-Ellmauer), 330
Karmen, Dr. Arthur, and Tritch, Harold R. Radioassay by Gas Chromatography of Compounds labelled with Carbon-14, 150
Karrer, K., and others : Combined Application of Hydrogen Peroxide and Ionizing Rays in Animal Experiments, 324
Kassenaar, A. A. H., and others : A New Class of Hormonally Active Steroids, 168
Katznelson, Dr H. (Rouatt, J. W., and) Influence of Light on Bacterial Flora of Roots, 659
Katoh, Dr. Sakae : Crystallization of an Algal Cytochrome, *Porphyra tenera*–Cytochrome 553, 138
  A New Copper Protein from *Chlorella ellipsoidea*, 533
Kaufman, Prof. H. : Thermodynamical Relations in Two-Component Two-Phase Systems, 299
Kauman, Dr. W. G. : Visco-Elastic Systems (Practical Effects arising on Drying Wood, namely, 'Collapse' and 'Set'), 943
Kaye, Dr. G. W. C., and Laby, Dr T H. · Tables of Physical and Chemical Constants and some Mathematical Functions, twelfth edition, *review* by T. M. Yarwood, 67
Keen, Prof. A Myra : A Bivalve Gastropod, 406
Keep, E : Nature and Exploitation of Crop Plant Resistance to Disease (Possible Control of a Disease by Breeding for Resistance to its Vector), 858
Keilin, Prof D. · The Problem of Language in Publications of Works in Scientific and other Fields of Learning, 912
Keith, R K. (Riek, R. F , and) : Effect of X-Rays on the Development of the Infective Larvae of *Oesophagostomum radiatum* (Rud. 1803) (Strongylidae : Nematoda), 981
Keller, Dr. A , and Bassett, D. C. : Co-ordination of Light and Electron Microscopy (Light and Electron Microscope Investigations of the Habit and Structure of Crystals), 672
Keller, W. E , and others Ultra-High Resolution γ-Ray Resonance in Zinc-67, 707
Kellner, Dr. Aaron, and others : Evidence for a New Allele in the Kidd Blood Group System in Indians of Northern Mato Grosso, Brazil, 481
Kelly, Dr Arthur L., and Jensen, Dr. David · Chronic Aortitis in the California Sea-lion, *Zalophus californianus*, 731
Kelly, Dr. P. (Nutting, Prof. J , and) : Co-ordination of Light and Electron Microscopy (Microscopical Techniques used in Metallurgy), 672
Kelly, W. A. : Passage of Insulin through the Wall of the Gastro-intestinal Tract of the Infant Mouse, 971
Kelts (Salmon) : Furunculosis in (Dr. Isabel W. Smith), 733
Kemmer, Prof. N. : Quantum Theory for the Scholar, *review*, 999
Kempson, Dennis A. · Elected an Associate *honoris causa* of the Linnean Society of London, 766
Kemsley, Rev. D. S. · Growth of Single Crystals of Copper, 33
Kendall, B. R. F. : Isotopic Composition of Potassium, 225
Kendall, D. G. · The Theory of Dams, *review*, 344
Kendall, Prof M. G. . Elected president of the Royal Statistical Society, 1020
Kendrew, Dr. J C. : Elected a Fellow of the Royal Society, 11
Kent, A K. : Distribution of Chromactivating Hormones in the Pituitary of the Minnow, 395
Kerkut, Dr. G A · Title of senior lecturer in physiology and biochemistry in the University of Southampton conferred on, 284
Kesteven, Dr Geoffrey · Appointed director of fisheries research in the Division of Fisheries and Oceanography of the Commonwealth Scientific and Industrial Research Organization at Cronulla, N S.W., 280 ; work of, 280
α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates : Maintenance of, by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine (Dr. Laurence M. Corwin and Dr. Klaus Schwarz), 1048
Khan, Dr M. A. : Non-Equilibrium Theory of Gas–Liquid Chromatography, 800
Khedouri, Ezra (Cohen, Prof. Saul G., and) : Requirements for Stereospecificity in Hydrolysis by Chymotrypsin—Diethyl β-Acetamidoglutarate, 75
Khoshoo, Dr. T. N. : Basic Chromosome Numbers in *Silene* and *Saponaria*, 412
Kibler, Prof. H. H. : Oxygen Consumption in Cattle in relation to Rate of Increase in Environmental Temperature, 972
Kidd Blood Group System : Evidence for a New Allele in the, in Indians of Northern Mato Grosso, Brazil (Dr. Richard T Silver, Jane M. Haber and Dr. Aaron Kellner), 481
Kidney . Collagenase Maceration of, for Microdissection (Nancy J Hayward), 403
Kidney (Rat) : Development of 5-Hydroxytryptophan Decarboxylase Activity in (Dr. Irene Huang, Sheila Tannenbaum and Dr. David Yi-Yung Hsia), 717
Kidney Cortex (Rat) : Increase in 'Alkaline' Ribonuclease of, after Lysozyme and Egg-White Administration (Dr. T. Maack, Dr. R. Brentani and Dr. M Rabinovitch), 158
Kilbey, B. J. : 'Sage', a Colour Modifier in *Aspergillus nidulans*, 906
Kim, Dr Ik Dong (Laing, Prof. Patrick G., and) · Clearance Rates of Sodium-24, Potassium-42 and Iodine-131 in Normal Dog Hip Joints, 898
Kimber, Gordon, and others : Position of the Gene determining the Diploid-like Meiotic Behaviour of Wheat, 259
Kimber Genetics Award of the United States National Academy of Sciences awarded to Prof. George Wells Beadle, 686
Kimmig, Prof. Josef : Elected a member of the Medicine Section of the Leopoldina Academy of Natural Sciences, 766
Kimpara, Atsushi Correlation of Occurrence of Whistlers with Geomagnetic Activities, 230
Kimura, K., and others : Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in Animal Cells and its Bearing on Cancer, 215
Kinard, Dr F. W., and others Erythropoietine Production in the Dog, 561
Kinard, Jun., F. W , and others : Erythropoietine Production in the Dog, 561
Kinetics of its Reactions : Structure of Graphite and the (Société de Chimie Physique Conference on), 284
Kinetics of Spontaneous Generation Thermodynamics and (Dr D. E. Hull), 693 ; (Prof. J. D. Bernal), 694
Kinetin : Foliar Abnormalities, including Repeated Branching and Root Formation, induced by, in Attached Leaves of *Marsilea* (Dr A. Allsopp and Alicja Szweykowska), 813
King, Dr. A. S . Appointed to a senior lectureship in veterinary anatomy in the University of Bristol, 284
King, Dr. R. (edited by Dr. Bruce Chalmers and) Progress in Metal Physics, Vol. 7 (1958), Vol 8 (1959), *review* by Prof. F C. Thompson, 666
King-Hele, D G. : Problems of Space Flight, *review*, 59
  Rotating Fluid Masses, *review*, 747
  Secular and Periodic Motions of the Node of an Artificial Earth Satellite, 875
King-Hele, D G , and Walker, D M C : Density of the Upper Atmosphere and its Dependence on the Sun, as revealed by Satellite Orbits, 928
King's College, London · Grant of £120,000 from the Wellcome Trust, towards the purchase of the lease of premises to house a Department of Biophysics, 439
  Appointment of A J. Buller as reader in physiology, 938
  Appointment of Dr. H. Harris to the University of London chair of biochemistry, 1020
King's College, Newcastle-upon-Tyne : Retirement of Prof. Meirion Thomas from the chair of botany, 1016
Kingston, R. S T. · Visco-Elastic Systems (Application of Rate-Process Theory to the Analysis of Time-dependent Mechanical Behaviour of Wood at High Stresses), 942
Kinman, Dr. T D · Globular Clusters, 608
Kinney, Prof C R , and others · Structure of High-Rank Coals deduced from Helium Densities, 792
Kinzel, Dr A. B. : Elected a member of the United States National Academy of Sciences, 773
Kira, Mohamed, and others : Antipyretic Action of *l*-Phenyl-3,5-pyrazolidinedione, 165
Kirkendall Effect · Analogy to the, in the Gas Phase (L. Miller and P. C. Carman), 549
Kirkham, Dr. D. S., and Flood, Dr. A. E. : Nature and Exploitation of Crop Plant Resistance to Disease (Apple and Pear Scab), 858
Kistiakowsky, Prof G. B. · Elected a Foreign Member of the Royal Society, 435
Kitching, Dr. J A. : Elected a Fellow of the Royal Society, 11

Kitching, Dr., and others · Australopithecine Tools, 205
Kitten · Activity of Muscle Receptors in the (Dr. Sten Skoglund), 478
Kleczek, Dr. J., and Křivský, Dr. L. : Solar Limb Surges accompanied by X-Ray Emission, 1035
Klein, Viola · Working Wives, 365
Kleinwachter, Vladimír : X-Ray Diffraction Study of Denatured Ferritin and Apoferritin, 313
Kleutch, K , and others . Effect of Supernatant Potassium-Level on Cardiac Activity in Quantitative Tissue Culture, 241
Kline, Gordon M. (edited by) : Analytical Chemistry of Polymers, Part I, Analysis of Monomers and Polymeric Materials—Plastics, Resins, Rubbers, Fibres, *review* by Prof. C. E. H. Bawn, 52
Kluyver, Albert Jan—His Life and Work (edited by A. F. Kamp, J. W. M. La Rivière and W Verhoevan), *review* by Prof. B. C. J. G. Knight, 44
Klyne, Dr W : Steroid Chemistry, *review*, 668
  Appointed to the University of London chair of chemistry in Westfield College, 938
Knight, Prof. B. C J G : Master of Microbiology, *review*, 44
Knight, Dr. R L · Nature and Exploitation of Crop Plant Resistance to Disease (Possible Control of a Disease by Breeding for Resistance to its Vector), 858
Knivett, Dr. V. A · Appointed to the Microbiology Section of Twyford Laboratories, Ltd., London, 523
Knott, Susan, and others : Mud Fauna of the Stour Estuary, 1018
Knowledge (Human) . The Integration of (Prof. Oliver L. Reiser), *review* by Dr John Tucker, 37
Kogan, M. : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Kohts, Prof. Alexander Eric : Elected an Associate *honoris causa* of the Linnean Society of London, 766
Konstantinidu, M , and others : Thyroid-Powder Feeding and Liver Nitrogen in Mice, 890
Koopman, Dr. H., and Daams, J. : 2,6-Dichlorobenzonitrile, a New Herbicide, 89
Koornneef, P. (van den Ende, J , and) : Gibberellic Acid and Osmotic Pressure, 327
Kopal, Prof Zdenek : Figures of Equilibrium of Celestial Bodies, with Emphasis on Problems of Motion of Artificial Satellites, *review* by D. G. King-Hele, 747
Kopeć, Ada C , and others : The ABO Blood Groups, *review* by Dr. F. Stratton, 581
Koprowski, Dr. Hilary, and others : An Indicator Plaque-forming System for Demonstration of Interference by Non-cytocidal Strains of Rabies Virus, 821
Korabl'-Sputnik, 598
Korotkov's Sounds—Action of the Heart (Wing-Comdr. J. E. Malcolm), 723
Korpássy, Prof. B., and others · Histochemical and Biochemical Studies of Rat Liver in Experimental Cirrhosis after Partial Hepatectomy, 397
Korzhinskii, D. S. : Physiochemical Basis of the Analysis of the Paragenesis of Minerals (translated from the Russian), *review* by Dr. Bernard E Leake, 745
Kotlensky, W. V. (Martens, H. E., and) · Tensile Behaviour of Pyrolytic Graphite at 2,750° C., 960
Kovács, O., and others : Effect of Diphenylamine on the Synthesis of Carotene, 235
Koyanagi, Prof Tatsuo, and Odagiri, Satoru . Effect of Vitamin A on the Cystine Content in Skin of Rats, 809
Kraus, Prof. E J. : *Obituary* by Sir Eric Ashby, 516
Kraus, Dr J D. : Apparent Radio Radiation at 11-m. Wave-Length from Venus, 462
Kraut, J , and Jensen, L. H. : Crystal Structure of Adenosine-5'-phosphate, 798
Kreyszig, Prof Erwin · Differential Geometry, *review*, 70
Krim, Dr. Mathilde, and Sachs, Dr. Leo . Virus Release from Single Cells of Mouse Parotid Tumours, 262
Krishna Marar, M. M. · Recent Advances in Coconut Research in India, 860
Kritchevsky, Prof. David : Cholesterol, *review* by Dr. D. T. Elmore, 745
Křivský, Dr. L. (Kleczek, Dr. J., and) : Solar Limb Surges accompanied by X-Ray Emission, 1035
Krizousacorixa femorata (Water-boatman) : Inheritance of Asymmetry in a (Dr Walter Peters), 737
Krnjević, K., and Mitchell, J. F. : Release of Acetylcholine in Rat Diaphragm, 241
Kroll, Dr W J. : Appointed the sixth Castner Memorial Lecturer by the Society of Chemical Industry, 685
  Castner Memorial Lecture (The Fusion Electrolysis of Titanium), 685
Kroman, Dr. R. A., and Parsons, Dr P A. : Genetic Basis of Two Melanin Inhibitors in *Drosophila melanogaster*, 411
Kruger, Jerome, and Ambs, William J. · Reaction between Copper and Solid Oxygen condensed at Very Low Temperatures from a Gas Discharge, 794
Krutschnitt, J. . Awarded a Gold Medal of the Institute of Mining and Metallurgy, 854
Ku, Dr Yuoh (Gilbert, Dr. James B., and) . Urinary Excretion of a Ninhydrin-positive Compound, probably a Peptide, after Administration of β-Aminoisobutyric Acid to the Mouse, 160
Kuhar, Stephan, and others : Synthetic Polyelectrolytes as Tumour Inhibitors, 778
Kuhlow, Dr. F. . Normal Susceptibility Levels of *Anopheles pharoensis* Theobald to DDT and Dieldrin, 410
Kukku, M , and others : Thyroid-Powder Feeding and Liver Nitrogen in Mice, 890
Kullback, Prof. Solomon : Information Theory and Statistics, *review* by Prof. Colin Cherry, 506
Kundu, Dr. M R., and Haddock, Prof F. T : A Relation between Solar Radio Emission and Polar Cap Absorption of Cosmic Noise, 610
Kunkel, Dr. L O. : *Obituary*, 434
Kuper, Dr. C. G. : Methodology and Superconductivity, *review*, 833
Kurian, Dr. C. · Recent Advances in Coconut Research in India, 861
Kurian, V C · Recent Advances in Coconut Research in India, 861
Kurth, Dr O E W R : Appointed senior lecturer in mathematics at the University of Durham, 937
Kurti, Dr. N · Appointed reader in physics at the University of Oxford, 767

LA RIVIÈRE, J. W. M., and others (edited by) Albert Jan Kluyver—His Life and Work, *review* by Prof. B C J. G Knight, 44
La Venta, Tabasco, 1955 : Excavations at (Philip Drucker, Robert F. Herzer and Robert J. Squier), 134
Labelling (Heterogeneous), of Acid-soluble Nucleoside 5'-Monophosphates during Short *in vivo* Incubation with Phosphate-^{32}P (Dr. T. D. Price, K. K. Tsuboi, H A Hinds and P. B. Hudson), 158
Labelling (Radiation), with Carbon-14 of Aliphatic Hydrocarbons (Fulvio Cacace and Angelo Guarino), 632
Laboratories (New), at the University of Liverpool, 844
Laboratory Animals in the Standardization of Drugs : The Use of (Research Defence Society, Pamphlet No 10), 438
Laboratory Course (Summer), in Techniques and Applications of the Electron Microscope (Cornell University), 127
Laboratory Mechanical Mixers and Mortars High-Pressure Phase Transformations in (Frank Dachille and Prof Rustum Roy), 34
Laboratory Primates . Diseases of (Prof Theodore C Ruch), *review* by Dr. C. R. Coid, 506
Laboratory Technicians and Assistants (Ministry of Labour and National Service, Choice of Careers Series No 94), 682
Laboratory and Field Manual of Ornithology (Olin Sewall Pettingill, Jr.), third edition, *review* by J. D. Macdonald, 65
Labour and National Service, Ministry of : Factories (Ionizing Radiations) Special Regulations—Second Preliminary Draft of Regulations, 13
Labour and National Service, Ministry of (Central Youth Employment Executive) : Choice of Careers, Series No. 1, Choosing your Career, 682
  Choice of Careers Series No 94, Laboratory Technicians and Assistants, 682
  Choice of Careers Series No. 100, The Scientist, 682
Laby, Dr. T. H (Kaye, Dr. G W C., and) : Tables of Physical and Chemical Constants and some Mathematical Functions, twelfth edition, *review* by T. M Yarwood, 67
Lack of Thinking in Examinations (Dr. Margaret Sutherland), 607
Lactic Streptococci : Heritable Changes in, induced by Physical Treatments (B. S. Gossling), 868
Lacy, Dr. D. : Co-ordination of Light and Electron Microscopy, 672
Lacy, Dr. D. (Bourne, Dr. Gordon L., and) : Ultra-Structure of Human Amnion and its Possible Relation to the Circulation of Amniotic Fluid, 952
Laing, Prof Patrick G., and Kim, Dr. Ik Dong : Clearance Rates of Sodium-24, Potassium-42 and Iodine-131 in Normal Dog Hip Joints, 898
Lajtha, Dr. L. G. (Oliver, R , and) : Hazard of Tritium as a Deoxyribonucleic Acid Label in Man, 91
Lajtha, Dr. L. G , and others Mechanism of the Radiation Effect on the Synthesis of Deoxyribonucleic Acid, 563
Lake, Philip Physical Geography, fourth edition, revised by Prof. J. A. Steers, *review* by Prof. L Dudley Stamp, 190
Lakes (Swedish) : Surface Temperature of, and the Origin of Rainfall (Vilhelm Irgens Pettersson), 945
Lamb, H. H : Results of the Royal Society's International Geophysical Year Expedition (Analysis of Upper-Air Measurements), 191
Lamond, Dr. D. R. . Seasonal Differences in Ovulating Hormone in the Merino Ewe, 971
Lampreys (Larval), *Petromyzon marinus* : Responsiveness of the Neurosecretory System of, to Light (Dr. Nezihe Oztan and Dr. Aubrey Gorbman), 167
Land (Agricultural) : An Assessment of the Quantities of Fission Products likely to be found in Milk in the Event of Aerial Contamination of (Dr. R. J. Garner), 1063
Landau, L. D. : Elected a Foreign Member of the Royal Society, 435
Landau, L. D., and Lifshitz, E. M. Fluid Mechanics (translated from the Russian by J B. Sykes and W. H. Reid), *review* by Dr. G K. Batchelor, 1000
Landau, L. D., and Smorodinsky, Ya. : Lectures on Nuclear Theory (translated from the Russian), revised edition, *review* by Dr T. E. Allibone, 917
Lane, Dr. G. R : Title of senior lecturer in botany in the University of Southampton conferred on, 284
Lang, Prof. A. (Blumenthal-Goldschmidt, Dr S , and) : Presence of Gibberellin-like Substances in Lettuce Seed, 815
Lange, R T , and Parker, C. A. : Nodulation Patterns on Legumes, 178
Langham, Dr. Derald G : Appointed lecturer (economic botany) in the Department of Botany in Yale University, 1020
Langston, Wann · *Anchiceratops* from the Oldman Formation of Alberta, 522
Language : The Problem of, in Publications of Works in Scientific and other Fields of Learning (Prof D. Keilin), 912
Language (English) · Letter Structure of the (A. D. Baddeley, R. Conrad and W. E. Thomson), 414
Lanthanum to Lutetium (Rare-Earth Elements) Abundances of the, in Chondritic Meteorites (Dr. R A. Schmitt, A. W. Mosen, C. S. Suffredini, J. E. Lasch, Dr. R A. Sharp and D. A. Olehy), 863
Lapage, Dr. G : Brompton Hospital Reports, *review*, 507
  Factors and Causes of Infective Diseases, *review*, 581
Lapis, K , and others Heterogeneity of Tumour Ribonucleic Acid and the Effect of 'Degranol' on it, 81
Larmor's 'Aether and Matter' · A Forerunner of Twentieth Century Physics—a Re-view of (Lancelot Law Whyte), 1010
Larsen, Lis Olesen (Jørgensen, C. Barker, and) : Control of Colour Change in Amphibians, 641
Larvae of *Calyptraea chinensis* (L) · Response of, to Light (H. V Wyatt), 328
Larvae of *Tendipes f l plumosus* L. . Haemoglobin Content of the, from Various Levels of Bed Sediment (B Czeczuga), 484
Larvae (Infective), of *Oesophagostomum radiatum* (Rud. 1803) (Strongylidae: Nematoda) : Effect of X-Rays on the Development of the (R F. Riek and R. K. Keith), 981
Larval Food (Honeybee) : Electrophoretic Components of the Proteins in (N. G. Patel, M. H Haydak and T A Gochnauer), 633
Larval Lampreys (*Petromyzon marinus*) : Responsiveness of the Neurosecretory System of, to Light (Dr. Nezihe Oztan and Dr. Aubrey Gorbman), 167
Lasch, J. E., and others · Abundances of the Rare-Earth Elements, Lanthanum to Lutetium, in Chondritic Meteorites, 863

- Late Precambrian Fauna in South Australia (M. F. Glaessner and B. Daily), 205
- Latham, Dr. R., and others : Growth of Surface Instabilities in a Linear Pinched Discharge, 624
- Lathyritic Rats . Aortic, Serum, Connective Tissue and Osseous Chemistry in (Dr. R. A Grant, M. Hathorn and Prof. Theodore Gillman), 164
- Latin-America . Scientific Institutions and Scientists in (Unesco, Centro de Cooperacion Cientifica para America Latina), Vol. 1, Paraguay ; Vol. 2, Chile, 203
- Latin American School of Physics (Centro Brasileiro de Pesquisas Fisicas), 361
- Latter, Pamela (Burges, Prof. Alan, and) : Decomposition of Humic Acid by Fungi, 404
- Lattice Defects and the Mechanical Properties of Solids (International Union of Crystallography Symposium on), 1020
- Laughton, A S. : Some Bottom Cores from the Swedish Deep-Sea Expedition (1947–48), 609
- Lawrence, Dr. M J : Appointed lecturer in genetics at the University of Birmingham, 522, 767
- Layer (Surface), of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide : Photo-stimulated Emission of Exo-electrons from the (J. Wawrzyniak and Dr. B. Sujak), 467
- Layers (Double), involving Solid Metals . Determination of Adsorption in (Dr. Erik A. Blomgren and Dr. John O'M. Bockris), 305
- Layers (Oxide), and Brittle Materials for Microdiffraction : A Technique for Sampling (A. M. Adams, M. A. Silva and Veronica M. Spiers), 147
- LeBlanc, jun., Dr. Oliver H (Huggins, Dr. Charles M., and) : Electrical and Magnetic Properties of β-Carotene Triiodide, 552
- LeCouteur, Prof. K. J. : Elected a Fellow of the Australian Academy of Science, 519
- Le Pelley, R. H. (compiled by) : Agricultural Insects of East Africa, *review* by Dr. Kenneth Mellanby, 65
- Le Play Society (Prof. L. Dudley Stamp), 606
  - Conference on Present Problems in World Affairs, 606
- Lea, K. R. (Smith, E. B., and) : A Monte Carlo Equation of State for Mixtures of Hard-Sphere Molecules, 714
- Lead : A Method of Staining Sectioned Tissues with, for Electron Microscopy (Dr. J. D. Lever), 810
- α-Lead Azide : Radiation-induced Changes in (G. Todd and E. Parry), 543
- Leake, Dr. Bernard E. : Russian Approach to Mineral Paragenesis, *review*, 745
- Leakey, Dr. L. S. B. : The Affinities of the New Olduvai Australopithecine, 458
- Learning : Brain—Memory— a Neurologist's View (Dr. W. Ritchie Russell), *review* by Dr Gilbert Hall, 39
  - Memory and—a Neurologist's Point of View, *review* by Dr. Gilbert Hall, 39
  - The Problem of Language in Publications of Works in Scientific and other Fields of (Prof. D. Keilin), 912
  - Theories of (Prof. Ernest R. Hilgard), second edition, *review* by Prof. K. R. L Hall, 40
  - The World of, 1959-60, tenth edition, *review*, 1003
- Learning in the Rhesus Monkey : Development of (Harry F. Harlow and colleagues), 211
- Learning Theory : 60 Years of, *review* by Prof. K. R. L. Hall, 40
- Leather Manufacturers Research Association (British) : Open Days, 17
  - Open Days (Dr. K. W. Pepper), 1024
- Leatherman, Gerald H., and Ellis, J. A. · Fluoridation of Drinking Water, 438
- Leaton, B. R. : Between Earth and Space, *review*, 68
- Leaves of *Marsilea* : Foliar Abnormalities, including Repeated Branching and Root Formation, induced by Kinetin in Attached (Dr. A. Allsopp and Alicja Szweykowska), 813
- Leaves (Tobacco) inoculated with Tobacco Mosaic Virus : Decarboxylation of Glutamic Acid in (M. S. Gubanski), 657
- Lebensvorgange : Die Ruckkoppelung als Urprinzip der (Bayerische Akademie der Wissenschaften Prize of 8,000 D. marks for an Essay on), 938
- Leblond, Prof. C. P., and others · Structures corresponding to Terminal Bars and Terminal Web in Many Types of Cells, 784
- Lecithin (Cortisone Acetate, Cholesterol and) : Enhancement of Staphylococcal Virulence for Mice by Intraperitoneal (Dr. Daniel Amsterdam and Dr. S. Stanley Schneierson), 101
- Lecithin and Cephalin (Albumin,) : Interaction between (Dr. Eric Ponder and Ruth V Ponder), 235
- Lecithins labelled with Phosphorus-32 : Heterogeneity of (Dr. F. D. Collins), 966
- Lectures on Nuclear Theory (L. D. Landau and Ya Smorodinsky), translated from the Russian, revised edition, *review* by Dr. T. E. Allibone, 917
- Lederer, E., and others : Mycosides, a New Class of Type-Specific Glycolipids of *Mycobacteria*, 887
- Lederle Medical Student Research Fellowships (American Cyanamid Company), 283
- Lee, Stephanie, and others : Development of Resistance in Mice to Tumour Induction by *S E* Polyoma Virus, 615
- Lees, G. : Appointed lecturer in road materials at the University of Birmingham, 767
- Legg, S P., and Sears, L. : Zinc Sulphate Treatment of Parakeratosis in Cattle, 1061
- Leguebe, André : A Phenylthiocarbamide Test, 970
- Legume : Cobalt in Nitrogen Fixation by a (Prof H M. Reisenauer), 375
- Legumes · Nodulation Patterns on (R. T. Lange and C. A. Parker), 178
- Lehmann, Dr. I. : Structure of the Upper Mantle as derived from the Travel Times of Seismic *P* and *S* Waves, 956
- Lehmann, Donald L. A Blood Parasite from the California Yellow-legged Frog, 765
- Lehnert, B. (edited by) : Electromagnetic Phenomena in Cosmical Physics (International Astronomical Union Symposium No. 6, Stockholm 1956), *review* by Dr. R. H Garstang, 67
- Leibowitz, Prof. J. (Frohwein, Y. Z., and) : Synthesis of 6-0-Acetyl-*α*-Glucose, 153
- Leitritz, Earl : Trout and Salmon Culture—Hatchery Methods, 204
- Lemoigne, M., et autres : Traité de Biochimie Générale, Vol. I, Composition Chimique des Organismes, *review* by Prof. F. G. Young, 51
- Length of Day : Insects and, 774
- Leopoldina Academy of Natural Sciences, Halle . Election of new Members, 766
- Lesions (Skin), of Cattle : Isolation of a Cytopathogenic Agent from (Dr. C. Huygelen, D. Thienpont and M Vandervelden), 979
- Lessie, T. (Aaronson, Dr. S., and) : Nonulosaminic Acid (Sialic) in Protists, 719
- Lethal Doses and Sterilizing Doses of X-Rays : Divergence between, with Progressive Development in *Habrobracon* Females (Dr. Howard E. Erdman), 254
- Lethality in Mice and Rats exposed to X-Rays : Inability of Methionine to affect (Prof. Zenon M. Bacq and Dr. Marie L. Beaumariage), 1064
- Letter Structure of the English Language (A. D. Baddeley, R. Conrad and W. E. Thomson), 414
- Lettuce Seed : Presence of Gibberellin-like Substances in (Dr. S. Blumenthal-Goldschmidt and Prof. A. Lang), 815
- Leucocytes (Human) : Culture of, on the Chorioallantoic Membrane of the Chick (Eugene Bell), 403
  - Infra-Red Spectra of Deoxyribonucleic Acids from (G. Zerbi, P. A. Bianchi and E. E. Polli), 964
- *Leuconostoc mesenteroides* : (+) S-Methyl-L-Cysteine Sulphoxide, an Inhibitor of Aspartic Acid Utilization in (Wilfred N. Arnold, Clayton J. Morris and John F. Thompson), 1051
- Leukaemia and Allied Diseases : Research on (Tata Memorial Trust Awards), 1020
- Level of Sulphydryl Compounds in Rat Liver following Feeding with Goitrogenous and Non-goitrogenous Cabbage (Jozef Sedlák), 892
- Level (Low-) Direct Current Signals : Transistor Modulators for (J. F. Evans), 626
- Level (Subnormal), of Carbonic Anhydrase in Blood of Carcinoma Patients? (Dr. N. W. H. Addink), 253
- Levels of Adenosine Triphosphate and Glycogen in the Liver : Changes in the, caused by Protein Administration (Dr. Catherine M. Clark, Dr. G. A. J. Goodlad, Dr. J. Chisholm and Dr. H. N. Munro), 719
- Levels of Ubiquinone and Ubichromenol in the Rat : Effect of Thyroxine and 2,4-Dinitrophenol on (E. E. Edwin, J. Green, A. T. Diplock and J. Bunyan), 725
- Levels (Normal Susceptibility), of *Anopheles pharoensis* Theobald to DDT and Dieldrin (Dr. F. Kuhlow), 410
- Levels (Various), of Bed Sediment : Haemoglobin Content of the Larvae of *Tendipes f l. plumosus* L. from (B. Czeczuga), 484
- Lever, Dr. J D. : A Method of Staining Sectioned Tissues with Lead for Electron Microscopy, 810
- Leverhulme Trust : Third Report (1956-59), 1026
- Levisohn, Dr. Ida : Effects of *Gibberella fujikuroi* on Fungal Root-Infections of *Pinus*, 987
- Levitus, R , and others · Some New Complexes of Rhenium, 233
- Levvy, Dr. G. A. : Mammalian α-L-Fucosidase, 472
- Lewin, Dr. Ralph A. : A *Spirochaeta* Phage, 901
- Lewis, Prof. D. : Nature and Exploitation of Plant Crop Resistance to Disease (Ways in which Fungal Variability may occur), 858
- Lewis, Dr. T. J., and Secker, Dr. P. E. : Effect of Cathode Surface Roughness and Oxidation on Arc Movement, 30
- Lettenmeyer, Dr. Lore (compiled by) : Atomic Terminology, a Dictionary of Nuclear Science, Engineering and Technology in Four Languages (English–German–French–Italian), *review* by Dr. J. B. Sykes, 67
- Liberation of Hexuronic Acid, Hexosamine and Hydroxyproline from Steer Hide by Stem Bromelain (E. A. Botan and T. B. Brother), 314
- Libraries (Manchester Public) : One hundred and seventh Annual Report (1958-59), 437
- Library (British), of Political and Economic Science : Annual Report for 1958-59, 520
- Library (National Reference), of Science and Invention, 934
- Library Association : Pamphlet No. 20, The Reproduction of Catalogue Cards (Philip S. Pargeter), 1020
- Library Association (North Western Group, Reference, Special and Information Section) : Russian Journals, 683
- Library Association (Medical), of America : Marcia G. Noyes Award given to Leslie T. Morton, 685
- Lieberman, M , and others : Ethylene Production by Tomato and Apple Fruits, 902
- Life : The Hand of—the Story of the Weizmann Institute (Ritchie Calder), *review*, 64
  - Interrelation of Tryptophan and Nicotinic Acid in Man during the First Month of (S. Auricchio, E. Quagliariello and A. Rubino), 639
- Life Insurance Co. (Metropolitan), New York : Statistical Bulletin, Vol. 40, New Weight Standards for Men and Women ; Fathers are Younger ; How Fatal Accidents occur in the Home ; Geographic Variations in Mortality by Cause, 445
- Life-like Preservation of Cytoplasmic Detail in Plant Cells (Dr. J Chayen, Prof. G J Cunningham, P. B. Gahan and A. A. Silcox), 1068
- Life-time (Radiative), of the Pyrene Dimer and the Possible Role of Excited Dimers in Energy Transfer Processes (Dr. B Stevens and E Hutton), 1045
- Lifshits, E. M., and Andronikashvili, E. L. : A Supplement to 'Helium', (translated from the Russian), *review* by Prof. J. F. Allen, 835
- Lifshitz, E. M. (Landau, L D., and) · Fluid Mechanics (translated from the Rusian by J B. Sykes and W. H. Reid), *review* by Dr. G. K. Batchelor 1000
- Ligand Exchange with its Metal Complex · Rate of, by a Polarimetric Method (B. Bosnich, Dr. F. P. Dwyer and Dr. A M. Sargeson), 966
- Light : Influence of, on Bacterial Flora of Roots (J. W. Rouatt and Dr. H. Katznelson), 659
  - Response of Larvae of *Calyptraea chinensis* (L) to (H. V. Wyatt), 328
  - Responsiveness of the Neurosecretory System of Larval Lampreys (*Petromyzon marinus*) to (Dr. Nezihe Oztan and Dr Aubrey Gorbman), 167
  - Velocity of, in a Magnetic Field (Prof R. V. Jones), 706
- Light (Polarized) : Discrimination of, by *Octopus* (The Visual System of *Octopus*), (M F. Moody and J. R. Parriss), 839
- Light (Ultra-Violet) : Electron Spin Resonance in Hydrogen Peroxide–Water Solutions at 90° K. irradiated with (Robert C. Smith and S J Wyatt), 226
  - Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide irradiated with (Prof. F. S. Dainton and S. A. Sills), 879

Light (Visible) : Inactivation by, of Yeast sensitized by a Nucleic Acid Fluorochrome (David Freifelder and Prof. Robert B. Uretz), 731
Light and Adenosine Triphosphate in Bacterial Photosynthesis : Equivalence of (Dr. M. Losada, Dr. A. V. Trebst, S Ogata and Prof. Daniel I. Arnon), 753
Light and Electron Microscopy : Co-ordination of (Royal Microscopical Society and the Electron Microscopy Group of the Institute of Physics Symposium on), 672
Light-initiated Organic Synthesis, *review* by Prof. R. N. Haszeldine, 53
Lilley, J. S. : Appointed to a Research Fellowship in nuclear physics at the University of Birmingham, 937
Limpet (Slipper), *Crepidula fornicata* L., in Ireland : Occurrence of the (D. C. Arnold), 95
Limulus polyphemus (Horseshoe Crab) : Visual Pigment of the (Dr. Ruth Hubbard and Prof. George Wald), 212
Lindsay Memorial Lectures, 1958 (The Study of Man), (Prof. Michael Polanyi), *review* by F. I. G. Rawlins, 347
Linear Pinched Discharge : Growth of Surface Instabilities in a (Dr. R. Latham, J. A. Nation, F. L. Curzon and Dr. A. Folkierski), 624
Ling, Dr. Wang (Dr. Joseph Needham, with the collaboration of) : Science and Civilization in China, Vol. 3, Mathematics and the Sciences of the Heavens and the Earth, *review* by Prof. W. M. Smart, 36
Ling, Dr. Wang, and others : Heavenly Clockwork—the Great Astronomical Clocks of Medieval China, *review* by Dr F. A. B. Ward, 834
Linnean Society of London : Election of Officers and Council for 1960-61, 766
  Linnean Gold Medals presented to Dr. Libbie Henrietta Hyman and Dr. H. Hamshaw Thomas, 766
  Trail Award and Medal presented to Dr. Lawrence Ernest Rowland Picken, 766
  Election of Prof. Dr. C G. G. van Steenis and Dr. Robert E. Snodgrass as Foreign Members, 766
  Election of H. F. Comber, Dennis A. Kempson and Prof. Alexander Eric Kohts as associates *honoris causa*, 766
Linstead, Sir Patrick : Honorary membership of the Institute of Mining and Metallurgy conferred on, 854
Linton, W. H. : Polymeric Progress (Acetal Polymers), 441
Lipaemia (Haemorrhagic), in the Rat (Sven Punsar, Gottfried Härtel, Antti Louhija and Olli P. Heinonen), 888
Lipid Metabolism : Drugs affecting (Institute of Pharmacology of the University of Milan Symposium on), 127
Lipophilic Agar Cells : Diffusion of Proteins through (Dr. Ch. Wunderly), 885
Lipoprotein (Structural), of Rat Liver : Binding of a Hepatocarcinogen to the—its Bearing on the Immunological Theory of Cancer (J. W. Westrop and Prof. H. N. Green), 350
Lippman, F. : X-Ray Determination of Phillipsite in a Sediment Core from the Central Equatorial Pacific (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 10, Special Investigations, No. 3), 609
Lipson, Prof. H. : Elected president of the Manchester Literary and Philosophical Society, 854
Liquid Friction Constant (Dr. G. H. A. Cole), 301
Liquid Helium (Prof. K. R. Atkins), *review* by Dr. J. G. Valatin, 345
Liquid Sulphur · Structure of the Viscous Phase of (Dr. E. McLaughlin), 76
Liquid (Gas–) Chromatography : Non-Equilibrium Theory of (Dr. M. A. Khan), 800
Liquids (Supercooled) : Reduced Temperatures for Nucleation in (Dr. E. R. Buckle), 875
Literary and Philosophical Society (Manchester) : Election of Officers, 854
Literature : Zoological, *review* by Dr. Edward Hindle, 831
Literature in Russian Language : Bibliographical Index of, for 1958 (Academy of Sciences of the U S.S.R.), 359
Lithium (Body-centred Cubic) : An Energy Band Interpolation Scheme, with Application to (J. F. Cornwell and Dr. E. P. Wohlfarth), 379
Littler, Dr. W. B. : Rocket Propellants, *review*, 58
Littlewood, Dr A. B. : Gas Chromatography, 944
Liu, S. L. : Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat, 475
Liver : Changes in the Levels of Adenosine Triphosphate and Glycogen in the, caused by Protein Administration (Dr. Catherine M. Clark, Dr. G. A. J Goodlad, Dr. J. Chisholm and Dr. H. N. Munro), 719
  Cirrhosis of the, induced in Rabbits by Gastric Instillation of 3-Monohydroxycholanic Acid (Dr. Paul Holsti), 250
  Measurement of the Intrahepatic Shunted Flow of Blood in Cirrhosis of the (T. Nakamura, S. Nakamura and K. Tokita), 243
Liver (Rat) : Binding of a Hepatocarcinogen to the Structural Lipoprotein of—its Bearing on the Immunological Theory of Cancer (J. W. Westrop and Prof H. N. Green), 350
  Level of Sulphydryl Compounds in, following Feeding with Goitrogenous and Non-goitrogenous Cabbage (Jozef Sedlák), 892
Liver (Rat), in Experimental Cirrhosis : Histochemical and Biochemical Studies of, after Partial Hepatectomy (I. Bartók, Gy. Domján, E Horváth and Prof. B. Korpássy), 397
Liver of Rats and Chicks : Vitamin A Isomers in the (O. R. Braekkan, H. Myklestad, L R. Njaa and F. Utne), 312
Liver Cancer : Effect of 3-Amino-1,2,4-triazole on the Experimental Production of (Munemitsu Hoshino), 174
Liver Homogenates (E-Deficient) : Maintenance of α-Ketoglutarate and Succinate Oxidation in, by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine (Dr. Laurence M. Corwin and Dr Klaus Schwartz), 1048
Liver Mitochondria (Fresh and Aged) · Swelling of, as affected by Succinate, Adenine Nucleotides and Thyroxine (Dr. P. Emmelot, C. J. Bos, P. J. Brombacher and I H M. Reyers), 556
Liver Mitochondria (Rat) : Effect of Pituitary Growth Hormone *in vivo* on the Phosphorus/Oxygen Ratios of Isolated (C N. Graymore, A. H. Melhuish and A. L. Greenbaum), 392
  Effects of Fatty Acids on the $_{32}$P-Adenosine Triphosphate Exchange Reaction in (K. Ahmed and Dr. P. G. Scholefield), 1046
Liver Nitrogen in Mice : Thyroid-Powder Feeding and (Dr. A N Granitsas, M. Kukku and M. Konstantinidu), 890
Liver–SH Levels of Mice : Body-Weight and (Dr G. Calcutt), 84
Liverpool Geological Society, 1859-1959 (R G. C. Bathurst), 9
Living and Fossil Unicellular Algae and Aplanospores (D M Churchill), 493
Livingston, Prof. Robert, and Pugh, Dr. A. C. P. : Role of the Triplet State in the Photoreduction of Chlorophyll, 969
Ljunggren, Prof. Pontus : Fall-out Radioactivity in Southern Sweden, 655
Lloyd, H. : Reactor Fuel Element Technology (Fabrication of *Dido*-type Fuel Elements including the Mark III Version, and their Application to Power Reactors), 1026
Loading (Structural), in Factories (Department of Scientific and Industrial Research), 851
Loads (Snow), and Roof Designs, 603
Localization of Amino-acids for Histochemical Estimation (Helen M. Notovny and Robert G. Owens), 1057
Locher, F. W. : Sedimentpetrografische Untersuchung der Lotkerne 255 und 257 (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Sediment Cores from the North Atlantic Ocean, No. 4), 609
  Ein Beitrag zum Problem der Tiefseesande im westliche Teil des aquatorialen Atlantiks (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Sediment Cores from the North Atlantic Ocean, No. 5), 609
Lockspeiser, Sir Ben : *Obituary* of Sir David Pye, 433
Locus Coeruleus of the Mammalian Brain · Histochemical Demonstration of Ascorbic Acid in the (Dr. Nobuo Shimizu, Tomokazu Matsunami and Satoko Onishi), 479
Loeser (Guenter) Memorial Lecture of the United States Geophysical Research Directorate (Dr. Hans E. Hinteregger), 523
Loev, Dr. Bernard : Structure of Bhilawanol, 389
Lofthus, Alf . A New Predissociation in Nitrogen, 302
Logic (Symbolic), and Intelligent Machines (Edmund C. Berkeley), *review* by Dr. A. D. Booth, 422
London (Fritz) Award for Low-Temperature Research, 205
London Hospital Medical College : Appointment of Dr. K. W. Cross to the University of London chair of physiology, 522, 598
London School of Dental Surgery (Royal Dental Hospital of) : Appointment of Dr. H. J. J. Blackwood as reader in oral anatomy, 938
Long-Chain Effect ? · Proton Magnetic Resonance in a Series of Dimethyl Siloxane Polymers—a Specific (Dr. J. G. Powles and A. Hartland), 26
Long-lived Natural Radioactivity : Use of, as an Atmospheric Tracer (W. M Burton and N G. Stewart), 584
Long-range Clock Synchronization Experiments : Preliminary Flight Tests of an Atomic Clock in Preparation of (Friedrich H. Reder and Gernot M. R. Winkler), 592
Longstaff, J. V. L., and Singer, Dr. K. : Gaussian Wave Functions for the Hydrogen Molecule, 799
Lords, House of : Debate on the Antarctic, 212
  Debate on the Crowther Report, 577
Losada, Dr. M., and others : Equivalence of Light and Adenosine Triphosphate in Bacterial Photosynthesis, 753
Losee, Capt. F. L., and others : An Association between Dental Caries and certain Soil Conditions in New Zealand, 695
Loss of Specificity on Passage of Immunologically Competent Cells in the Chick Embryo (Sir Macfarlane Burnet and Georgiana Boyer), 175
Losses (Food), in Field and Store (Nutrition Society Symposium on), 685
Lotkerne 255 und 257 : Sedimentpetrografische Untersuchung der (F. W. Locher), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Sediment Cores from the North Atlantic Ocean, No. 4), 60
Loughborough College of Technology : Appointment of Dr. W. F. Floyd as first head of the Department of Ergonomics and Cybernetics, 523
Loughnan, C. J. : Motion of Geomagnetic Field Lines, 33
Louhija, Antti, and others : Haemorrhagic Lipaemia in the Rat, 888
Lovell, Prof. Reginald : The Aetiology of Infective Diseases, *review* by Dr. G. Lapage, 581
Lovering, J. F. : Origin of Tektites—High-Temperature Fusion of Possible Parent Materials for Tektites, 1028
Low, Prof. Barbara W., and Einstein, J. Ralph : Symmetry of Insulin Dimers and Hexamers, 470
Low-Energy Nuclear Physics, *review* by Dr. E. Bretscher, 58
Low Frequency (Very) Geomagnetic Fluctuations : Influence of Geological Features on (H. J. Duffus, J. A. Shand and Sir Charles Wright), 141
Low-level Direct Current Signals : Transistor Modulators for (J. F. Evans), 626
Low Sea-Level Air Pressure : New Record (C L. Jordan), 283
Low-Temperature Photoproducts : Regeneration of Visual Pigments from their (Dr. C. D. B. Bridges), 292
Low-Temperature Research : Fritz London Award for, 205
Low Temperatures : Coloured Sulphur Deposits at (Dr. B. Meyer and Prof. E. Schumacher), 801
Low Temperatures (Very) : Reaction between Copper and Solid Oxygen condensed at, from a Gas Discharge (Jerome Kruger and William J. Ambs), 794
Lowenstein, Prof. O. : Sensory Specialization in Response to Environmental Demands, 688
Lower Olefines : The Industrial Chemistry of the (Chemical Society, the Institute of Petroleum, the Royal Institute of Chemistry and the Society of Chemical Industry Symposium on), 285
Lower Olfactory Pathway of the Toad : Potential Oscillations in the (Dr. S F. Takagi and Dr T. Shibuya), 724
Lower Tertiary Microfossils from McMurdo Sound, Antarctica (Dr. Lucy M. Cranwell (Mrs Watson Smith), Dr. H. J. Harrington and I. G. Speden), 700
Lowry, G C. . Elected to Fellowship of the Imperial College of Science and Technology, London, 522
Lubricant : Action of Graphite as a (W. Bollmann and J. Spreadborough), 29
Lucilia cuprina Wied. . Genetics of Resistance to Dieldrin in (G. J. Shanahan), 181
  Selection for High-Order Resistance to 'Dieldrin' in (G. J. Shanahan), 100
Ludwig, T. G., and others : An Association between Dental Caries and certain Soil Conditions in New Zealand, 695
Lunar Surface The (V. A. Firsoff), 826 ; (Dr. B E. J. Pagel), 826
Lung (Chopped Guinea Pig) : Inhibition of the Anaphylactic Release of Histamine from, by Chymotrypsin Substrates and Inhibitors (Dr. K. F Austen and Dr. W. E. Brocklehurst), 866
Luria, Prof. S. E. · Elected a member of the United States National Academy of Sciences, 773
Lutetium (Rare-Earth Elements, Lanthanum to) : Abundances of the, in Chondritic Meteorites (Dr. R. A. Schmitt, A. W. Mosen, C. S. Suffredini, J. E. Lasch, Dr R. A. Sharp and D. A. Olehy), 863

Lycopersicum . Interspecific Hybrids of (Dr Donald Michie), 1071 ; (Helgi Nirk), 1071
Lyle (Thomas Ranken) Medal for 1959 of the Australian Academy of Science presented to Prof. E. S. Barnes, 519
Lymphogranuloma (Trachoma, Inclusion Blennorrhoea and) Transmission of the Viruses of, to Mice (Dr. E. Weston Hurst and P. Reeve), 336
Lynden-Bell, D. : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Lynn, Dr. R. (Griew, Dr S , and) : Construct 'Reactive Inhibition' in the Interpretation of Age Changes in Performance, 182
Lysis (Streptomycin-induced), of Penicillin-treated *Staphylococci* (Dr. R Hancock), 658
Lysozyme and Egg-White Administration Increase in 'Alkaline' Ribonuclease of Rat Kidney Cortex after (Dr. T. Maack, Dr. R. Brentani and Dr. M. Rabinovitch), 158
Lytic Blood-Typing Tests . Bacterially Mediated False-Positive Reactions in (Prof. Clyde Stormont, Yoshiko Suzuki and W. J. Miller), 247

MAACK, Dr T., and others : Increase in 'Alkaline' Ribonuclease of Rat Kidney Cortex after Lysozyme and Egg-White Administration, 158
Macaca irus : Haptoglobin Types in (Lars Beckman and Gunilla Cedermark), 643
Macan, Dr T. T · A Guide to Freshwater Invertebrate Animals, *review* by Dr J P Harding, 345
McAulay, I. R. (Delaney, Dr. C F. G , and) : Radiocarbon Dating System using Scintillation Techniques, 204
McBurney, Ralph E . Appointed head of the Technical Information Service of the National Research Council of Canada, 17
Maccabaeans, Society of : Meldola Medals for 1959 awarded to Dr. J. I. G. Cadogan and Dr. T. C. Waddington, 519
McCallan, S E A , and others (edited by) · Plant Pathology, Problems and Progress, 1908-1958, *review* by W. C. Moore, 47
McCloy, D. : Appointed lecturer in mechanical engineering at the Queen's University, Belfast, 767
McCrea, Prof. W. H. . The Interpretation of Cosmology, 1035
McDermott, E. D. · Awarded a Gold Medal of the Institute of Mining and Metallurgy, 854
MacDonald, Dr. D K C. : Elected a Fellow of the Royal Society, 11
McDonald, I. W. : Nitrogen in Tropical Agriculture (Nitrogen Intake and Excretion of Grazing Animals), 941
Macdonald, J D. A Laboratory and Field Manual of Ornithology, *review*, 65
McDonald, Dr M P. (Collison, Dr Roger, and) . Broadening of the Water Proton Line in High-Resolution Nuclear Magnetic Resonance Spectra of Starch Gels, 548
MacDowall, J. : Results of the Royal Society's International Geophysical Year Expedition (Work done in Seismology, Glaciology and Meteorology), 191
Macer, Dr. R C. F : Nature and Exploitation of Crop Plant Resistance to Disease, 857
Maceration (Collagenase), of Kidney for Microdissection (Nancy J. Hayward), 403
Machines (Intelligent) : Symbolic Logic and (Edmund C Berkeley), *review* by Dr A D. Booth, 422
Machlis, Leonard (edited by, in association with John G. Torrey) : Annual Review of Plant Physiology, Vol 10, *review* by Prof. W Stiles, 747
MacIntosh, Dr. D. · Medical Research in the British Caribbean (Diabetes mellitus), 862
McIntyre, A D (Burdon-Jones, C , and) : *Stereobalanus*, a Genus New to the Old World, 491
MacIver, A. M · Appointed to the newly established chair of philosophy in the University of Southampton, 284
MacIver, Dr. - , and Back, Dr. -. : Medical Research in the British Caribbean (Megaloblastic Anaemia in Malnourished Infants), 863
MacKay, Dr. Donald M. Appointed to the new Granada research chair of communication in the University College of North Staffordshire, 599 ; work of, 599
McKay, H A. C : The Cento Institute of Nuclear Science in Tehran, 513
McKeller, Dr Andrew : *Obituary* by Prof. R O. Redman, 1014
McKenzie, A. W. : Visco-Elastic Systems (Influence of Inter-Fibre Bonding), 942
McKeown, Prof T. . Human Growth (Influences affecting Human Prenatal Growth), 20
McKinnon, N. A. First Stage of Work Hardening in Aluminium Single Crystals, 148
McLaughlin, Dr E. Structure of the Viscous Phase of Liquid Sulphur, 76
MacLennan, A. P., and others : Mycosides, a New Class of Type-Specific Glycolipids of *Mycobacteria*, 887
McLintock, Dr. W. F. P : *Obituary* by Prof. C. F. Davidson, 200
McManus, W R. (Goldhammer, Helen, and) : Effects of Non-Ionic Surfactants upon Animal Tissues, 317
McMurdo Sound, Antarctica . Lower Tertiary Microfossils from (Dr Lucy M. Cranwell (Mrs. Watson Smith), Dr. H. J. Harrington and I. G. Speden), 700
McNeill, Prof. K. G., and Trojan, O A. D. : Caesium-137 in Toronto Milk during 1959, 399
Macpherson, Dr. I. A , and Allner, K. : *L* Forms of Bacteria as Contaminants in Tissue Culture, 992
Macromolecules required : Are, for Growth of Single Isolated Mammalian Cells ? (Ralph B Gwatkin), 984
Macronucleus of *Spirostomum* and *Blepharisma* : Effect of Centrifugation on the (Prof B. R. Seshachar), 333
Macroscopic Scale Quantum Effects on a, *review* by Dr. J. G. Valatin, 345
Madshus, K., and Baarli, J. : Radiocaesium and Potassium-40 in Norwegian-produced Milk, 527
Maggs, Dr. F A. P., and others : Adsorption of Helium on Carbons—Influence on Measurement of Density, 956
Magnesium in Human Cerebrospinal Fluid : Calcium and (Dr. G Hunter and Honor V. Smith), 161
Magnetic Annealing, 439
Magnetic Field . Velocity of Light in a (Prof. R. V. Jones), 706
Magnetic Observatory : The Watheroo (Melbourne), 606
Magnetic Properties (Electrical and), of β-Carotene Triiodide (Dr Charles M Huggins and Dr. Oliver H. LeBlanc, jun.), 552
Magnetic Resonance : Nuclear—Applications to Organic Chemistry (Prof. J. D. Roberts), *review* by Prof E. R. Andrew, 55
Magnetic Resonance (Nuclear) Optical Detection of (J Brossel), 440
Magnetic Resonance (Proton), in a Series of Dimethyl Silozane Polymers—a Specific Long-Chain Effect ? (Dr. J. G Powles and A. Hartland), 26
Magnetic Resonance Spectra (High-Resolution Nuclear), of Starch Gels : Broadening of the Water Proton Line in (Dr. Roger Collison and Dr. M. P McDonald), 548
Magnetization (Natural Remanent), of some Welsh Slates : Anisotropy of Susceptibility and the (M. D Fuller), 791
Magnetohydrodynamics (Plasma Physics and), and their Applications to Controlled Thermonuclear Reactions . Bibliography on (J. D. Ramer), 522
Magneto-Ionosphere Disturbances (Academy of Sciences of the U.S.S.R.), 359
Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine (Dr Laurence M Corwin and Dr Klaus Schwartz), 1048
Maisin, Prof. J , and others . Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in Rats receiving an Acute Whole-Body Dose of X-Rays, 487
Maitland, Prof H. B (Postlethwaite, Dr. R , and) : Eclipse Phase of Vaccinia Virus, 335
Majer, Dr. J. R. : Appointed lecturer in chemistry at the University of Birmingham, 937
Major Source of Electrical Energy ? . Fuel Cells—Will they soon become a (F T. Bacon), 589
Malaya . Medical Research in, 944
Malaya, Government of the Federation of, and others : International Conference on Natural Rubber Research, 767
Malcolm, Wing-Comdr. J. E. : Korotkov's Sounds—Action of the Heart, 723
Male, J C., and Prior, J. R. : Intrinsic Recombination Radiation in Diamond, 1037
Male (Adult), and Nymph Development Stages of *Triatoma infestans* . Non-Identity of Triosephosphate Dehydrogenase of (Prof M. Agosin, A. Neghme and N Scaramelli), 1052
Male Fern in Pharmacognosy . Indian Substitutes of (Prof. P. N. Mehra and T C Mittal), 722
Male Sex Organ in certain Fern Species · Purification of a Specific Inducer of the (Ross B Pringle, Ulrich Naf and Armin C. Braun), 1066
Malformations : Congenital (International Medical Congress, Ltd., International Conference on), 685
Malinowski, Edmund · Genetyka, *review* by Dr. P. S. Hudson, 507
Malkani, T. M. . Fellowship of the City and Guilds of London Institute conferred on, 13
Mallon, H D , and Runciman, I. G. : Optical Properties of Bismuth, 709
Malonaldehyde–Thiobarbituric Acid Reaction . Estimation of 3-Deoxy Sugars by means of the (Dr. Morris A Cynkin and Dr. Gilbert Ashwell), 155
Mammalian Brain : Histochemical Demonstration of Ascorbic Acid in the Locus Coeruleus of the (Dr. Nobuo Shimizu, Tomokazu Matsunami and Satoko Onishi), 479
Mammalian Cells (Isolated) Are Macromolecules required for Growth of Single ? (Ralph B Gwatkin), 984
Mammalian α-L-Fucosidase (Dr G. A. Levvy), 472
Mammals . East Anglian (Lord Cranbrook), 770
Man Actinomycins and their Importance in the Treatment of Tumours in Animals and (New York Academy of Sciences Conference on), 771
  The Antecedents of (Prof. Sir Wilfrid E. Le Gros Clark), *review* by Dr G G. Simpson, 665
  Chromosome Abnormalities in (Dr. C. O Carter), 683
  Hazard of Tritium as a Deoxyribonucleic Acid Label in (R. Oliver and Dr. L. G. Lajtha), 91
  Interrelation of Tryptophan and Nicotinic Acid in, during the First Month of Life (S Auricchio, E. Quagliariello and A. Rubino), 639
  Radiation, Genes and (Prof Bruce Wallace and Prof. Th. Dobzhansky), *review* by Dr A. G. Searle, 109
  A Simplified Method for the Study of Chromosomes in (C. Bottura and I Ferrari), 904
  The Study of (Prof Michael Polanyi), *review* by F. I. G. Rawlins, 347
Man among the Primates, *review* by Dr G G Simpson, 665
Man and Monkey Serotonin Content of the Pineal Glands of (Prof Nicholas J Giarman, Daniel X. Freedman and Luis Picard-Ami), 480
Man's Conquest of the Stars (Pierre Rousseau), *review* by D. H. P. Jones, 69
Man-powered Flight (Financial grants from the Royal Aeronautical Society Man Powered Aircraft Group, for promising projects designed to further the achievement of), 1020
Management : Organization and Methods, a Service to (edited by G E. Milward), *review* by E. S Hiscocks, 62
Management of Research Personnel, *review* by E. S. Hiscocks, 579
Management, Education and Business Studies, 743
Management Education and of Business Studies : The Future Development of—Revision of Joint Examination Schemes (Ministry of Education, Circular 1/60), 743
Management Studies : Report of the Working Party appointed to examine the Scheme of (Ministry of Education, Appendix to Circular 1/60), 743
Management (Research) · The Human Element in (Dr. B. E Noltingk), *review* by E. S Hiscocks, 579
Managers (Works), Institution of . Appointment of Lawrence Sutton as education officer, 206
Manchester College of Science and Technology . Summer School in Modern Methods of Crystal Structure Determination, 766
  Retirement of Prof. H Wright Baker from the chair of mechanical engineering in the Faculty of Technology of the University of Manchester, 1015
  Appointment of W Johnson to the chair of mechanical engineering in the Faculty of Technology of the University of Manchester, 1015
Manchester Literary and Philosophical Society : Election of Officers, 854
Manchester Museum : Annual Report for 1958-59, 521
Manchester Public Libraries · One hundred and seventh Annual Report (1958-59), 437

Mandelic Acid : Acidic Dissociation Constant of Alcoholic Hydroxyls of Oxycarboxylic Acids— (Dr. M. T. Beck and M. Halmos), 388
Mandelstam, Dr. S. : Appointed to the newly established chair of mathematical physics in the University of Birmingham, 937
Manganese Edetate . Effect of, on Blood Formation in Rats (T. J. Sullivan), 87
Manganese Toxicity in *Grevillea robusta* (Dr. R. Child and A N Smith), 1067
Mani Pintar (Groundnut Variety) : Genetic Instability and Outcrossing in the (J. Smartt), 1070
Mann, Dr. F G : The Organic Chemistry of Sulphur, *review*, 53
Mansfield, A. W., and Fisher, H D : Age Determination in the Harbour Seal, *Phoca vitulina* L , 92
Mantle (Upper) · Structure of the, as derived from the Travel Times of Seismic *P* and *S* Waves (Dr I Lehmann), 956
Manton, Prof. I Co-ordination of Light and Electron Microscopy (Co-ordinated Use of Electron Microscopy and a group of Optical Techniques in Plant Cytology), 672
Mapping Britain (Seventy-fifth Anniversary Exhibition of the Royal Scottish Geographical Society), 523
Marcinkiewicz, S., and others : Ubiquinones and Ubichromenols in the Rat, 554
Marcuse, Dr. Reinhard . Antioxidative Effect of Amino-Acids, 886
Marder, Dr. L. : Appointed a lecturer in mathematics at the University of Southampton, 284
Mare (Pregnant) Serum Gonadotropin · Effect of *p*H on Biological Activity of (Bengt H. Persson and Stig E J. Melander), 163
Marine Biological Association of the United Kingdom · Grant of 30,000 dollars from the Rockefeller Foundation, for the purchase of research equipment for use in the Plymouth laboratory, 361
Marine Biology or Oceanography : Grants for research in (Challenger Society), 854
Marine Laboratories (Development Commissioners Scheme), (Challenger Society and representatives from the) . Joint Meeting in Cambridge, 685, 938
Marine Nuclear Propulsion for the United Kingdom, 122
Maritome Museum (National), Greenwich : Appointment of Lieut.-Comdr. D. W Waters as curator of navigation and astronomy, 12
Markham, R L., and others Antithromboplastin in Human Serum and Plasma, 248
Marriage-Rate of American College Graduates, 22
Marriott, Dr F. H. C. · Sensory Specialization in Response to Environmental Demands (Sensitivity Limits of Photoreceptors), 689
Marshall, Dr N. B. : How Animals Move, *review*, 921
Marshall, Dr. R. D. (Bishop, Dr. A. C., and) : Optical Properties of the αω-Dimethanesulphonoxyalkanes, 74
Marshall, Dr. R. D , and Neuberger, Prof. A. Amide Nitrogen Content of Ovomucoid, 311
Marsilea : Foliar Abnormalities, including Repeated Branching and Root Formation, induced by Kinetin in Attached Leaves of (Dr. A. Allsopp and Alicja Szweykowska), 813
Marston, J. E . Suffolk Ponds and Pond Animals, 771
Martens, H. E., and Kotlensky, W. V. . Tensile Behaviour of Pyrolytic Graphite at 2,750° C , 960
Martin, A E. . Nitrogen in Tropical Agriculture (Nitrogen Transformations in Soil), 941
Martin, A. E., and Skyring, G W. : Nitrogen in Tropical Agriculture (Losses of Nitrogen from the Soil/Plant System), 941
Martin, A. E. (Hubble, G. D , and) : Nitrogen in Tropical Agriculture (Nitrogen Status of Queensland Soils), 941
Martin, A R. H. . A Mesozoic Microflora from South Africa, 95
Martin, E. M , and others : Crystallization of Purified Mouse Encephalomyocarditis Virus Particles, 908
Martin, Dr. G. M., and others : Vanadium Catalysis of the Oxidation of Catechol Amines, Dihydroxyphenylalanine and 5-Hydroxyindoles, 884
Martin, K. G : Visco-Elastic Systems (A Micro-Viscometer and Factors in its Operation), 943
Mason, Dr. Brian : Origin of Chondrules and Chondritic Meteorites, 230
Mason, Dr B. J. : Awarded the Hugh Robert Mill Medal and Prize for 1959 of the Royal Meteorological Society, 440
Mason, Revil J., and others : Australopithecine Tools, 205
Mass of Elementary Particles (Dr S. E. Horning), 708
Mass Transfer (Indian Institute of Science Symposium on), 691
Massachusetts General Hospital, Boston · Grant of £50,000 from the Wellcome Trust, for the establishment of a Henry S. Wellcome research chair in medical science, 937
Massey, C. . Visco-Elastic Systems (Tests on several Thermoplastics with reference to their Suitability for Model Structural Analysis), 943
Massey, H. S. H : Russian Machine Translation Dictionary, 852
Masson, D. Ryle (edited by) · Register of Current Scientific Research at South African Universities, 1959 (South African Council for Scientific and Industrial Research), 854
Mast Cell Granules : A Specific Stain for (Dr B. G. Radden), 400
Mast Cells Antigen-induced Damage to Isolated Sensitized (Dr. I. Mota and W. Dias da Silva), 245
Master of Microbiology, *review* by Prof B C. J. G. Knight, 44
Material (Genetic) : Exchange of—Mechanisms and Consequences (Cold Spring Harbor Symposia on Quantitative Biology, Vol. 23), *review* by Prof Kenneth Mather, 832
Material (Recording), for X-Ray Microscopy : Silver-activated Nitrocellulose as (Saara K. Asunmaa), 1036
Materials (Agricultural), in the United Kingdom, 1958-59 : Strontium-90 in Milk and (Agricultural Research Council), 852
Materials (Brittle), for Microdiffraction : A Technique for Sampling Oxide Layers and (A. M. Adams, M A. Silva and Veronica M. Spiers), 147
Materials (Non-Infectious Adenovirus) : Antigenic Structure of (Dr. H. G. Pereira), 571
Materials (Possible Parent), for Tektites · High-Temperature Fusion of (Origin of Tektites), (L. F. Lovering), 1028
Mathematical Functions : Tables of Physical and Chemical Constants and some (Dr. G. W. C. Kaye and Dr. T. H. Laby), twelfth edition, *review* by T. M. Yarwood, 67
Mathematical Works . Stevin's, *review* by Dr. J F. Scott, 60
Mathematics : Physics and (edited by Donald J. Hughes, J. E Sanders and J Horowitz), Vol. 3 (Progress in Nuclear Energy, Series 1), *review* by Dr. E. R. Rae, 68
Mathematics and the Conduction of Heat in Solids, *review* by Prof. L. S. Goddard, 421
Mathematics, Education and Industry—a Record of a Conference of Teachers, Research Scientists and Industrialists, held at the University of Liverpool (1959), 1017
Mathematics and the Sciences of the Heavens and the Earth (Dr. Joseph Needham, with the collaboration of Dr Wang Ling), (Science and Civilization in China, Vol. 3), *review* by Prof. W. M. Smart, 36
Mathematics Teaching : Science and, 850
Mathen, K. : Recent Advances in Coconut Research in India, 861
Mather, Prof Kenneth . Genetic Recombination, *review*, 832
Matheson, Colin *Caretta kempi* Garman on the Welsh Coast, 989
Matheson, Prof. J. A. L. : Hyperstatic Structures, Vol. I, *review* by Prof. A. J. S. Pippard, 582
Mathew, A S. · Recent Advances in Coconut Research in India, 861
Mathieson, Robert T. . Orientation of Stearic Acid Monolayers on Silver Single Crystals, 301
Mathur, R. S. (Gatenby, Dr. J. Bronte, and) : Position of the Proximal Centriole in Flagellate Spermatozoa, 900
Matkovics, Dr. B , and others : Effect of Diphenylamine on the Synthesis of Carotene, 235
Mato Grosso (Northern), Brazil : Evidence for a New Allele in the Kidd Blood Group System in Indians of (Dr. Richard T. Silver, Jane M. Haber and Dr Aaron Kellner), 481
Matsuda, Ryuichi (Usinger, Prof. Robert L., and) : Classification of the Aradidae (*Hemiptera-Heteroptera*), *review* by R. G. Fennah, 46
Matsunaga, Prof E , and Murai, Kyoko : Haptoglobin Types in a Japanese Population, 320
Matsunami, Tomokazu, and others Histochemical Demonstration of Ascorbic Acid in the Locus Coeruleus of the Mammalian Brain, 479
Matsushima, Tatsuaki, and others · Effect of Electrical Stimulation on a Muscle Fibre Model in the Presence of Adenosine Triphosphate, 318
Matthews, Dr. C. M. E., and Fowler, Dr. J. F. : A Comparison of Iodine-124 and Iodine-131 Thyroid Dosimetry, 983
Matthews, Dr L. Harrison : Explorations of the Galápagos Islands, 365
Matzen, Prof. Friedrich Elected a member of the Medicine Section of the Leopoldina Academy of Natural Sciences, 766
Maw, George A. (Young, Leslie, and) : The Metabolism of Sulphur Compounds, *review* by Dr. G. D. Greville, 424
Maxima (Polarographic) Brighteners for Nickel Plating and (Hideya Okada and Takeo Ishida), 152
Maya Hieroglyphic Writing (J. Eric S Thompson), second edition, *review* by Dr. G. H. S. Bushnell, 580
Maya Hieroglyphics, *review* by Dr. G. H S Bushnell, 580
Mayer (André) Fellowships for 1960 (Food and Agriculture Organization of the United Nations), 15
Mayer, Prof. Jean (Thompson, Marilyn M , and) : Coenzyme A Content of Adipose Tissue, 640
Maynard, J M , and others A New Type of Autoxidation Reaction—Cause of the Instability of Cytochrome *c* Reductase, 1032
Mazia, Prof D. : Elected a member of the United States National Academy of Sciences, 773
Mazumdar, Prof G P. : *Obituary* by Dr. R. M. Datta, 356
Meaning of Binomial Distribution (A. W. F. Edwards), 1074
Measurement : Thyroid Radioiodine Uptake (Dr. Marshall Brucer), *review* by Dr. E. E. Pochin, 424
Measurement of Density : Adsorption of Helium on Carbons—Influence on (Dr. F A P Maggs, P. H. Schwabe and J. H. Williams), 956
Measurement of Information, *review* by Prof. Colin Cherry, 506
Measurement of the Intrahepatic Shunted Flow of Blood in Cirrhosis of the Liver (T. Nakamura, S Nakamura and K Tokita), 243
Measurement of Rock Pressure in Mines (Nils Hast), 936
Measurement of Transaminases in Serum (Dr. H Yatzidis), 79
Measurement of Wind Speeds near a Tornado, 360
Measurements of the Total Acoustic Radiation Impedance of Rigid Pistons in an Array (J S M Rusby), 144
Measurements (Electron Density), in the Upper Ionosphere using the Faraday Rotation of Radio Signals from Artificial Satellites (Dr. D. McL. A Wilson), 623
Measurements (X-Ray Crystallinity) : Effect of a Second Crystalline Modification in Polyethylene on (Dr. C. G. Vonk), 962
Mécanique Quantique (Prof. Albert Messiah), *review* by Prof N Kemmer, 999
Mechanical Engineering at Manchester, 1015
Mechanical Mixers and Mortars (Laboratory) : High-Pressure Phase Transformations in (Frank Dachille and Prof. Rustum Roy), 34
Mechanical Properties of Solids : Lattice Defects and the (International Union of Crystallography Symposium on), 1020
Mechanics : Celestial (E Finlay-Freundlich), *review* by Dr. R. H. Garstang, 60
  Fluid (L. D Landau and E. M. Lifshitz), translated from the Russian by J. B Sykes and W. H. Reid, *review* by Dr. D. K. Batchelor, 1000
Mechanics (Celestial) . Stability in (Prof. Yusoke Hagihara), *review* by Dr R. H. Garstang, 60
Mechanism of the Electroreduction of Complexes of the Type $[M(NH_3)_5X]^{n+}$ (Prof George W Watt and Joe W. Vauhgn), 309
Mechanism of the Gastric Secretion of Hydrogen Ions (Prof Spyridon G A. Alivisatos), 368
Mechanism of Immunity in Haemorrhagic Septicaemia (R V S. Bain), 734
Mechanism of the Oxidation and Reduction of Metal Ions by Hydrogen Atoms (Prof. J Halpern, G Czapski, J. Jortner and Dr. G Stein), 629
Mechanism of the Radiation Effect on the Synthesis of Deoxyribonucleic Acid (Dr R J. Berry, E. Hell, Dr L. G. Lajtha and Dr. M Ebert), 563
Mechanism (Non-Genetic) . Reactivation of Poxviruses by a (Dr. W. K. Joklik, Pamela Abel and I H. Holmes), 992
Mechanism (Possible), for the Anti-Inflammatory Action of Corticosteroids : Accumulation of Substrate by Isolated Rat Diaphragm—a (Prof Ira G. Wool), 728
Mechanisms of Peroxide Reactions (Office of Ordnance Research of the United States Army and Brown University Conference on), 127
Mechanisms of Resistance of the Adult Housefly (*Musca domestica*) to 'Cyclodiene' Insecticides (Dr. G. T. Brooks), 96
Medford, R. D , and others · 'Prize', a Pre-ionized 'Theta' Pinch, 706
Media for Publication : Microtexts as (Hertfordshire County Council Technical Information Service), 602

INDEX

- Media (Embedding), for Preparation of Ultra-Thin Sections : Water-Soluble Methacrylates as (Dr. O. Wichterle, Dr. P. Bartl and Dr. M. Rosenberg), 494
- Mediated (Bacterially) False-Positive Reactions in Lytic Blood-Typing Tests (Prof. Clyde Stormont, Yoshiko Suzuki and W. J. Miller), 247
- Medical Care (Ambulatory and Domiciliary) : Role of Hospitals in—Second Report of the Expert Committee on Organization of Medical Care (United Nations, World Health Organization, Technical Report Series No 176), 202
- Medical Congress, Ltd. (International) : International Conference on Congenital Malformations, 685
- Medical Electronics (Electronics and Communications Section of the Institution of Electrical Engineers and the International Federation for Medical Electronics International Conference on, and associated Exhibition), 523
- Medical Electronics, International Federation for (Electronics and Communications Section of the Institution of Electrical Engineer and the) : International Conference on Medical Electronics, and associated Exhibition, 523
- Medical Genetics : An Introduction to (Dr. J. A. Fraser Roberts), second edition, *review* by R. H. Mole, 1003
- Medical Library Association of America : Marcia C. Noyes Award given to Leslie T. Morton, 685
- Medical Research in Malaya, 944
- Medical Research : Fellowships for (Beit Memorial Trust Elections), 520
  - Grants for (Wellcome Trust), 439
  - Significant Trends in (Ciba Foundation Symposium on), (edited by G. E. W. Wolstenholme, Cecilia O'Connor and Maeve O'Connor), *review* by Prof. L. J. Witts, 42
- Medical Research, Institute for (Federation of Malaya) : Annual Report for 1958, 955
- Medical Research Committee (Colonial) : Report for 1958-59, 501
- Medical Research Council : Grant of £1,100 to the Department of Biomolecular Structure in the University of Leeds, to establish a research fellowship, 767
- Medical Research Council (Agricultural Research Council and the) : Joint Committee on Feeding Antibiotics to Farm Animals, 280
- Medical Sciences, Council for International Organizations of (Commission Administrative du Patrimoine Universitaire de Liège and the) : Symposium on Biological Problems of Grafting, *review* by Dr. D. M. V. Parrott, 51
- Medical Sciences (Biological and) : Statistical Methods in, *review* by R. M. Cormack, 746
- Medical Student Research Fellowships : Lederle (American Cyanamid Company), 283
- Medical and Biological Sciences : Current Indexing and Abstracting Periodicals in the (United Nations, World Health Organization, Library News, Vol. 12, Supp. 2), 936
- Medical and Technical Conferences (Scientific,) : Guide to Press Arrangements for (edited by Ronald Bedford), 437
- Medical and Technical Papers, prepared by Research Workers (Cyanamid International, London, new list of), 523
- Medicine : Biochemistry and, *review* by Prof. D. C. Harrison, 422
  - Biochemistry in relation to (C. W. Carter, Dr. R. V. Coxon, D. S. Parsons and Prof. R. H. S. Thompson), third edition, *review* by Prof. D. C. Harrison, 422
  - A Diversity of Trends in, *review* by Prof. L. J. Witts, 42
  - Shakespeare and (R. R. Simpson), *review* by Sir Russell Brock, 35
  - Sub-aquatic (Club Alpin Sous-Marin International Colloquium on), 440
- Medicine in Shakespeare's Writings, *review* by Sir Russell Brock, 35
- Medicine and the Biological Sciences : Elementary Statistics with Applications in (Prof. Frederick E. Croxton), *review* by R. M Croxton, 746
- Medicine and Science (Early) : Parasites and Parasitic Infections in (Prof R. Hoeppli), *review* by Dr. Ben Dawes, 46
- Medieval China : Horology in, *review* by Dr. F. A. B. Ward, 834
- Mediterranean Sea and the Red Sea : Sediment Cores from the (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 8, No 1), 609
- Medizinische Radiologie : Sechzig Jahre (Prof. Hans R. Schinz), *review* by Dr. R. E. Steiner, 921
- Medveczky, E. . A Micromethod for Testing for Niacin, 332
- Megson, N. J. L. : Polymeric Progress (High-temperature Resistant Materials), 442
- Mehlberg, Prof. Henryk : The Reach of Science, *review* by F. I. G. Rawlins, 1003
- Mehnert, Dr. K. R. : Orogens (Study of the Distribution of Alkalis throughout the Body of an Orogen), 690
- Mehra, Prof P. N., and Mittal, T. C. : Indian Substitutes of Male Fern in Pharmacognosy, 722
- Meier, G , and others : Frequencies of the Haptoglobin Serum Groups among Blood Donors from Austria and Germany, 976
- Meier, Dr Richard L : Modern Science and the Human Fertility Problem, *review* by Dr. Kenneth Walker, 188
- Meigh, D. F., and others : Ethylene Production by Tomato and Apple Fruits, 902
- Meiotic Behaviour of Wheat . Position of the Gene determining the Diploid-like (Dr. Ralph Riley, Victor Chapman and Gordon Kimber), 259
- Melander, Stig E. J. (Persson, Bengt H., and) : Effect of *p*H on Biological Activity of Pregnant Mare Serum Gonadotropin, 163
- Melanin Inhibitors in *Drosophila melanogaster* : Genetic Basis of Two (Dr. R. A. Kroman and Dr. P. A. Parsons), 411
- Meldola Medals for 1959 of the Society of Maccabaeans awarded to Dr. J. I G Cadogan and Dr. T. C. Waddington, 519
- Melhuish, A. H , and others : Effect of Pituitary Growth Hormone *in vivo* on the Phosphorus/Oxygen Ratios of Isolated Rat Liver Mitochondria, 392
- Mellanby, Dr. Kenneth : Agricultural Insects of East Africa, *review*, 65
- Mellitic Acid : Crystal Structure of (S. F. Darlow), 542
- Mellor, D. H : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
- *Meloidogyne* spp. (Root-Knot Nematodes) : Plants Recorded as Resistant to (Mary T. Franklin and D. J Hooper), 684
- Membrane (Chorioallantoic), of the Chick : Culture of Human Leucocytes on the (Eugene Bell), 403
- Membrane Potential Changes associated with Stimulation of Smooth Muscle by Adrenalin (G. Burnstock), 727
- Membranes (Perforated Supporting), for Electron Microscopy : A Simple Method for obtaining (V. Drahoš and A. Delong), 104
- Memory—Learning : Brain— a Neurologist's View (Dr. W. Ritchie Russell), *review* by Dr. Gilbert Hall, 39
- Memory Disorder : Dichotic Stimulation and (Prof James Inglis), 181
- Memory and Learning, a Neurologist's Point of View, *review* by Dr. Gilbert Hall, 39
- Men (Scientific) : Movements of, 763
- Men and Women : New Weight Standards for (Metropolitan Life Insurance Co., Ltd , New York, Bulletin, Vol. 40), 445
- Menadione and Diphenylphenylenediamine : Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by α-Tocopherol, a Tocopherol Metabolite, (Dr. Laurence M. Corwin and Dr. Klaus Schwarz), 1048
- Meninges and in Meningiomas : Alkaline Phosphatase in the (Dr. W. J Pepler), 979
- Meningiomas . Alkaline Phosphatase in the Meninges and in (Dr. W. J. Pepler), 979
- Menon, Dr. K. P. V. : Recent Advances in Coconut Research in India, 861
- Mental Health Problems of Automation : Study Group on the (World Health Organization, Report Series No. 183), 364
- Mental Health Research Fund : Grant of £3,330 to the University of Oxford, for research on the physiology of drive, to be carried out in the Institute of Experimental Psychology, 126
- Mercaptan Mixtures (Volatile) : A Rapid Method for Qualitative Analysis of (John F. Carson, William J. Weston and Jack W. Ralls), 801
- Mercury Arc Harmonic Generator : Millimetre Waves from (Dr. K. D. Froome), 959
- Merino Ewe : Seasonal Differences in Ovulating Hormone in the (Dr. D. R. Lamond), 971
- Mesopause Region of the Ionosphere (Dr. J. D. Whitehead), 461
- Mesozoic Microflora from South Africa (A. R. H. Martin), 95
- Messel, Prof. H. (edited by Prof. S. T. Butler and) : From Nucleus to Universe—a Course of Selected Lectures in Physics and Astronomy, University of Sydney, 1960, *review* by G. R. Noakes, 748
- Messiah, Prof Albert : Mécanique Quantique, *review* by Prof. N. Kemmer, 999
- Metabolic Activity : Neurokeratin Network of the Peripheral Nerve Fibre Myelin Sheath as a Centre of (Dr. H. B. Tewari and Prof. Geoffrey H. Bourne), 645
- Metabolic-Rate of the Young Pig : Body-Weight and Age in relation to the (Dr. L. E. Mount and J. G. Rowell), 1054
- Metabolically Distinct Classes of Ribonucleic Acids in Animal Cells : Fractionation of Two, and its Bearing on Cancer (Prof. A. Sibatani, K. Yamana, K. Kimura and T. Takahashi), 215
- Metabolism of Sulphur Compounds (Leslie Young and George A. Maw), *review* by Dr. G. D. Greville, 424
- Metabolism (Lipid) : Drugs affecting (Institute of Pharmacology of the University of Milan Symposium on), 127
- Metabolism (Trehalose), of Trypanosomes (Dr. David Weinman), 166
- Metabolite (Tocopherol), Menadione and Diphenylphenylenediamine : Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by α-Tocopherol, a (Dr. Laurence M. Corwin and Dr. Klaus Schwarz), 1048
- Metagalaxy : The Inner (Prof. Harlow Shapley), *review* by Dr. D W. Dewhirst, 109
- Metal : Bonds between Rubber and, *review* by Dr W. C. Wake, 189
- Metal Bonding : Rubber to (Dr. S. Buchan), second edition, *review* by Dr. W. C. Wake, 189
- Metal Complex : Rate of Ligand Exchange with its, by a Polarimetric Method (B. Bosnich, Dr. F. P Dwyer and Dr. A. M. Sargeson), 966
- Metal Fresnel Zone-plate to Focus Extreme Ultra-violet and Soft X-Rays : A Self-supporting (Dr. Albert V. Baez), 958
- Metal Hydrazine Complexes : The 'Irving–Williams' Order in the Metal-ligand Stretching Frequencies of some (Prof. L. Sacconi and A Sabatini), 549
- Metal Ions : Mechanism of the Oxidation and Reduction of, by Hydrogen Atoms (Prof. J. Halpern, G. Czapski, J. Jortner and Dr. G. Stein), 629
- Metal Ions (Transition) : Heats and Entropies of Reaction of, with Ethylenediamine (M. Ciampolini, P. Paoletti and Prof. L. Sacconi), 880
- Metal Phase of Enstatite Chondrites . Silicon in the (A. E. Ringwood), 465
- Metal Physics : Progress in (edited by Dr. Bruce Chalmers and Dr. R. King), Vol. 7 (1958), Vol. 8 (1959), *review* by Prof. F. C. Thompson, 666
- Metal Powder Industries Federation : International Conference on Powder Metallurgy, 361
- Metal-ligand Stretching Frequencies of some Metal Hydrazine Complexes : The 'Irving–Williams' Order in the (Prof. L. Sacconi and A. Sabatini), 549
- Metallic Perchlorate Solutions : Preparation of Pure Standard (E. P Serjeant), 963
- Métallurgie, Société Française de (Non-destructive Testing Group of the Institute of Physics and the) . Conference on Physical and Structural Aspects of Non-destructive Testing of Metals, 284
- Metallurgists, Institution of : Election of Officers, 854
- Metallurgy at Leeds, 201
- Metallurgy . Powder (Metal Powder Industries Federation International Conference on), 361
- Metals : Physical and Structural Aspects of Non-destructive Testing of (Non-destructive Testing Group of the Institute of Physics and the Société Française de Métallurgie Conference on), 284
  - Principles of the Extraction of (Dr. D. J G. Ives), 765
- Metals (Amphoteric) : Photo-stimulated Emission of Exo-electrons from the Surface Layer of, reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide (J. Wawrzyniak and Dr. B. Sujak), 467
- Metals (Solid) : Determination of Adsorption in Double Layers involving (Dr. Erik A. Blomgren and Dr John O'M. Bockris), 305
- Meteorites Exist : Do, Consisting Predominantly of Feldspar ? (Prof. K. Przibram), 300
- Meteorites (Chondritic) : Abundances of the Rare-Earth Elements, Lanthanum to Lutetium, in (Dr. R. A. Schmitt, A. W. Mosen, C. S. Suffredini, J. E. Lasch, Dr. R A. Sharp and D. A. Olehy), 863
  - Origin of Chondrules and (Dr Brian Mason), 230
- Meteorites (Iron) : Exposure Ages for (Oliver A. Schaeffer and David E. Fisher), 1040

Meteorological Institute of Belgium (Royal) : Ionospheric Observations over Belgium during the International Geophysical Year, 203
Meteorological Society (Royal) : Buchan Prize for 1955-59 awarded to Dr. R. J. Murgatroyd, 440
  Hugh Robert Mill Medal and Prize for 1959 awarded to Dr. B. J. Mason, 440
  Darton Prizes—(*a*) Home Awards, first prize to Dr. C. J Adkins, and second prize to Dr. J. A. Funk ; (*b*) Canadian Awards, first prize jointly to R. H. Douglas and Dr. W. Hitschfeld, and second prize to D. K. A. Gillies, 440
  Symposium on Convection, 604
  Symposium on Agricultural Meteorology, 604
Meteorological Use of Pulsed Doppler Radar (J. R. Probert-Jones), 271
Meteorology : Agricultural (Royal Meteorological Society Symposium on), 604
Methacrylates (Water-Soluble), as Embedding Media for Preparation of Ultra-Thin Sections (Dr. O Wichterle, Dr. P Bartl and Dr M. Rosenberg), 494
Methacrylic Acid (Crystalline) : Polymerization of, initiated by Ultra-violet Radiation (Dr. C. H. Bamford, A. D. Jenkins and J. C. Ward), 713
Methane Exhalation in Sheep (E. Cresswell), 560
Methionine : Inability of, to affect Lethality in Mice and Rats exposed to X-Rays (Prof. Zenon M Bacq and Dr. Marie L. Beaumariage), 1064
Methionine labelled with Sulphur-35 from Muscle Tissue and Mitochondria : Release of (Dr. R. Zák and Dr I. Drahota), 973
Method for Characterizing *Pseudomonas solanacearum* (A C. Hayward), 405
Method of Staining Sectioned Tissues with Lead for Electron Microscopy (Dr. J. D. Lever), 810
Method (An Ion-Exchange Resin), for the Fractionation of Alcoholic Plant Extracts (Dr. Dalton Wang), 326
Method (A Micro-) for Testing for Niacin (E. Medveczky), 332
Method (A New) in the Theory of Superconductivity (N N. Bogoliubov, V. V Tolmachev and D. V. Shirkov), translated from the Russian, *review* by Dr. C. G. Kuper, 833
Method (Polarimetric) : Rate of Ligand Exchange with its Metal Complex by a (B. Bosnich, Dr F. P Dwyer and Dr A. M. Sargeson), 966
Method (A Rapid), for Qualitative Analysis of Volatile Mercaptan Mixtures (John F. Carson, William J. Weston and Jack W. Ralls), 801
Method (Replica) : Size Distribution of Tobacco Smoke Droplets by a (W. J. Harris), 537
Method (A Simple), for Obtaining Perforated Supporting Membranes for Electron Microscopy (V. Drahoš and A. Delong), 104
Method (A Simplified), for the Study of Chromosomes in Man (C. Bottura and I. Ferrari), 904
Method (A Systematic), for the Construction of Error-correcting Group Codes (Prof. R B. Banerji), 627
Method (The Tesla-coil), for Producing Free Radicals from Solids (Dr. C. H. Bamford, A. D. Jenkins and J. C. Ward), 712
Methoden der Molekulphysik und ihre Anwendungsbereiche (Dr. H. Preuss), *review* by Prof. C. A. Coulson, 54
Methodology and Superconductivity, *review* by Dr. C. G. Kuper, 833
Methods : Organization and—a Service to Management (edited by G. E. Milward), *review* by E. S Hiscocks, 62
Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds (Society for Applied Bacteriology and the Microbiology Group of the Society of Chemical Industry Symposium on), 131, *erratum*, 206
Methods (Modern) of Crystal Structure Determination (Manchester College of Science and Technology Summer School in), 766
Methods (Scientific), in the Care of Works of Art (F. I. G. Rawlins), 437
Methods (Statistical), in Biological and Medical Sciences, *review* by R. M. Cormack, 746
Methods (Statistical), in Biology (Dr. Norman T. J. Bailey), *review* by R. M. Cormack, 746
2(*o*-Methoxyphenoxymethyl)-5-Oxazolidone : Synergetic Action of, on Morphine Dihydrocodeine and Aminopyrine Analgesia (Dr. E. Fischer, J. L. J. Szabó and M. Stamburgo), 893
Methyl Acetylene : Decomposition of (F. Fitzgerald), 386
Methyl Cytidine from the Ribonucleic Acid of *Anacystis nidulans* (Dr. B. B. Biswas and J. Myers), 238
5-Methyl-5'-deoxycytidylic Acid : Enzymatic Deamination of 5-Deoxycytidylic Acid and of, in Growing and in Non-growing Tissues (Dr. Eduardo Scarano, Massimo Talarico, Luisa Bonaduce and Benita De Petrocellis), 237
(+) S-Methyl-L-Cysteine Sulphoxide, an Inhibitor of Aspartic Acid Utilization in *Leuconostoc mesenteroides* (Wilfred N. Arnold, Clayton J. Morris and John F. Thompson), 1051
Methylene Blue : Selective Elimination of Single Sense Cells with (Dr. Ulrich Clever), 812
γ-Methyleneglutamic Acid : Degradation of, by Plants (Dr. L Fowden), 897
Methylpentynol : Effect of, on Acetylcholine in the Rat's Brain (Giancarlo Pepeu and Prof. Nicholas J. Giarman), 638
Metropolitan Life Insurance Co , New York : Statistical Bulletin, Vol. 40, New Weight Standards for Men and Women ; Fathers are Younger ; How Fatal Accidents occur in the Home ; Geographic Variations in Mortality by Cause, 445
Meyer, Dr. B., and Schumacher, Prof. E. : Coloured Sulphur Deposits at Low Temperatures, 801
Meyrick, Edward (described by) : Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History), (J F. Gates Clarke), Vol. 3, Tortricidae, Olethreutidae, Noctuidae, *review* by R. G. Fennah, 188
Meyrick's Microlepidoptera, *review* by R. G Fennah, 188
Miall, L. M. : Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds, 131
Mice : Body-Weight and Liver-SH Levels of (Dr. G Calcutt), 84
  Development of Resistance in, to Tumour Induction by *S E* Polyoma Virus (Sarah E. Stewart, Bernice E Eddy, Marjean Irwin and Stephanie Lee), 615
  Enhanced Resistance of, to Infection with *Pasteurella pestis* following Vaccination with Fractions of Phenol-killed Tubercle Bacilli (Prof. David W. Weiss), 1060
  Enhancement of Staphyloccal Virulence for, by Intraperitoneal Cortisone Acetate, Cholesterol and Lecithin (Dr. Daniel Amsterdam and Dr S. Stanley Schneierson), 101
  Inability of Thiotaurine to protect, against Ionizing Radiation (Dr. D, Cavallini and L. Tentori), 254
  Thyroid-Powder Feeding and Liver Nitrogen in (Dr. A. N. Granitsas, M. Kukku and M. Konstantinidu), 890
  Transmission of the Viruses of Trachoma, Inclusion Blennorhoea and Lymphogranuloma to (Dr. E Weston Hurst and P. Reeve), 336
Mice (Inbred and Hybrid), reared at Two Different Temperatures : The Growth in Weight and Tail Length of (Prof. G. A. Harrison, R. J. Morton and Dr. J. S Weiner), 446
Mice and Rats exposed to X-Rays : Inability of Methionine to affect Lethality in (Prof. Zenon M Bacq and Dr. Marie L. Beaumariage), 1064
Michailow, Prof A A. : Elected a member of the Astronomy Section of the Leopoldina Academy of Natural Sciences, 766
Michie, Dr. Donald : Interspecific Hybrids of *Lycopersicum*, 1071
Michot, Dr P. : Orogens, 690
Micro Gas Chromatograph (Prof. Nobuki Sasaki, Kimimichi Tominaga and Masaya Aoyagi), 309
Microbial Biochemistry : Annual Ciba Lectures in (Dr. M. R. J. Salton), 284
Microbial Cell Walls (Annual Ciba Lectures in Microbial Biochemistry), (Dr. M R J. Salton), 284
Microbiological 11β-Hydroxy Dehydrogenation of Corticosterone (M. Shirasaka, R. Takasaki and M. Tsuruta), 390
Microbiological Reactions : Steric Course of (edited by G. E. W. Wolstenholme and Cecilia M. O'Connor), *review* by Prof. D. C Harrison, 835
Microbiology : Annual Review of (edited by Charles E. Clifton, Sidney Raffel and Mortimer P Starr), Vol 13, *review* by Dr. B. A. Newton, 49
  Master of, *review* by Prof. B. C. J. G Knight, 44
Microdiffraction : A Technique for Sampling Oxide Layers and Brittle Materials for (A. M. Adams, M. A. Silva and Veronica M. Spiers), 147
Microdissection : Collagenase Maceration of Kidney for (Nancy J. Hayward), 403
Micro-electrodes ('Weightless'), for Recording Extracellular Unit Action Potentials from the Central Nervous System (Prof B. Delisle Burns and Dr J G. Robson), 246
Micro-electrophoresis of Human White Cells and Platelets (Dr. William P. Creger and Phyllis Menna Thomas), 171
Microflora (A Mesozoic), from South Africa (A. R H. Martin), 95
Microfossils (Lower Tertiary), from McMurdo Sound, Antarctica (Dr. Lucy M. Cranwell (Mrs. Watson Smith), Dr. H. J. Harrington and I. G. Speden), 700
Micrography (Ciné) : An Apparatus for Panning in (Dr. W. H. Hughes and Dr. P. N. Cardew), 258
Microlepidoptera : Meyrick's, *review* by R. G. Fennah, 188
Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick : Catalogue of the Type Specimens of (J. F. Gates Clarke), Vol 3, Tortricidae, Olethreutidae, Noctuidae, *review* by R. G. Fennah, 188
Micromethod for Testing for Niacin (E. Medveczky), 332
Micromosaic Patterns in Single Crystals of Potassium Chloride containing Barium Chloride (J. Ewles and J. B. Dawson), 381
<2 Micron Fractions in a Sediment Core from the Mindanao Trough : Mineralogical Composition of some (J. Ch. L. Favejee), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No. 5), 609
Micro-organisms : Organization, Control and Synthesis in, *review* by Dr. B. A. Newton, 49
Micropulsations (Regular), of the Earth's Field at the Equator (Rosemary Hutton), 955
Microquantitative Infra-Red Analysis—Application to Gas Chromatographic Fractions (J. E. Stewart, R. O Brace, T. Johns and W. F. Ulrich), 628
Micro-reproduction : Document, 602
Microscope (Electron) : Techniques and Applications of the (Cornell University Summer Laboratory Course in), 127
  Yolk Formation in Oocytes of *Patella coerulea* L. and *Aplysia depilans* L. as observed in the (A Bolognani), 490
Microscopic Structure of some Wools : Anomalies in the (T. D. Brown and W. J. Onions), 93
Microscopical Society (Royal), and the Electron Microscopy Group of the Institute of Physics : Symposium on the Co-ordination of Light and Electron Microscopy, 672
Microscopy (Electron) : Co-ordination of Light and (Royal Microscopical Society and the Electron Microscopy Group of the Institute of Physics Symposium on), 672
  A Method of Staining Sectioned Tissues with Lead for (Dr. J. D. Lever), 810
  A Simple Method for Obtaining Perforated Supporting Membranes for (V Drahoš and A. Delong), 104
Microscopy (Electron), and the Crystal Structure of Indanthrene (Lewis T. Chadderton), 541
Microscopy (X-Ray) : Silver-activated Nitrocellulose as Recording Material for (Saara K. Asunmaa), 1036
Microsporum gypseum : Perfect Stage of (Dr. D. M. Griffin), 94
Microtexts as Media for Publication (Hertfordshire County Council Technical Information Service), 602
Middlesex Hospital Medical School, London : Appointment of Dr. J. H. Green as reader in physiology, 938
Midgley, Dr. D : The Possibility of a Self-sustaining Corbino Disk, 377
Migrants (Insect), High in the Air : Mortality and Viability of (L. R. Taylor), 410
Migration (Insect), and Dispersal by Flight : A Basis for a General System of (C. G. Johnson), 348
Migratory Ducks : Food Habits of (Harry G. Anderson), 17
Mihaescu, Dr. C., and Mihaescu, Edith : Seromucoid Contents of Human Bile, 394
Mihaescu, Edith (Mihaescu, Dr. C., and) : Seromucoid Contents of Human Bile, 394
Miles, Prof. John W. : The Potential Theory of Unsteady Supersonic Flow, *review* by L. E. Fraenkel, 505
Miles Laboratories, Inc. : To establish a basic research programme in England, 127
Milk : An Assessment of the Quantities of Fission Products likely to be found in, in the Event of Aerial Contamination of Agricultural Land (Dr. R. J Garner), 1063
  Removal of Strontium from (Dr. Leon Singer and Dr. W. D. Armstrong), 484

Milk from Cattle Inheritance of β-Globulins in Serum and (Bo Gahne, Jan Rendel and Dr Ole Venge), 907
Milk (Norwegian-produced) : Radiocaesium and Potassium-40 in (K. Madshus and J Baarli), 527
Milk (Spray-dried Danish) : Caesium-137 in (Per Gert Jensen), 562
Milk (Toronto), during 1959 : Caesium-137 in (Prof. K. G McNeill and O A D. Trojan), 399
Milk-ejecting Action of Ergot (Prof. Ranjit Roy Chaudhury and Mandakini B. Dikshit), 722
Milk Secretion in Goats : Influence of Cervical Sympathectomy and Pituitary Stalk Section upon (G. B Tverskoy), 782
Milk Testing (Dr. J. G. Davis), second edition, *review* by A L. Provan, 835
Milk and Agricultural Materials in the United Kingdom, 1958-59 : Strontium-90 in (Agricultural Research Council), 852
Mill (Hugh Robert) Medal and Prize for 1959 of the Royal Meteorological Society awarded to Dr B J Mason, 440
Miller, Dr. C. G. : Medical Research in the British Caribbean (Size of Liver in apparently Healthy Children), 863
Miller, D S (Fox, H C., and) : Ackee Toxin, a Riboflavin Antimetabolite ?, 561
Miller, E : Water Resources, *review*, 423
Miller, Jr., Franklin : A Student's Introduction to Physics, *review* by T. M. Yarwood, 68
Miller, Dr. John H. : Appointed instructor (developmental morphology) in the Department of Botany in Yale University, 1020
Miller, J. R. . Awarded a Ciba Fellowship for 1960-61, 684
Miller, L., and Carman, P. C. : Analogy to the Kirkendall Effect in the Gas Phase, 549
Miller, Dr. R E, and Wynne-Jones, Prof W. F. K. : Electron Transfer Reactions involving *s*-Trinitrobenzene, 149
Miller, W. J., and others : Bacterially Mediated False-Positive Reactions in Lytic Blood-Typing Tests, 247
Millidge, Dr. A. F. Industrial Chemistry of the Lower Olefines (Industrial Chemicals based on Ethylene and Propylene), 285
Millimetre Waves from Mercury Arc Harmonic Generator (Dr. K. D. Froome), 959
Mills, Dr C. F. : Minor Elements in Nutrition (Comparative Studies of Copper, Molybdenum and Sulphur Metabolism in the Ruminant and the Rat), 940
Mills, Prof. C Wright : The Sociological Imagination, *review* by E. Gellner, 504
Mills, J P *Obituary* by Prof. J. H Hutton, 1015
Milne, Lorus and Margery Paths Across the Earth, *review* by Sir Landsborough Thomson, 64
Milner, D R. Appointed Lucas Fellow in metal-joining in the Department of Industrial Metallurgy, University of Birmingham, 767
Milner, H B : Geology of Petroleum, *review*, 268
Milward, E S (edited by) Organization and Methods, a Service to Management, *review* by E. S. Hiscocks, 62
Mindanao Trough : A Sediment Core from the (H. Fredriksson), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No. 4), 609
  Mineralogical Composition of some <2 Micron Fractions in a Sediment Core from the (J. Ch L Favejee), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No. 5), 609
  A Note on the Foraminifera in a Sediment Core from the (R A Reyment), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No. 6), 609
  Fragments of Calcareous Algae in a Sediment Core from the (H Horn af Rantzein), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No. 7), 609
Mine-waters Iron Bacteria in (Dr. L G M Baas Becking and Dr. D Moore), 670
Mineral : A Regular Mixed-Layer Chlorite–Vermiculite (Dr. M. Nakahira and S Sugiura), 877
Mineral Paragenesis Russian Approach to, *review* by Dr. Bernard E Leake, 745
Mineralogical Composition of some <2 Micron Fractions in a Sediment Core from the Mindanao Trough (J Ch L Favejee), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No 5), 609
Mineralogical Periodicals : New, 683
Mineralogical Society, All-Union (East Siberian Division) : *Zapiski Vostochno-Sibirskogo, Otdeleniya Vsesoyuznogo Mineralogicheskogo Obshchestva*, Vol. 1, No. 1, 683
Mineralogical Society of India : *The Indian Mineralogist*, No 1, 683
Minéralogie et de Cristallographie, Société Française de Index of Crystallographic Supplies (edited by Dr A. J. Rose), second edition, 1019
Mineralogy in the U S S R (V F Alyavdin), 853
  Reference Books on (Academy of Sciences of the U S.S R.), 203
Minerals : Physiochemical Basis of the Analysis of the Paragenesis of (D. S. Korzhinskii), translated from the Russian, *review* by Dr Bernard E. Leake, 745
Mines The Measurement of Rock Pressure in (Nils Hast), 936
Miniature Gyroscopes : Use of, in Aircraft and Guided Missiles (W. R. Simons), 522
Mining Engineers, Institute of . Summer Meeting, 127
Mining and Metallurgy, Institute of : Gold Medals awarded to E D. McDermott and J. Kruttschnitt, 854
  Honorary membership conferred on the Rt Hon Lord Robins, Sir Patrick Linstead and George Augustus Whitworth, 854
Minnis, C. M : An Estimate of the Peak Sunspot Number in 1968, 462
Minnow : Distribution of Chromactivating Hormones in the Pituitary of the (A. K. Kent), 395
Minor Elements in Nutrition (Nutrition Society Symposium on), 939
Miocene Floras of the Columbia Plateau, Part 1, Composition and Interpretation (Ralph W. Chaney) ; Part 2, Systematic Considerations (Ralph W Chaney and Daniel I. Axelrod), *review* by Prof. J. Walton, 66
Mirza, R. : Acetylation of 4-Quinazolone, 716
Misra, Prof. A. P., and Haque, S. Q : Perfect Stage of *Sclerotium rolfsii* Sacc., 567
Missiles (Ballistic) : Development of, 358
Missile (Ballistic) Early Warning Station at Fylingdales Moor, 357
Missiles (Guided) : Use of Miniature Gyroscopes in Aircraft and (W. R. Simons), 522
Mistletoe in Australia (G. C. Greenham), 135
Misuse of a Statistical Test of Significance . Earthquakes and Uranus—(E J Burr), 336 , (Prof. R. Tomaschek), 337
Mitchell, J F (Krnjević, K., and) Release of Acetylcholine in Rat Diaphragm, 241
Mitchell, Dr. R L. : Minor Elements in Nutrition (Trace Elements in Scottish Soils), 939
Mitchell, Prof S A. : *Obituary* by Prof F. J M. Stratton, 200
Mite (Red Spider), *Tetranychus telarius* (L.) (Acarina : Tetranychidae) : Effect of Relative Humidity on Hatching and on Toxicity of Ovicides to Eggs of the (R A. Harrison and A. G. Smith), 409
Mitochondria Release of Methionine labelled with Sulphur-35 from Muscle Tissue and (Dr. R. Zák and Dr. Z. Drahota), 973
Mitochondria (Fresh and Aged Liver) : Swelling of, as affected by Succinate, Adenine Nucleotides and Thyroxine (Dr P. Emmelot, C. J. Bos, P. J. Brombacher and I. H. M. Reyers), 556
Mitochondria (Rat Liver) : Effect of Pituitary Growth Hormone *in vivo* on the Phosphorus/Oxygen Ratios of Isolated (C N. Graymore, A. H. Melhuish and A. L Greenbaum), 392
  Effects of Fatty Acids on the ^{32}P-Adenosine Triphosphate Exchange Reaction in (K Ahmed and Dr P. G Scholefield), 1046
Mitosis : Blocking of, by Heat Shock (Per Bergan), 905
Mitotic Non-disjunction A Mosaic of *Drosophila* consisting of 1X, 2X and 3X Tissue and its Probable Origin by (Prof. Curt Stern), 179
Mitra, M N, and others : Smilagenone and *Epi*-Smilagenin from *Dioscorea* Saponin, 236
Mitsui, - (Nagao, - , and) Factors affecting Tubers in *Begonia evansiana* Andr , 766
Mittal, L C, and others : Position of the Proximal Centriole in Flagellate Spermatozoa, 899
Mittal, T C (Mehra, Prof. P. N., and) : Indian Substitutes of Male Fern in Pharmacognosy, 722
'Mixed Layer' of the Atlantic Ocean : Strontium-90 in the (Dr. Vaughan T. Bowen and Prof. Thomas T. Sugihara), 71
Mixed-Layer Chlorite–Vermiculite Mineral : A Regular (Dr M. Nakahira and S Sugiura), 877
Mixers and Mortars (Laboratory Mechanical) : High-Pressure Phase Transformations in (Frank Dachille and Prof Rustum Roy), 34
Mixtures of Hard-Sphere Molecules A Monte Carlo Equation of State for (E. B Smith and K R Lea), 714
Mixtures of Permanent Gases Self-Quenching Geiger Counters containing (Dr. Oswald Riedel), 876 ; (A J. L Collinson, I. C Demetsopoullos, J. A. Dennis and J M Zarzycki), 876
Mixtures (Anaesthetic) : Analysis of, by Gas Chromatography (E. R. Adlard and D W. Hill), 1045
Mixtures (Haptoglobin) : Variations in Electrophoretic Position of, in Agar-gel Electrophoresis (Dr. Jan Hirschfeld), 894
Mixtures (Helium–Butane Gas), as Fillings for Geiger-Muller Tubes (Dr V. Moses and Dr J. F Fowler), 538
Mixtures (Volatile Mercaptan) . A Rapid Method for Qualitative Analysis of (John F. Carson, William J. Weston and Jack W. Ralls), 801
Model for Morphogenesis (Dr R. J. Goldacre and A D. Bean), 294
Model to account for the Production of Vibrationally Hot Molecules in Free-Radical Reactions (Dr. J. P. Simons), 551
Model (Muscle Fibre) : Effect of Electrical Stimulation on a, in the Presence of Adenosine Triphosphate (Prof Masahiro Fujino, Tatsuaki Matsushima, Tomizo Muroya, Hideyo Yabu, Saburo Yamaguchi and Masaki Takahashi), 318
Model-Making with 'Araldite' (E. J. R Thomas), 360
Modern Explosives (the late Dr. Wilfrid Taylor), 204
Modern Methods of Crystal Structure Determination (Manchester College of Science and Technology Summer School in), 766
Modern Philosophy of Science (Hans Reichenbach), translated and edited by Maria Reichenbach, *review* by Prof. Herbert Dingle, 503
Modern Science and the Human Fertility Problem (Dr. Richard L Meier), *review* by Dr Kenneth Walker, 188
Modern Trends in Enzymology, *review* by Prof. J Brachet, 267
Modes of Radiation-induced Cross-Linking in Hydrocarbon Polymers (T. F. Williams), 544
Modification for Washing the Benzidine Sulphate Precipitate in the Determination of Sulphate (Dr. I P T. Häkkinen), 232
Modification (Second Crystalline), in Polyethylene : Effect of a, on X-Ray Crystallinity Measurements (Dr. C. G. Vonk), 962
Modifier (Colour), in *Aspergillus nidulans* : 'Sage', a (B J Kilbey), 906
Modulators (Transistor), for Low-level Direct Current Signals (J. F. Evans), 626
Mohan, M. S (Patel, Dr. C C, and) Nature of the Colour-forming Species in Peroxy Titanium Sulphate, 803
Mohgaonkalan Cherts A New Specimen of *Nipa* Fruit from (Dr. S. D. Chitaley), 495
Mohler, Prof Hermann (herausgegeben von) . Chemische Reaktionen Ionisierender Strahlen (Radiation Chemistry), *review* by Prof. F. S. Dainton, 344
Mohres, Prof. F P Sensory Specialization in Response to Environmental Demands (Sonic Orientation of Bats and other Animals), 689
Moisture Effect of, on Carboxylic Acid Adsorption to Steel (M. E. Schrader and J L. Kalinsky), 710
Mole, R. H : An Introduction to Medical Genetics, *review*, 1003
Molecular Quadrupole Moment of Nitric Oxide (Dr. D. V. G L. Narasimha Rao), 881
Molecular Structure : Effect of, upon Concentration of Hydrocarbons in 'Painted' Mouse Skin (Mary Burnham and Fred G. Bock), 323
Molecule (Hydrogen) : Gaussian Wave Functions for the (J. V L Longstaff and Dr. K. Singer), 799
Molecules Electronic Structure of, *review* by Prof. C. A Coulson, 54
  Thermal Motion in Crystals and (International Union of Crystallography Symposium on), 1020
Molecules (Hard-Sphere) : A Monte Carlo Equation of State for Mixtures of (E. B Smith and K R. Lea), 714
Molecules (Macro-) required : Are, for Growth of Single Isolated Mammalian Cells ? (Ralph B. Gwatkin), 984
Molecules (*n*-Paraffin) : Ionization of (W. M Fairbairn), 151
Molecules (Stearic Acid), in Monolayers : Overturning of (George L. Gaines, jun.), 384

Molecules (Vibrationally Hot), in Free-Radical Reactions : A Model to account for the Production of (Dr J P. Simons), 551
Molekulphysik Die Methoden der, und ihre Anwendungsbereiche (Dr. H. Preuss), *review* by Prof. C. A. Coulson, 54
Mollison, Dr. P. L., and others : Role of C'_4 in the Antiglobulin Reaction, 482
Molluscan Oocytes : Golgi Bodies and Golgi Zones in (A. Bolognari), 565
Momose, Haruo, and Ikeda, Prof Yônosuke · Isolation of Mutants of *Bacillus subtilis* requiring D-Glutamic Acid, 567
  Physiology of D-Glutamic Acid-requiring Mutants of *Bacillus subtilis*, 818
Monkey . Foetal Haemoglobin in the (N. N. Sen, K. C Das and B. K. Aikat), 977
  Serotonin Content of the Pineal Glands of Man and (Prof. Nicholas J. Giarman, Daniel X Freedman and Luis Picard-Ami), 480
Monkey (Rhesus) : Development of Learning in the (Harry F. Harlow and colleagues), 211
  Diurnal Temperature Variation in the, under Normal and Experimental Conditions (Dr. Lloyd B Erikson), 83
Monkeys Cross-Modal Transfer of Training in (D. Burton and Dr. G Ettlinger), 1071
Monkeys and Disease, *review* by Dr. C. R. Coid, 506
Monoamine Oxidase · Inhibition of, by Benactyzine *in vitro* and *in vivo* (Dr. V. Vítek and K. Ryšánek), 244
Monoamine Oxidase Inhibitors Suppression of Increased Capillary Permeability in Injury by (W. G Spector and D. A Willoughby), 162
3-Monohydroxycholanic Acid : Cirrhosis of the Liver induced in Rabbits by Gastric Instillation of (Dr. Paul Holsti), 250
Monolayers : Overturning of Stearic Acid Molecules in (George L. Gaines, jun.), 384
  Polyvinyl Benzoate (Herman E. Ries, jun , Nicky Beredjick and Joseph Gabor), 883
Monolayers (Stearic Acid) : Orientation of, on Silver Single Crystals (Robert T. Mathieson), 301
Mononucleotide (Nicotinamide) Synthesis by Human Erythrocytes : Age Difference in (Dr. Vlastimil Habermann and Sona Habermannová), 389
5'-Monophosphates (Nucleoside) : Heterogeneous Labelling of Acid-soluble, during Short *in vivo* Incubation with Phosphate-^{32}P (Dr. T D. Price, K. K. Tsuboi, H. A Hinds and P B. Hudson), 158
Monoxenic Cultivation of an Enchytraeid Annelid (Dr. Ellsworth C. Dougherty and Bjørn Solberg), 1067
Monoxide (Carbon) Oxidation of Beryllium in Carbon Dioxide and in (Dr S. J. Gregg, Dr R. J. Hussey and Dr W B. Jepson), 468
Monoxide (Carbon), and in Carbon Dioxide Gas : Formation of Beryllium Carbide during the Corrosion of Beryllium in (V. D Scott), 466
Monte Carlo Equation of State for Mixtures of Hard-Sphere Molecules (E B Smith and K. R Lea), 714
Montgomery, Dr R. D. Medical Research in the British Caribbean, 862
Montmorillonite (Calcium–) Complexes of, with Polymers (W. W Emerson), 573
  Swelling of (Dr. A V. Blackmore and Prof. B P Warkentin), 823
Moody, M. F., and Parriss, J R. · The Visual System of *Octopus*—Discrimination of Polarized Light by *Octopus*, 839
Moon as a Radar Reflector · Roughness of the (V A Hughes), 873
Moore, Dr. D (Baas Becking, Dr. L. G. M , and) . Iron Bacteria in Minewaters, 670
Moore, R H , and others : Infra-red Spectra of Deuterium-labelled Carbohydrates, 307
Moore, Prof. S Elected a member of the United States National Academy of Sciences, 773
Moore, W C. · Progress in Plant Pathology, *review*, 47
Moran, Prof. P A P · The Theory of Storage, *review* by D G Kendall, 344
Moran, Dr T. : Research Association of British Flour Millers—New Laboratories, 856
Morant, Dr. M. J : Appointed lecturer in applied physics at the University of Durham, 937
Mordike, Dr. B L. : Awarded a Ciba Fellowship for 1960-61, 684
Morgan, H. D. · Fellowship of the City and Guilds of London Institute conferred on, 13
Morgan, Jeanne : The Morphology and Anatomy of American Species of the Genus *Psaronius*, *review* by Prof. John Walton, 190
Morowitz, H J , and others : A Connexion between S–S Bond Breakage and Inactivation by Radiation of a Dry Enzyme, 312
Morphine : Tolerance to Drugs, especially to (Dr. Guy Nadeau and Georges Sobolewski), 169
Morphine, Dihydrocodeine and Aminopyrine Analgesia · Synergetic Action of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on (Dr E. Fischer, J. L. J. Szabó and M Stamburgo), 893
Morphogenesis : A Model for (Dr R J Goldacre and A. D Bean), 294
Morphology (Nuclear), of Human Spermatozoa (Dr. Landrum B. Shettles), 648
Morphology and Anatomy of American Species of the Genus *Psaronius* (Jeanne Morgan), *review* by Prof. John Walton, 190
Morphy, D W : Fellowship of the City and Guilds of London Institute conferred on, 13
Morris, Clayton J , and others . (+) S-Methyl-L-Cysteine Sulphoxide, an Inhibitor of Aspartic Acid Utilization in *Leuconostoc mesenteroides*, 1051
Morrow, P F W , and others : A New Type of Autoxidation Reaction—Cause of the Instability of Cytochrome *c* Reductase, 1032
Morse, Dr Stephen I · Isolation of a Phagocytosis-Inhibiting Substance from Culture Filtrates of an Encapsulated *Staphylococcus aureus*, 102
Mortality (Accidental), of Guppies exposed to Elevated Temperature : Sex Difference in (Prof. John A. Freeman), 491
Mortality and Viability of Insect Migrants High in the Air (L. R. Taylor), 410
Mortars (Laboratory Mechanical Mixers and) High-Pressure Phase Transformations in (Frank Dachille and Prof Rustum Roy), 34
Morton, Prof F : Industrial Chemistry of the Lower Olefines, 285
Morton, Leslie T. : Given the Marcia C Noyes Award of the Medical Library Association of America, 685
Morton, Prof R. A., and others Dolichol, a Naturally Occurring Isoprenoid Alcohol, 470
Morton, R J., and others : The Growth in Weight and Tail Length of Inbred and Hybrid Mice reared at Two Different Temperatures, 446
Morton, Prof R. K., and others : A New Type of Autoxidation Reaction—Flavin Dissociation and Inactivation of Cytochrome b_2 by Oxygen, 1033
Mosaic of *Drosophila* consisting of 1X, 2X and 3X Tissue and its Probable Origin by Mitotic Non-disjunction (Prof. Curt Stern), 179
Mosaic (Micro-) Patterns in Single Crystals of Potassium Chloride containing Barium Chloride (J. Ewles and J. B. Dawson), 381
Mosaic Texture of Graphites (E G. Steward and B. P. Cook), 797
Mosaic Virus (Cauliflower) · Purification and Properties of (Prof Thomas P. Pirone, Glenn S. Pound and Robert J Shepherd), 656
Mosaic Virus (Tobacco) Decarboxylation of Glutamic Acid in Tobacco Leaves inoculated with (M. S. Gubanski), 657
  Primary Structure of the Protein of (F. A Anderer, H. Uhlig, E. Weber and Prof. G Schramm), 922
Mosaic Virus (Turnip Yellow) : Protein Components from (Dr. J. M. Kaper), 219
Mosaics (Photographic Emulsion) : Spectroscopic Applications of (Prof. R. W. Nicholls), 715
Moseman, Dr. A H : Appointed director for the agricultural sciences in the Rockefeller Foundation, 681 ; work of, 681
Mosen, A. W , and others : Abundances of the Rare-Earth Elements, Lanthanum to Lutetium, in Chondritic Meteorites, 863
Moses, Dr. V., and Fowler, Dr. J F. Helium–Butane Gas Mixtures as Fillings for Geiger-Muller Tubes, 538
Moss, H J , and others A Role for Thiol and Disulphide Groups in Determining the Rheological Properties of Dough made from Wheaten Flour, 451
Mostly about Museums (Dr. A E. Parr), *review* by Dr. F. S. Wallis, 110
Mota, Dr. I , and da Silva, W Dias : Antigen-induced Damage to Isolated Sensitized Mast Cells, 245
Motion of Artificial Satellites . Figures of Equilibrium of Celestial Bodies, with Emphasis on Problems of (Prof. Zdeněk Kopal), *review* by D. G. King-Hele, 747
Motion of Geomagnetic Field Lines (C. J. Loughnan), 33
Motion (Accelerated), in the Theory of Relativity : Analysis of (Robert T. Jones), 790
Motion (Thermal), in Crystals and Molecules (International Union of Crystallography Symposium on), 1020
Motions (Secular and Periodic), of the Node of an Artificial Earth Satellite (Prof Leon Blitzer), 874 , (D. G King-Hele), 875
Motivation (Prof Dalbir Bindra), *review* by Prof J Drever, 39
Moullin, Prof. E. B. . Retirement from the chair of electrical engineering in the University of Cambridge, 680 ; work of, 680
Moult and Handling Blood Glucose in Crayfishes in relation to (Dr J. A. Riegel), 727
Mount, Dr L. E , and Rowell, J G : Body-Weight and Age in relation to the Metabolic-Rate of the Young Pig, 1054
Mountains (Sor-Rondane), Queen Maud Land : Geological Reconnaissance of the (Prof E E. Picciotto), 740
Mourant, Dr. A. E., and others : The ABO Blood Groups, *review* by Dr. F. Stratton, 581
Mourkides, G. A , and others : Non-Enzymic Reactions of Indoles with Coenzyme I, 718
Mouse Influence of Route of Inoculation and Strain of, on Infectivity Titrations of the Virus of Foot-and-Mouth Disease (Wendy Heatley, H H. Skinner and H. Subak-Sharpe), 909
  Urinary Excretion of a Ninhydrin-positive Compound, probably a Peptide, after Administration of β-Aminoisobutyric Acid to the (Dr James B. Gilbert and Dr. Yuoh Ku), 160
Mouse (Infant) : Passage of Insulin through the Wall of the Gastrointestinal Tract of the (W A. Kelly), 971
Mouse (Young) · Selection of Iodinated Protein in the (W. A. Hemmings), 399
Mouse Encephalomyocarditis Virus Particles : Crystallization of Purified (P Faulkner, E. M. Martin, S Sved and Dr T. S. Work), 908
Mouse Parotid Tumours : Virus Release from Single Cells of (Dr Mathilde Krim and Dr. Leo Sachs), 262
Mouse Sarcoma 37 Cells Changes in the Deoxyribonucleic Acid Content of, following Serial Irradiation (Dr A. E. G. Pearson and N. B. Atkin), 647
Mouse Skin · Conjugation of 3:4-Benzpyrenols in (Dr. K. H Harper and Dr G Calcutt), 80
Mouse Skin ('Painted') : Effect of Molecular Structure upon Concentration of Hydrocarbons in (Mary Burnham and Fred G. Bock), 323
Mouse Tumour Blood Volumes Estimation of, employing a Radioactive Isotope Technique (F S. Stewart and Dr A. E. G. Pearson), 250
Move · How Animals (Sir James Gray), *review* by Dr. N. B. Marshall, 921
Movement (Arc) : Effect of Cathode Surface Roughness and Oxidation on (Dr. T. J. Lewis and Dr. P. E Secker), 30
Movement (Capillary), of Nitrate towards Tropical Soil Surfaces (R. Wetselaar), 572
Movements in the Foregut of *Schistocerca gregaria* Forsk. : Nervous Control of (Dr. K. U. Clarke and H. Grenville), 98
Movements of Scientific Men, 763
Movements (Roosting), of Starlings : Radar 'Ring Angels' and the (E. Eastwood, G A Isted and G. C. Rider), 112
Mucopolysaccharides of Serum and Pleural Fluid (Prof. C. W Fishel), 804
Mucoprotein (Salivary) · Correlation between Composition, Structure, Shape and Function of a (Dr. Alfred Gottschalk), 949
Mud Fauna of the Stour Estuary (Frances Bull, Helen Honeyman and Susan Knott), 1018
Mud Surfaces (Sprayed) : Determination of Dieldrin Deposits on (Dr. R. E. Ford), 994
Mukherjee, Dr. Bibhuti · Uraninite and Thorianite, 464
Mukherjee, Dr J N. : Elected president for 1960 of the Agricultural Society of India, 937
Muller, C J. · Separation of the α- and β-Chains of Globins by means of Starch-gel Electrophoresis, 643
Muller, H K , and others (edited by) : Documenta Ophthalmologica (Advances in Ophthalmology, Vol. 13), *review* by R. C. Davenport, 42
Mullins, B P : Explosions, Detonations, Flammability and Ignition, Part 2, *review* by Dr H. F. Coward, 666
Mullite Problem : A New Interpretation of the (J. H Welch), 545
Multiple Infections of Trematodes in a Snail (Wm. H Ewers), 990

Multiple Spot Formation by Pure Substances · Paper Chromatography—(Dr. A. H. Beckett, M. A. Beaven and Dr. Ann E. Robinson), 775
Mundaring Geophysical Observatory, 606
Munro, Dr. H. N., and others : Changes in the Levels of Adenosine Triphosphate and Glycogen in the Liver caused by Protein Administration, 719
Murai, Kyoko (Matsunaga, Prof. E., and) : Haptoglobin Types in a Japanese Population, 320
Murgatroyd, Dr. R. J. · Awarded the Buchan Prize for 1955-59 of the Royal Meteorological Society, 440
Muroya, Tomizo, and others : Effect of Electrical Stimulation on a Muscle Fibre Model in the Presence of Adenosine Triphosphate, 318
Murray, K., and others : Behaviour of some Aldehydes on a Sulphonated Polystyrene Resin, 469
Murray, R. K., and Connell, G. E. Elevation of Serum Haptoglobin in Rabbits in Response to Experimental Inflammation, 86
Murray, Prof. Raymond L. : Nuclear Reactor Physics, *review* by J. Fell, 68
Murrell, K. F. H. : Appointed a Research Fellow in the Department of Psychology in the University of Bristol, 937
Musca domestica (Adult Housefly) : Mechanisms of Resistance of the, to 'Cyclodiene' Insecticides (Dr. G. T. Brooks), 96
Muscle (Depolarized Smooth) : Calcium and Contractility in (Dr. P. A. Robertson), 316
Muscle (Rat), *in vitro* : Effect of Denervation on Potassium-42 Uptake by the (Dr. Z. Drahota and O. Hudlická), 396
Muscle (Smooth) : Membrane Potential Changes associated with Stimulation of, by Adrenalin (G. Burnstock), 727
Muscle during Activity : Determination of Small Rapid Volume Changes in a (Prof B. C. Abbott and R. J. Baskin), 1055
Muscle Fibre Model in the Presence of Adenosine Triphosphate : Effect of Electrical Stimulation on a (Prof. Masahiro Fujino, Tatsuaki Matsushima, Tomizo Muroya, Hideyo Yabu, Saburo Yamaguchi and Masaki Takahashi), 318
Muscle Receptors in the Kitten : Activity of (Dr. Sten Skoglund), 478
Muscle Tissue and Mitochondria · Release of Methionine labelled with Sulphur-35 from (Dr. R. Zák and Dr. Z. Drahota), 973
Muscles (Injured and Regenerating) : Treatment of, with Plant Extracts (S. Hoja and J. Vrttek), 283
Muscular (Neuro-) Transmission in the Earthworm (Dr. G. A. Horridge and Dr. M. B. V. Roberts), 650
Museum of Applied Arts and Sciences, Sydney : Annual Report for 1958, 683
Museum (Australian) : Exhibit entitled 'These are Invertebrates', 438
Museum (Bernice P. Bishop), and others : Tenth Pacific Science Congress of the Pacific Science Association, 604
Museum (Manchester) : Annual Report for 1958-59, 521
Museum (National), of Canada : Natural History Paper No. 3, *Anchiceratops* from the Oldman Formation of Alberta (Wann Langston), 522
Bulletin No. 160, Contributions to Botany, 1017
Bulletin No. 162, Contributions to Anthropology, 1017
Bulletin No. 166, Contributions to Zoology, 1017
Museum (National), of Wales : Annual Report (1958-59), 15
Museum (National Maritime), Greenwich : Appointment of Lieut.-Comdr. D. W. Waters as curator of navigation and astronomy, 12
Museum (Transvaal) : *Bulletin* of the, No. 4, 936
Annals of the, Vol. 14, Part 1, 936
Museum and Art Gallery, Durban : Annual Report for 1958-59, 203
Museums : Mostly about (Dr. A. E. Parr), *review* by Dr. F. S. Wallis, 110
The Philosophy of, *review* by Dr. F. S. Wallis, 110
Mustafa, Prof. Ahmed, and others : Antipyretic Action of 1-Phenyl-3,5-pyrazolidinedione, 165
Mutants of *Bacillus subtilis* requiring D-Glutamic Acid : Isolation of (Haruo Momose and Prof Yônosuke Ikeda), 567
Mutants (D-Glutamic Acid-requiring), of *Bacillus subtilis* : Physiology of (Haruo Momose and Prof. Yônosuke Ikeda), 818
c-Mutations : Induction and Reversion of, by Irradiation of the Extracellular χ-Phage of *Serratia* (Prof. R. W. Kaplan, U. Winkler and H. Wolf-Ellmauer), 330
Mycobacteria : Mycosides, a New Class of Type-Specific Glycolipids of (Donald W. Smith, H. M. Randall, A P. MacLennan and E Lederer), 887
Mycological Conference : Sixth Commonwealth (Commonwealth Mycological Institute), 361, 523
Mycological Institute (Commonwealth) · Sixth Commonwealth Mycological Conference, 361, 523
Mycological Society (British) : Applications invited from members, and heads of departments, for grants from the Cheesman and Pethybridge funds to enable students of mycology to attend the Spring or Autumn Foray, or the Plant Pathology Field Meeting, 440
Presidential Address, Research into Griseofulvin (Dr. P W. Brian), 853
Mycological Society, British (Association of Applied Biologists and the) : Symposium on the Nature and Exploitation of Crop Plant Resistance to Disease, 857
Mycology (Commonwealth Mycological Institute Commonwealth Conference on), 361, 523
Mycorrhiza, *review* by Dr. J. Warren Wilson, 48
The Biology of (Dr. J. L. Harley), *review* by Dr. J. Warren Wilson, 48
Mycosides, a New Class of Type-Specific Glycolipids of *Mycobacteria* (Donald W. Smith, H. M. Randall, A. P. MacLennan and E. Lederer), 887
Myelin Sheath (Peripheral Nerve Fibre) : Neurokeratin Network of the, as a Centre of Metabolic Activity (Dr. H. B. Tewari and Prof. Geoffrey H. Bourne), 645
Myelinated, Isolated Nerve Fibres of the Frog : Effect of Curare on Conduction in (Dr Wolf D. Dettbarn), 891
Myers, J. (Biswas, Dr. B. B., and) : A Methyl Cytidine from the Ribonucleic Acid of *Anacystis nidulans*, 238
Myklestad, H., and others . Vitamin A Isomers in the Liver of Rats and Chicks, 312
Myoglobin from *Thunnus thynnus* · Oxygen Equilibrium of (Prof. A. Rossi-Fanelli, E. Antonini and R. Giuffrè), 896
Myosin-5'-Nucleotidase : Activity in relation to *p*H of (Darcy Gilmour), 295

NADEAU, Dr. Guy, and Sobolewski, Georges : Tolerance to Drugs, especially to Morphine, 169
Näf, Ulrich, and others : Purification of a Specific Inducer of the Male Sex Organ in certain Fern Species, 1066
Nagao, —., and Mitsui, —. : Factors affecting Tubers in *Begonia evansiana* Andr., 766
Nagao, —. (Esashi, —., and) : Factors affecting Tubers in *Begonia evansiana* Andr , 766
Nagata, Yutaka, and others : Active Transport of γ-Aminobutyric Acid in Brain Cortex Slices, with special reference to Phosphorus-32 Turnover in Phospholipids in Cytoplasmic Particulates, 474
Nagatsu, Ikuko, and others : Condensation Product of Ethylenediamine with Noradrenaline or 3,4-Dihydroxymandelic Acid, 310
Nagatsu, Toshiharu, and others : Condensation Product of Ethylenediamine with Noradrenaline or 3,4-Dihydroxymandelic Acid, 310
Nagel, Ernest, and Newman, James R. : Godel's Proof, *review* by F. I. G. Rawlins, 61
Nagle, D. E., and others : Ultra-High Resolution γ-Ray Resonance in Zinc-67, 707
Naha, Pritindra Mohan · Nuclear Phenomena in *Trametes cingulata* Berk., 903
Nair, M. K. C : Recent Advances in Coconut Research in India, 861
Nair, R. Gopinathan : Recent Advances in Coconut Research in India, 861
Nair, U. K., and Radha, Dr. K. : Recent Advances in Coconut Research in India, 861
Nakahira, Dr. M., and Sugiura, S. : A Regular Mixed-Layer Chlorite—Vermiculite Mineral, 877
Nakamura, S , and others : Measurement of the Intrahepatic Shunted Flow of Blood in Cirrhosis of the Liver, 243
Nakamura, T., and others : Measurement of the Intrahepatic Shunted Flow of Blood in Cirrhosis of the Liver, 243
Nakič, Dr. B., and others : Graft versus Host Reaction in Parabiotic Disease, 322
Nakič, Z., and others · Graft versus Host Reaction in Parabiotic Disease, 322
Nambiar, C. K. Balakrishnan : Recent Advances in Coconut Research in India, 861
Nambiar, M. C. : Recent Advances in Coconut Research in India, 861
N-1-Naphthyl Phthalamic Acid : A Comparison of Adhering and Abscising Fruits of Peach treated with (Prof. Loyd E. Powell and Charlotte Pratt), 814
Narasimha Rao, Dr. D. V. G. L. : Molecular Quadrupole Moment of Nitric Oxide, 881
Narcotic Drugs : International Control of, 21
Narrow Tubes , Flow of Blood through (Dr. G. W. Scott Blair), 708
Nath, P. R. : Recent Advances in Coconut Research in India, 861
Nath, Prof. Vishwa, and others · Position of the Proximal Centriole in Flagellate Spermatozoa, 899
Nation, J. A., and others : Growth of Surface Instabilities in a Linear Pinched Discharge, 624
National Academy of Sciences (United States) : Biographical Memoirs of the, Vol. 33, *review*, 70
J. Lawrence Smith Medal awarded to Dr. E. J. Öpik, 280, 686 ; *erratum*, 361
James Craig Watson Medal awarded to Prof. Yusuke Hagihara, 686
Agassiz Medal awarded to Dr. Anton Frederick Bruun, 686
Kimber Genetics Award awarded to Prof George Wells Beadle, 686
Public Welfare Medal awarded to Dr. Alan T. Waterman, 686
Election of Dr. Lloyd V. Berkner as treasurer, 773
Election of Prof. G. Evelyn Hutchinson and Dr. Robley C. Williams as members of the Council, 773
Election of new Members, 773
National Academy of Science, United States (National Research Council) : The Radiochemistry of Cadmium (James R. DeVoe), 602
The Radiochemistry of Arsenic (Harold C Beard), 602
The Radiochemistry of Francium (Earl K. Hyde), 602
National Academy of Sciences (United States), and others : Tenth Pacific Science Congress of the Pacific Science Association, 604
National Aeronautics and Space Administration (United States) : Grant of 216,000 dollars to the University of Maryland, to accelerate its programme on basic research dealing with the growth and metabolism of unicellular algae, 604
National Bureau of Standards (United States) : Monograph No 5, Preservation of Documents (W. K. Wilson and B. W. Forshee), 124
National Certificates (Higher), and Professional Status, 123
National Coal Board · Grant of £1,600 to the University of Oxford, for the continuation of research on hot and humid conditions, being carried out in the Department of Human Anatomy, 126
National Council for Technological Awards : Honorary diploma in technology (engineering) awarded to Lord Hives, 767
National Institute of Adult Education : Residential Short Courses, 685
National Institute of Agricultural Botany . Thirty-ninth Report (1958), 287
National Institute of Economic and Social Research : Economic and Social Studies, Vol. 18, British Industrialists—Steel and Hosiery, 1850-1950 (Charlotte Erickson), *review* by R. Brightman, 347
National Institute of Genetics, Japan : Annual Report No. 9 (1958), 286
National Institute of Industrial Psychology : Vernon Prize for 1960 awarded to Dr. R. B. Buzzard, 938
National Institute for Research in Nuclear Science : Grant of £10,450 to the University of Oxford for an investigation of the alignment of nuclei for the proton linear accelerator, to be carried out in the Clarendon Laboratory, 126
National Maritime Museum, Greenwich : Appointment of Lieut.-Comdr. D. W. Waters as curator of navigation and astronomy, 12
National Museum of Canada . Natural History Paper No. 3, *Anchiceratops* from the Oldman Formation of Alberta (Wann Langston), 522
Bulletin No. 160, Contributions to Botany, 1017
Bulletin No. 162, Contributions to Anthropology, 1017
Bulletin No. 166, Contributions to Zoology, 1017
National Museum of Wales : Annual Report (1958-59), 15
National Park : The Serengeti (Dr. A. S Thomas), 605
National Parks : Britain's (edited by Harold M. Abrahams), *review*, 70
National Parks Commission . Annual Report (1958-59), 281
National Physical Laboratory Name of the Control Mechanisms and Electronics Division to be changed to the Autonomics Division, 440
Open Days, 523

National Reference Library of Science and Invention, 934
National Research Corporation (United States) Appointment of Dr. Milo P. Hnilicka as scientific assistant to the vice-president and director of research, 604
National Research Council of Canada : Appointment of Ralph E. McBurney as head of the Technical Information Service, 17
  Review (1959), 124
  Scholarships for 1960-61, 854
National Research Council, United States (National Academy of Sciences) : The Radiochemistry of Cadmium (James R. DeVoe), 602
  The Radiochemistry of Arsenic (Harold C. Beard), 602
  The Radiochemistry of Francium (Earl K. Hyde), 602
National Research Development Corporation of India : Fifth Annual Report (1958-59), 202
National Science Foundation (United States) : Projects in Colleges and Universities on the Economic and other Impacts of Scientific Research and Development, 14
  Bibliography on the Economic and Social Implications of Scientific Research and Development, 14
  Ninth Annual Report (1958-59), 362
  Title of *Science Information News* to be changed to *Scientific Information Notes*, 437
  Award of Graduate Fellowships for 1960-61, 684
  Science and Engineering in American Industry—Report of a 1956 Survey, 763
  Report on Research and Development in Colleges and Universities in the Fiscal Year 1958, 1016
National Science Foundation, United States (Organization for European Economic Co-operation and the) . Award of Senior Visiting Fellowships in Science, 1019
National Union of Students : Memorandum to the University Grants Committee on the Expansion of University Education (1960-1970), 687
National Union of Teachers · University Entrance—the Basic Facts, 14
Native Protein and Inorganic Salts · Specific Interaction of (Folke Rønnike), 88
NATO · Grant from the Research Grants Advisory Panel of £25,000 to the Department of Physics, University of Bristol, for the support of an International expedition to the central Mediterranean, 284
NATO (Advisory Group for Aeronautical Research and Development) : AGARDograph No. 31, Explosions, Detonations, Flammability and Ignition, Part 1 (Prof. S. S. Penner) ; Part 2 (B. P. Mullins), *review* by Dr. H. F. Coward, 666
  Meeting on Ionospheric Research, 685
  Discussion on Boundary Layer Research, 1022
Natural Bradykinin · Bradykinin Activity of some Synthetic Peptides with only Slight Structural Resemblance to (Dr. G. L. Tritsch and Prof D. W. Woolley), 76
Natural History Societies · School, 282
Natural History Survey (Illinois) : Bulletin, Vol. 27, Article 4, Food Habits of Migratory Ducks (Harry G. Anderson), 17
Natural Radioactivity (Long-lived) : Use of, as an Atmospheric Tracer (W M. Burton and N. G. Stewart), 584
Natural Remanent Magnetization of some Welsh Slates : Anisotropy of Susceptibility and the (M. D. Fuller), 791
Natural Resources, International Union for Conservation of Nature and : Seventh General Assembly, jointly with the eighth Technical Meeting, 206
Natural Rubber Research (Rubber Research Institute of Malaya, the Government of the Federation of Malaya and the Rubber Producers' Council International Conference on), 767
Natural Sciences : A Quarter Century in the (Dr. Warren Weaver), 20
Naturalists Society (Suffolk) : Transactions, Vol. 1, Part 3, Mud Fauna of the Stour Estuary (Frances Bull, Helen Honeyman and Susan Knott), 1018
Naturally Occurring Isoprenoid Alcohol : Dolichol, a (J. F. Pennock, F. W. Hemming and Prof R A Morton), 470
Nature of the Colour-forming Species in Peroxy Titanium Sulphate (Dr. C. C. Patel and M. S. Mohan), 803
Nature of Cupric Alkanoate Solutions (Dr. D. P. Graddon), 715
Nature (Dual), of the Third Component of Complement : Further Evidence for the (Dr. J. D. Hawkins), 483
Nature Conservancy : Annual Report (1958-59), 128
  Strathy Bog Nature Reserve, 358
  Additions to the Rannoch Moor Nature Reserve, 358
Nature Conservation in Africa, 935
Nature Reserve (New), in Scotland, 358
Nature and Exploitation of Crop Plant Resistance to Disease (Association of Applied Biologists and the British Mycological Society Symposium on), 857
Nature and Natural Resources, International Union for Conservation of · Seventh General Assembly, jointly with the eighth Technical Meeting, 206
Naudé, Dr. S. M. . Elected president for 1960 of the Royal Society of South Africa, 766
Nectria haematococca Berk. and Br . Is, the Perfect Stage of *Fusarium oxysporum* Schl. forma *pisi* (Lindf.) S. and H. ? (W. L. Gordon), 903
Needham, Dr. A. E. : Arrow Symbol in Biology, 103
Needham, Dr. Joseph, with the collaboration of Dr Wang Ling · Science and Civilization in China, Vol. 3, Mathematics and the Sciences of the Heavens and the Earth, *review* by Prof. W. M. Smart, 36
Needham, Dr. Joseph, and others : Heavenly Clockwork—the Great Astronomical Clocks of Medieval China, *review* by Dr F A. B. Ward, 834
Needs of University Students, 687
Negative Ions formed by Charge Transfer · Detection of (T. M. Donahue and F. Hushfar), 1038
Neghme, A., and others : Non-Identity of Triosephosphate Dehydrogenase of Adult Male and Nymph Development Stages of *Triatoma infestans*, 1052
Nelken, Dr D , and others · Blood Groups in Rabbits, 321
Nelson, C. D , and others : Evidence of Concurrent Translocation, 205
Nelson, Dr. S. M. : Appointed lecturer in organic chemistry at the Queen's University, Belfast, 767
Nematodes (Root-Knot), *Meloidogyne* spp. : Plants Recorded as Resistant to (Mary T. Franklin and D. J. Hooper), 684
Nematology at the Imperial College of Science and Technology, London, 205
Neolithic Revolution : The (Sonia Cole), 360
Neoplastic Growth (Primary) : Chromosomes in (Dr. K. Bayreuther), 6
Nerve Fibre Myelin Sheath (Peripheral) : Neurokeratin Network of the, as a Centre of Metabolic Activity (Dr. H. B. Tewari and Prof. Geoffrey H. Bourne), 645
Nerve Fibres (Myelinated, Isolated), of the Frog : Effect of Curare on Conduction in (Dr Wolf D. Dettbarn), 891
Nervous Activity (Higher) Pavlov Journal of (translated from the Russian), 935
Nervous Control of Movements in the Foregut of *Schistocerca gregaria* Forsk. (Dr. K. U. Clarke and H. Grenville), 98
Nervous System (Central) : 'Weightless' Micro-electrodes for Recording Extra-cellular Unit Action Potentials from the (Prof. B. Delisle Burns and Dr. J. G. Robson), 246
Net Electric Charges on Stars : Existence of (Prof. V. A. Bailey), 508
Netter, Prof. Hans : Elected a member of the Medicine Section of the Leopoldina Academy of Natural Sciences, 766
Network (Neurokeratin), of the Peripheral Nerve Fibre Myelin Sheath as a Centre of Metabolic Activity (Dr. H. B. Tewari and Prof. Geoffrey H. Bourne), 645
Neuberger, Prof. A. (Marshall, Dr. R. D., and) · Amide Nitrogen Content of Ovomucoid, 311
Neurokeratin Network of the Peripheral Nerve Fibre Myelin Sheath as a Centre of Metabolic Activity (Dr. H. B. Tewari and Prof. Geoffrey H. Bourne), 645
Neurologists's View : Brain—Memory—Learning—a (Dr. W. Ritchie Russell), *review* by Dr. Gilbert Hall, 39
Neuromuscular Junctions (Crayfish) : Spontaneous Potential Changes at (Dr. Josef Dudel and Richard K Orkand), 476
Neuro-Muscular Transmission in the Earthworm (Dr. G. A. Horridge and Dr. M. B. V. Roberts), 650
Neurons (Ageing), of some Teleosts : Cytoplasmic Inclusions of the (Prof. A Stolk), 332
Neurosecretory System of Larval Lampreys (*Petromyzon marinus*) : Responsiveness of the, to Light (Dr. Nezihe Oztan and Dr Aubrey Gorbman), 167
Neuroses Cardiac, *review* by Dr. D. C. Deuchar, 423
Neuroses (Cardiac) : The Chemical Prevention of (Prof. Hans Selye), *review* by Dr. D. C. Deuchar, 423
Neutron : Comparison of the Charges of the Electron, Proton and (A. M. Hillas and T. E. Cranshaw), 459
Neutron Physics, *review* by Dr. P. A. Egelstaff, 187
  Introduction to (Dr. L F. Curtiss), *review* by Dr. P. A. Egelstaff, 187
New to the Old World : *Stereobalanus*, a Genus (C. Burdon-Jones and A. D. McIntyre), 491
New Allele in the Kidd Blood Group System : Evidence for a, in Indians of Northern Mato Grosso, Brazil (Dr. Richard T. Silver, Jane M. Haber and Dr. Aaron Kellner), 481
New Ammonia Plant to be built at Severnside (Imperial Chemical Industries, Ltd.), 202
New Antibacterial Sulphonamide . Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methyl*iso*thiazole), a (A. Adams, W. A. Freeman, A. Holland, D. Hossack, J. Inglis, J. Parkinson, H. W. Reading, K. Rivett, R. Slack, R. Sutherland and R. Wren), 221
New Biology Building of the University College of Wales, Aberystwyth (Prof. T. A. Stephenson and Prof. P. F. Wareing), 1021
New British Computer, 201
New British Transistorized Computer (General Electric Co , and International Computers and Tabulators, Ltd.), 936
New Class of Hormonally Active Steroids (Dr. E. H. Reerink, H. F. L. Scholer, P. Westerhof, A. Querido, A. A. H. Kassenaar, E Diczfalusy and K. C. Tillinger), 158
New Class of Type-Specific Glycolipids of *Mycobacteria* : Mycosides, a (Donald W. Smith, H M. Randall, A. P. MacLennan and E. Lederer), 887
New Clathrate Compounds of the Inert Gases (J. G. Waller), 429
New Complexes of Rhenium : Some (R. Colton, R. Levitus and Prof. G. Wilkinson), 233
New Copper Protein from *Chlorella ellipsoidea* (Dr. Sakae Katoh), 533
New Cosmography : The, *review* by Dr. D. W Dewhirst, 109
New Electrophoretic Medium and its Application to the Resolution of Human Haemoglobin Variants (Dr. E. R. Huehns and Dr. A. O. Jakubovic), 729
New Herbicide : 2,6-Dichlorobenzonitrile, a (Dr. H Koopman and J. Daams), 89
New Instruments for Electronic Engineers, 852
New Interpretation of the Mullite Problem (J. H Welch), 545
New Laboratories at the University of Liverpool, 844
New Method in the Theory of Superconductivity (N. N. Bogoliubov, V. V. Tolmachev and D. V. Shirkov), translated from the Russian, *review* by Dr. C. G. Kuper, 833
New Mineralogical Periodicals, 683
New Nature Reserve in Scotland, 358
New Olduvai Australopithecine : The Affinities of the (Dr. J. T. Robinson), 456 ; (Dr. L. S. B Leakey), 458
New Predissociation in Nitrogen (Alf Lofthus), 302
New Psychotomimetic Agent : Blocking Effect of Tetrahydroaminacrin on a (Dr. Samuel Gershon), 1072
New Purine Riboside Isolated from *Fusarium* Species : Characterization of a (Dr Alessandro Ballio, Dr Carlo Delfini and Dr. Serena Russi), 968
New Record Low Sea-Level Air Pressure (C. L. Jordan), 283
New Scientific Journals : Rapid Increase in the number of (Scientific Publications Council Discussion on), 18
New Specimen of *Nipa* Fruit from Mohgaonkalan Cherts (Dr. S D. Chitaley), 495
New States : Science in the Advancement of (Weizmann Institute of Science International Conference on), 604
New Technique for Studying the Quantitative Aspects of Cytochemical Reactions and its Application to the Feulgen Reaction (P. van Duijn and J. -P. Persijn), 805
New Type of Autoxidation Reaction—Cause of the Instability of Cytochrome c Reductase (Dr Malcolm Dixon, J. M. Maynard and P. F. W. Morrow), 1032 ; Flavin Dissociation and Inactivation of Cytochrome b_2 by Oxygen (J. McD Armstrong, Dr. J. H. Coates and Prof R. K. Morton), 1033

New Weight Standards for Men and Women (Metropolitan Life Insurance Co Ltd , New York, Bulletin, Vol. 40), 445
New York Academy of Sciences · Symposium on Cardiovascular Effects of Nicotine and of Smoking, 525
  Conference on the Actinomycins and their Importance in the Treatment of Tumours in Animals and Man, 771
New Zealand : An Association between Dental Caries and certain Soil Conditions in (T. G Lugwig, W. B Healy and Capt. F. L Losee), 695
  A Red Water Bloom of Rotifers in Cook Strait (Vivienne Cassie), 328
  The Redpoll in—Interbreeding Sub-species (David Stenhouse), 488
New Zealand Antarctic Expedition (Sir Edmund Hillary), 526
New Zealand Department of Scientific and Industrial Research : Report for 1958-59, 129
Newell, jun , Homer E : Sounding Rockets, *review* by W H Stephens, 269
Newitt, Prof D. M Fellowship of the City and Guilds of London Institute, *honoris causa*, conferred on, 13
Newman, E L. (Aldrich, Dr B I., and) : Visco-Elastic Systems (Couette Viscometer designed for Testing Syrup), 943
Newman, J. A. S (Kallmes, O , and) : Structure of the Outer Secondary Wall on Unbleached Spruce Sulphite Fibres, 566
Newman, James R. (Nagel, Ernest, and) : Godel's Proof, *review* by F. I. G Rawlins, 61
Newstead, Prof Gordon, and Watt, P A. · A Telemetered Seismic Net In Tasmania, 704
Newton, Dr. B. A. Organization, Control and Synthesis in Micro-organisms, *review*, 49
  Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds (The Mechanism of the Bacterial Action of Synthetic Surface-Active Compounds), 132
Niacin : A Micromethod for Testing for (E Medveczky), 332
Nicholas, Dr. D. J. D , and Fisher, D. J. : Nitrogen Fixation in Extracts of *Azotobacter vinelandii*, 735
Nicholls, Prof R W. . Spectroscopic Applications of Photographic Emulsion Mosaic, 715
  Interpretation of Intensity Distributions in the N_2 Lyman–Birge–Hopfield and CO Fourth Positive Band Systems, 958
Nicholson, D. E. · Infra-Red Spectra of Ammonia adsorbed on Silica–Alumina Catalysts, 630
Nickel Plating : Brighteners for, and Polarographic Maxima (Hideya Okada and Takeo Ishida), 152
Nicol, Dr Davidson · Appointed principal of Fourah Bay College (University College of Sierra Leone), 599 ; work of, 599
Nicol, Prof T. (Ware, C C., and) Duration of Stimulation of Phagocytic Activity of the Reticulo-Endothelial System after Cessation of Treatment with Diethylstilboestrol, 974
Nicotinamide Mononucleotide Synthesis by Human Erythrocytes : Age Difference in (Dr Vlastimil Habermann and Sona Habermannová), 389
Nicotine · Cardiovascular Effects of, and of Smoking (New York Academy of Sciences Symposium on), 525
Nicotinic Acid in Man : Interrelation of Tryptophan and, during the First Month of Life (S Auricchio, E Quagliariello and A. Rubino), 639
Nicotinic Acid and Nicotinic Acid Adenine Dinucleotide : Excretion of, by Biotin–deficient Yeast (Dr Anthony H Rose), 139
Nicotinic Acid Adenine Dinucleotide · Excretion of Nicotinic Acid and, by Biotin–deficient Yeast (Dr. Anthony H Rose), 139
Nidifugous Birds A Positive Fundamental in the Behaviour of Young (Dr. Peter M. Driver), 416
Niewiarowski, Dr. S. (Steinbuch, Dr. M., and) : Rivanol in the Preparation of Plasminogen (Profibrinolysin), 87
Nigeria : Grooved Rocks at Apoje (William Fagg), 205
Nigerian Children · Sickle-Cell Anaemia in (R. G. Hendrickse), 1027
Nigerian Plants · The Photoperiodic Response of some (E. Njoku), 438
Night Sky in May, 284 ; in June, 604 ; in July, 938
Nineteenth-Century Botanist, *review* by Sir Edward Salisbury, 44
Ninhydrin-positive Compound, probably a Peptide : Urinary Excretion of a, after Administration of β-Aminoisobutyric Acid to the Mouse (Dr. James B. Gilbert and Dr. Yuoh Ku), 160
Nipa Fruit : A New Specimen of, from Mohgaonkalan Cherts (Dr S. D. Chitaley), 495
Nirk, Helgi Interspecific Hybrids of *Lycopersicum*, 1071
Nissan, Prof A. H (edited by) . Textile Engineering Processes, *review* by Prof C. S Whewell, 189
Nitrate Capillary Movement of, towards Tropical Soil Surfaces (R. Wetselaar), 572
Nitrate Electrode A Reversible (P. H T Beckett), 879
Nitric Oxide Effect of Oxygen and, on the Radiosensitivity of Human Cells in Tissue Culture (Dr D. L. Dewey), 780
  Molecular Quadrupole Moment of (Dr. D V G. L. Narasimha Rao), 881
Nitrocellulose (Silver-activated), as Recording Material for X-Ray Microscopy (Saara K Asunmaa), 1036
Nitrogen : A New Predissociation in (Alf Lofthus), 302
Nitrogen in Tropical Agriculture (Australian Commonwealth Scientific and Industrial Research Organization Symposium on), 941
Nitrogen (Active) : Reaction of, with Polyethylene (Dr. J. L. Weininger), 546
Nitrogen (Liver), in Mice : Thyroid-Powder Feeding and (Dr. A. N. Granitsas, M Kukku and M. Konstantinidu), 890
Nitrogen Fixation in Extracts of *Azotobacter vinelandii* (Dr. D. J. D Nicholas and D J Fisher), 735
Nitrogen Fixation by a Legume · Cobalt in (Prof. H M Reisenauer), 375
N_2 Lyman–Birge–Hopfield and CO Fourth Positive Band Systems . Interpretation of Intensity Distributions in the (Prof. R. W. Nicholls), 958
Nitrogen (Amide) Content of Ovomucoid (Dr R D. Marshall and Prof A. Neuberger), 311
Nitrogenous Compounds · Use of Ionizing Radiation In Spot Tests for (H. J. M. Bowen, E Arter and P. A Cawse), 383
Nitrous Acid : Application of Pyramidone to Detection of (Prof. Wiktor Wawrzyczek), 883
Nitrous Oxide . Use of, to discriminate between the Forms of Hydrogen Atoms (H· and H_2^+ ?) produced by γ-Irradiation of Aqueous Solutions (Prof F. S. Dainton and Dr. D. B. Peterson), 878
  Use of, to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide Irradiated with Ultra-violet Light (Prof. F. S. Dainton and S. A. Sills), 879
Njaa, L. R., and others : Vitamin A Isomers in the Liver of Rats and Chicks, 312
Njoku, E The Photoperiodic Response of some Nigerian Plants, 438
Noades, Jean, and others : An Rh Antibody Specific for V and R's, 171
  M_1, a Subdivision of the Human Blood Group Antigen M, 642
Noakes, G R. · From Nucleus to Universe, *review*, 748
Nobel Prizes Tenth Annual Meeting of Holders of, 938
Node of an Artificial Earth Satellite Secular and Periodic Motions of the (Prof Leon Blitzer), 874 ; (D G King-Hele), 875
Nodulation Patterns on Legumes (R T Lange and C. A. Parker), 178
Nodules (Root), of *Casuarina cunninghamiana* : Haemoglobin In the (Dr. H E. Davenport), 653
Noise, Committee on the Problem of : Ready to receive evidence, 1020
Noise (Atmospheric Radio) : Observations of (G R A Ellis), 229
Noise (Cosmic) : A Relation between Solar Radio Emission and Solar Cap Absorption of (Dr. M. R. Kundu and Prof F. T Haddock), 610
Noise Control · Acoustic Tiles for, 602
Noltingk, Dr. B E. : The Human Element in Research Management, *review* by E. S Hiscocks, 579
Nomenclature · Chemical, *review* by Prof H. J Barber, 54
  Geological (English–Dutch–French–German), (edited by A. A. G. Schieferdecker), *review* by Dr V. A. Eyles, 57
Nomenclature (Chemical) . An Introduction to (Dr. R. S Cahn), *review* by Prof H. J. Barber, 54
Non-cytocidal Strains of Rabies Virus An Indicator Plaque-forming System for Demonstration of Interference by (Dr. Martin M. Kaplan, Dr. Eberhard Wecker, Dr Zlatko Forsek and Dr Hilary Koprowski), 821
Non-destructive Testing of Metals · Physical and Structural Aspects of (Non-destructive Testing Group of the Institute of Metals and the Société Française de Métallurgie Conference on), 284
Non-disjunction (Mitotic) A Mosaic of *Drosophila* consisting of 1*X*, 2*X* and 3*X* Tissue and its Probable Origin by (Prof Curt Stern), 179
Non-Enzymic Reactions of Indoles with Coenzyme I (Prof. S. G. A. Alivisatos, G. A. Mourkides and A. Jibril), 718
Non-Equilibrium Theory of Gas–Liquid Chromatography (Dr. M A Khan), 800
Non-Fibrillar Elastin In the Earthworm . Occurrence of a (Dr. P. Van Gansen-Semal), 654
Non-Genetic Mechanism · Reactivation of Poxviruses by a (Dr W. K. Joklik, Pamela Abel and I. H. Holmes), 992
Non-goitrogenous Cabbage (Goitrogenous and) · Level of Sulphydryl Compounds In Rat Liver following Feeding with (Jozef Sedlák), 892
Non-growing Tissues (Growing and in) : Enzymatic Deamination of 5-Deoxycytidylic Acid and of 5-Methyl-5′-deoxycytidylic Acid in (Dr. Eduardo Scarano, Massimo Talarico, Luisa Bonaduce and Benita De Petrocellis), 237
Non-Identity of Triosephosphate Dehydrogenase of Adult Male and Nymph Development Stages of *Triatoma infestans* (Prof M. Agosin, A. Neghme and N Scaramelli), 1052
Non-Infectious Adenovirus Materials : Antigenic Structure of (Dr. H. G. Pereira), 571
Non-Ionic Surfactants · Effects of, upon Animal Tissues (Helen Goldhammer and W R McManus), 317
Non-Protein Sulphydryl Group in the Original Strain and Sub-line of the Ascites Tumour resistant to Alkylating Reagents (Iwao Hirono), 1059
Non-Specific Tolerance of Graft and the Dissociation of Two Types of Immunity (Dr. Milan Hašek and Dr. Jan Hort), 985
Nonulosaminic Acid (Sialic Acid), in Protists (Dr S Aaronson and T. Lessie), 719
Noradrenaline or 3,4-Dihydroxymandelic Acid · Condensation Product of Ethylenediamine with (Kunio Yagi, Toshiharu Nagatsu and Ikuko Nagatsu), 310
Nordisk Institut for Teoretisk Atomfysik, Copenhagen : Årsberetning (1957-58), 850
Nordmann, Jean, and others (edited by) · Documenta Ophthalmologica (Advances in Ophthalmology, Vol 13), *review* by R C Davenport, 42
Norin, E. · The Sediments of the Central Tyrrhenian Sea (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 8, Sediment Cores from the Mediterranean Sea and the Red Sea, No. 1), 609
Normal Dog Hip Joints : Clearance Rates of Sodium-24, Potassium-42 and Iodine-131 in (Prof Patrick G Laing and Dr. Ik Dong Kim), 898
Normal Human Sera : Agar-gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_2-Globulin Region of (Dr. Jan Hirschfeld), 321
Normal Implantation in Ovariectomized Guinea Pigs (Dr. Ruth Deanesly), 327
Normal Susceptibility Levels of *Anopheles pharoensis* Theobald to DDT and Dieldrin (Dr F. Kuhlow), 410
Normal and Atherosclerotic Aortas from Chickens receiving Differently Saturated Fats for Three Years . Essential Fatty Acids of (Prof H Fisher and A S. Feigenbaum), 85
Normal and Experimental Conditions · Diurnal Temperature Variation in the Rhesus Monkey under (Dr Lloyd B. Erikson), 83
Normal and Hageman Plasma : Initiation of Clotting in, by Glass (Dr. Preben Ollendorff), 173
Norman, A. G (edited by) : Advances in Agronomy, Vols. 10 and 11, *review* by G V. Dyke, 1000
Norris, D. O. : Nitrogen in Tropical Agriculture (Biology of Nitrogen Fixation), 941
Norris, D. O , and Henzell, E F. : Nitrogen in Tropical Agriculture (Processes by which Nitrogen is added to the Soil/Plant System), 941
Norris, K H , and others : Ethylene Production by Tomato and Apple Fruits, 902
North Atlantic Ocean · Sediment Cores from the (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 7, Nos. 4-5), 609
North Devon Countryside : Preservation of, 935
Northern Advisory Council on Further Education : Training of Technical Teachers, 281
  Report for 1958-59, 281
Norway : Atomic Physics in, 850
Norwegian-produced Milk : Radiocaesium and Potassium-40 in (K. Madshus and J Baarli), 527
Notovny, Helen M , and Owens, Robert G. : Localization of Amino-acids for Histochemical Estimation, 1057
Nováková, V., and Dlouhá, H. Effect of Severing the Olfactory Bulbs on the Intake and Excretion of Water in the Rat, 638
Novel Synthesis of Polypeptides (Dr. J. Oró and C. L. Guidry), 156

Noyes (Marcia C.) Award of the Medical Library Association of America given to Leslie T Morton, 685
Nuclear Congress : Fifth (Comitato Nazionale per le Richerche Nucleari), 127
Nuclear Electronics—Proceedings of the International Symposium on Nuclear Electronics organized by the French Society of Radioelectricians, (Sessions 1-5), *review* by W. Abson, 583
Nuclear Energy (Association des Ingénieurs Electriciens sortis de l'Institut Électrotechnique Montefiore International Information Day about), 440
Nuclear Energy in Britain : Development of, 1
Nuclear Energy : Progress in, Series 1, Physics and Mathematics, Vol. 3, (edited by Donald J. Hughes, J. E. Sanders and J. Horowitz), *review* by Dr. E. R. Rae, 68
Nuclear Energy and Power Reactors · Fundamentals of (Henry Jacobowitz), *review* by Dr. T. E. Allibone, 917
Nuclear Magnetic Resonance—Applications to Organic Chemistry (Prof. J. D Roberts), *review* by Prof. E. R. Andrew, 55
Nuclear Magnetic Resonance : Optical Detection of (J Brossel), 440
Nuclear Magnetic Resonance Spectra (High-Resolution), of Starch Gels : Broadening of the Water Proton Line in (Dr Roger Collison and Dr. M. P McDonald), 548
Nuclear Morphology of Human Spermatozoa (Dr Landrum B. Shettles), 648
Nuclear Phenomena in *Trametes cingulata* Berk (Pritindra Mohan Naha), 903
Nuclear Physics . Low-Energy, *review* by Dr. E. Bretscher, 58
Proceedings of the International Conference on—Low-Energy Nuclear Interactions and Nuclear Structure, Paris 1958 (presented by P. Gugenberger), *review* by Dr. E. Bretscher, 58
Nuclear Propulsion (Marine), for the United Kingdom, 122
Nuclear Radiations · Stimulating Effects of, on Development and Productivity of Rice Plants (Dr. Maung Mya Thaung), 982
Nuclear Reactor Physics (Prof Raymond L. Murray), *review* by J Fell, 68
Nuclear Research, European Organization for . Appointment of J. B. Adams as interim director-general, 523
Personal library of the late Prof. Wolfgang Pauli transferred to the, 1017
Nuclear Science Soviet Reviews of, on the 40th Anniversary of the October Revolution, *review* by Dr T. E. Allibone, 917
Nuclear Science, CENTO Institute of, In Tehran (H. A. C. McKay), 513
Symposium on Recent Developments in the Applications of Nuclear Science for Peaceful Purposes, 685
Nuclear Science, National Institute for Research in Grant of £10,450 to the University of Oxford, for an investigation of the alignment of nuclei for the proton linear accelerator, to be carried out in the Clarendon Laboratory, 126
Nuclear Science for Peaceful Purposes : Recent Developments in the Applications of (CENTO Institute of Nuclear Science Symposium on), 685
Nuclear Test Explosions Radioactivity of the Atmosphere due to Distant (D. H. Peirson, R N Crooks and E M R. Fisher), 224
Nuclear Theory : Introductory (Dr. L. R. B. Elton), *review* by Dr. T. E. Allibone, 917
Lectures on (L D. Landau and Ya. Smorodinsky), translated from the Russian, revised edition, *review* by Dr. T. E. Allibone, 917
Nuclear Theory and its Utilization, *review* by Dr. T E. Allibone, 917
Nucleation in Supercooled Liquids Reduced Temperatures for (Dr. E. R. Buckle), 875
Nuclei of Rat Pineal Parenchymal Cells : Effects of Injection of Bovine Pineal Extract on the (Dr. Uno Holmgren, Dr. Mark D. Altschule and Dr. Richard J Wurtman), 393
Nuclei (Cell) : Quantitative Cytochemical Observations on a Specific Nucleoprotein Reaction in (Dr E A Barnard), 447
Nucleic Acid Fluorochrome Inactivation by Visible Light of Yeast sensitized by a (David Freifelder and Prof Robert B Uretz), 731
Nucleolus Problem (Dr. J. L. Sirlin), 275
Nucleoprotein Reaction (Specific), in Cell Nuclei · Quantitative Cytochemical Observations on a (Dr. E. A. Barnard), 447
Nucleoside 5'-Monophosphates (Acid-soluble) : Heterogeneous Labelling of, during Short *in vivo* Incubation with Phosphate-^{32}P (Dr. T. D. Price, K. K. Tsuboi, H. A. Hinds and P. B Hudson), 158
Nucleotidase (Myosin-5'-) Activity in relation to *p*H of (Darcy Gilmour), 295
Nucleotides (Yeast Ribonucleic Acid and its), as Recovery Factors in Rats receiving an Acute Whole-Body Dose of X-Rays (Prof. J Maisin, P. Dumont and A. Dunjic), 487
Nucleotides (Adenine), and Thyroxine (Succinate,) : Swelling of Fresh and Aged Liver Mitochondria as affected by (Dr. P. Emmelot, C. J. Bos, P. J Brombacher and I. H. M. Reyers), 556
Nucleus In a Basidiomycete (A Bakerspigel), 522
Nucleus to Universe . From—a Course of Selected Lectures in Physics and Astronomy, University of Sydney, 1960 (edited by Prof. S T. Butler and Prof. H. Messel), *review* by G. R. Noakes, 748
Nucleus (Testicular Interstitial Cell), in the Adult Rat Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the (S. L. Liu), 475
Nuffield Foundation : Grant of £2,000 to the Department of Surgery, University of Bristol, for work on vascular disease, 284
Grant of £100,000 to the Zoological Society of London, to found an Institute of Comparative Medicine and to provide two senior research fellowships, 435
Formation of a Unit for the History of Scientific Ideas, 436
Numbers of Erythrocytes : Differences in, between Inbred Lines of Chickens (Dr. P. Jaffe), 978
Nutrition : Minor Elements in (Nutrition Society Symposium on), 939
Nutrition Society : Symposium on Food Losses in Field and Store, 685
Symposium on Minor Elements in Nutrition, 939
Nutting, Prof J. : Appointed to the chair of metallurgy in the University of Leeds, 201 , work of, 201
Nutting, Prof J , and Kelly, Dr. P. : Co-ordination of Light and Electron Microscopy (Microscopical Techniques used in Metallurgy), 672
Nyasaland (Federation of Rhodesia and) : Government Organizations and Statutory Bodies concerned with Scientific Research and Technical Services in the, 202
Nymph Development Stages (Adult Male and), of *Triatoma infestans* · Non-Identity of Triosephosphate Dehydrogenase of (Prof. M. Agosin, A. Neghme and N. Scaramelli), 1052

OAT Variety (A Spring), resistant to the Stem Eelworm (T. Glyn Davies), 813
Oatley, Prof. C. W. : Appointed to the chair of electrical engineering in the University of Cambridge, 680 ; work of, 680
Oberling, Prof. Ch., and others : Ultra-structure of the Clear Cells in Renal Carcinomas and its Importance for the Demonstration of their Renal Origin, 402
Obligate Anaerobes · Specific Inhibition of (Dr. Herbert N. Prince), 816
Observations of Atmospheric Radio Noise (G. R. A. Ellis), 229
Observations on Globin, Haemoglobin and Haptoglobin using a Rabbit Antiglobin Serum (D. S. Rowe and J. F. Soothill), 975
Observations (Quantitative Cytochemical), on a Specific Nucleoprotein Reaction in Cell Nuclei (Dr. E. A. Barnard), 447
Observations (Rocket and Satellite), of the Solar Ultra-violet Spectrum (R. Grant Athay), 1036
Observatory : Mundaring Geophysical, 606
The Watheroo Magnetic (Melbourne), 606
Obtaining Perforated Supporting Membranes for Electron Microscopy : A Simple Method for (V. Drahoš and A. Delong), 104
Occupational Hygiene Society (British) : International Symposium on Inhaled Particles and Vapours, 524
Occurrence of *Falkenbergia rufolanosa* on the West Coast of Scotland (Dr. Elsie Conway), 566
Occurrence of *Halimeda opuntia* var *minor* on Jamaican Shores (P. F. James), 493
Occurrence of a Non-Fibrillar Elastin in the Earthworm (Dr. P. Van Gansen-Semal), 654
Occurrence of the Slipper Limpet, *Crepidula fornicata* L , in Ireland (D. C. Arnold), 95
Occurrence of Whistlers with Geomagnetic Activities : Correlation of (Atsushi Kimpara), 230
Ocean (Atlantic) · Strontium-90 in the 'Mixed Layer' of the (Dr Vaughan T. Bowen and Prof Thomas T. Sugihara), 71
Ocean (North Atlantic) : Sediment Cores from the (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Nos. 4-5), 609
Oceanography : Grants for research in Marine Biology or (Challenger Society), 854
O'Connor, Cecilia M. (edited by G E. W. Wolstenholme and) . Steric Course of Microbiological Reactions, *review* by Prof D. C Harrison, 835
O'Connor, Cecilia, and others (edited by) : Ciba Foundation Symposium on Significant Trends in Medical Research, *review* by Prof. L. J. Witts, 42
O'Connor, D. A. . Appointed lecturer in physics at the University of Birmingham, 522, 767
O'Connor, Maeve (edited by G E. W Wolstenholme and) · Ciba Foundation Symposium on the Biosynthesis of Terpenes and Sterols, *review* by Dr D. T. Elmore, 745
O'Connor, Maeve, and others (edited by) Ciba Foundation Symposium on Significant Trends in Medical Research, *review* by Prof L J. Witts, 42
October Revolution · Soviet Reviews of Nuclear Science on the 40th Anniversary of the, *review* by Dr. T E. Allibone, 917
Octopus · Discrimination of Polarized Light by (The Visual System of *Octopus*), (M. F. Moody and J. R Parriss), 839
Regularities in the Retina and Optic Lobes of, in relation to Form Discrimination (The Visual System of *Octopus*), (Prof. J. Z Young), 836
Theories of Shape Discrimination in (The Visual System of *Octopus*), (Dr. N. S. Sutherland), 840
The Visual System of—Regularities in the Retina and Optic Lobes of *Octopus* in relation to Form Discrimination (Prof. J Z Young), 836 ; Discrimination of Polarized Light by *Octopus* (M. F. Moody and J R. Parriss), 839 ; Theories of Shape Discrimination in *Octopus* (Dr. N. S Sutherland), 840
Odagiri, Satoru (Koyanagi, Prof Tatsuo, and) : Effect of Vitamin A on the Cystine Content in Skin of Rats, 809
Oesophagostomum radiatum (Rud. 1803) (Strongylidae.Nematoda) . Effect of X-Rays on the Development of the Infective Larvae of (R. F Riek and R K. Keith), 981
Œstrogen–Insulin Interaction of the Uterus of the Rat (Dr. R. Michel Zilberstein), 635
Ogata, S., and others : Equivalence of Light and Adenosine Triphosphate in Bacterial Photosynthesis, 753
Ogawa, Dr. Yoshito : Synthesis of Contractile Proteins in the X-Irradiated Embryo, 77
Oginsky, E. L , and Umbreit, Wayne W. : An Introduction to Bacterial Physiology, second edition, *review* by Dr. R H. Gorrill, 111
O'Hara, M J. . Appointed lecturer in geology at the University of Edinburgh, 767
Okada, Hideya, and Ishida, Takeo : Brighteners for Nickel Plating and Polarographic Maxima, 152
Okagaki, H., and Sibatani, Prof. A. : Effects of Chloramphenicol on the Recovery of Ultra-violet-Irradiated *Escherichia coli B*, 818
Old World : *Stereobalanus*, a Genus New to the (C. Burdon-Jones and A D. McIntyre), 491
Oldman Formation of Alberta : *Anchiceratops* from the (Wann Langston), 522
Oldroyd, H. · Insect Photography, *review*, 187
Olduvai Australopithecine · The Affinities of the New (Dr. J. T. Robinson), 456 ; (Dr L. S. B. Leakey), 458
Olefines (Lower) : The Industrial Chemistry of the (Chemical Society, the Institute of Petroleum, the Royal Institute of Chemistry and the Society of Chemical Industry Symposium on), 285
Olehy, D A , and others : Abundances of the Rare-Earth Elements, Lanthanum to Lutetium, in Chondritic Meteorites, 863
Olfactory Bulbs : Effect of Severing the, on the Intake and Excretion of Water in the Rat (V. Nováková and H. Dlouhá), 638
Olfactory Pathway (Lower), of the Toad : Potential Oscillations In the (Dr. S. F. Takagi and Dr. T. Shibuya), 724
Oliver, R , and Lajtha, Dr. L. G. : Hazard of Tritium as a Deoxyribonucleic Acid Label in Man, 91
Ollendorff, Dr. Preben : Initiation of Clotting in Normal and Hageman Plasma by Glass, 173

100 Years : Changes in the Suffolk Flora during the Past (F. W Simpson,) 771
Onions, W. J (Brown, T. D., and) : Anomalies in the Microscopic Structure of some Wools, 93
Onishi, Satoko, and others : Histochemical Demonstration of Ascorbic Acid in the Locus Coeruleus of the Mammalian Brain, 479
Oocytes (Molluscan) : Golgi Bodies and Golgi Zones in (A Bolognari), 565
Oocytes of *Patella coerulea* L. and *Aplysia depilans* L. : Yolk Formation in, as observed in the Electron Microscope (A. Bolognani), 490
Opalina ranarum Parasitic in *Rana temporaria* : Endocrine Control of Sexual Reproduction in (Dr. M. El Mofty and Prof J D Smyth), 559
Opfell, John B. : Distribution-Free Interpretation of Spray-Drop Data, 822
Ophthalmologica Documenta (Advances in Ophthalmology, Vol. 13), (edited by G von Bahr, G. B. Bietti, J. ten Doesschate, H Fischer von Bunau, J Francois, H Goldmann, H. K. Muller, Jean Nordmann, A. J. Schaeffer and Arnold Sorsby), *review* by R. C Davenport, 42
Ophthalmology Advances in, Vol 13, Documenta Ophthalmologica (edited by G von Bahr, G B. Bietti, J ten Doesschate, H. Fischer von Bunau, J. Francois, H. Goldmann, H. K. Muller, Jean Nordmann, A. J. Schaeffer and Arnold Sorsby), *review* by R. C Davenport, 42
Öpik, Dr. E. J : Awarded the J. Lawrence Smith Medal of the United States National Academy of Sciences, 280, 686 ; work of, 280 ; *erratum*, 361
Optic Lobes of *Octopus* in relation to Form Discrimination : Regularities in the Retina and (The Visual System of *Octopus*), (Prof J Z. Young), 836
Optical Design : Research in, at the Imperial College, London, 934
Optical Detection of Nuclear Magnetic Resonance (J. Brossel), 440
Optical Properties of Bismuth (H D. Mallon and I. G. Runciman), 709
Optical Properties of the αω-Dimethanesulphonoxyalkanes (Dr. A. C. Bishop and Dr. R. D. Marshall), 74
Optical Society of America, and others : Conference on Coherence Properties of Electromagnetic Radiation, 127
Optics and Spectroscopy : Russian–English Glossary of, *review* by Prof. S. I Tomkeieff, 347
Orbit of *Sputnik* III . Profile of Upper-Atmosphere Air Density at the Height of 180-212 km. derived from the (Z. V. Bochníček), 460
Orbits (Satellite) : Density of the Upper Atmosphere and its Dependence on the Sun, as revealed by (D. G. King-Hele and D. M. C. Walker), 928
Oregon State College : Appointment of Prof. Kenton L. Chambers as associate professor and curator of the Herbarium, 1020
Oreopithecus · *Apidium* and (Dr. Elwyn L. Simons), 824
Organ (Male Sex), in certain Fern Species : Purification of a Specific Inducer of the (Ross B. Pringle, Ulrich Naf and Armin C. Braun), 1066
Organic Acid Synthesis in Tomato Roots (J. van Die), 603
Organic Bases : Addition Compounds between Copper Complexes and (R. C Traill), 631
Organic Chemistry in the University of New South Wales, 357
Organic Chemistry : Nuclear Magnetic Resonance—Applications to (Prof. J. D. Roberts), *review* by Prof. E. R. Andrew, 55
  Principles of (T. A. Geissman), now available in England, 17
Organic Chemistry of Sulphur, *review* by Dr. F. G. Mann, 53
  Aspects of the (Prof. Frederick Challenger), *review* by Dr. F. G. Mann, 53
Organic Compounds : Use of Solvents containing Ethyl Iodide in the Investigation of Phosphorescence Spectra of (Dr. I. J. Graham-Bryce and J. M. Corkill), 965
Organic Crystals : Bulk Conductivity in (Dr. M. Kallmann and Dr. M. Pope), 31
Organic Syntheses, Vol. 39 (edited by Max Tishler), *review* by Prof. John Read, 669
Organic Synthesis : Light-initiated, *review* by Prof. R. N. Haszeldine, 53
Organische Photochemie : Praparative (Prof. Alexander Schonberg), *review* by Prof. R. N. Haszeldine, 53
Organismes : Composition Chimique des (Traité de Biochemie Générale, par M. Javillier, M. Polonovski, M. Florkin, P. Boulanger, M. Lemoigne, J. Roche et R. Wurmser, Tome 1), *review* by Prof. F. G. Young, 51
Organization : British Industries and their (Prof. G. C. Allen), fourth edition, *review* by R. Brightman, 70
Organization for European Economic Co-operation : Seminar on the Status and Development of the Teaching of Chemistry, 208
  Seminar on Policy for School Science, 850
  Co-operation in the Field of Scientific and Technical Research, 998
Organization for European Economic Co-operation and the Scientific Future, 520
Organization for European Economic Co-operation and the United States National Science Foundation : Award of Senior Visiting Fellowships in Science, 1019
Organization of Medical Care : Second Report of the Expert Committee on—Role of Hospitals in Ambulatory and Domiciliary Medical Care (United Nations, World Health Organization, Technical Report Series No 176), 202
Organization, Control and Synthesis in Micro-organisms, *review* by Dr. B A. Newton, 49
Organization and Methods, a Service to Management (edited by G. E. Milward), *review* by E S Hiscocks, 62
Organization (Chemical), of Cells, Normal and Abnormal (Conference at the University of Wisconsin), 604
Organizations . European (Political and Economic Planning), 830
Organizations (Government), and Statutory Bodies concerned with Scientific Research and Technical Services in the Federation of Rhodesia and Nyasaland, 202
Orientation of Stearic Acid Monolayers on Silver Single Crystals (Robert T. Mathieson), 301
Origin of Chondrules and Chondritic Meteorites (Dr. Brian Mason), 230
Origin of Rainfall : Surface Temperature of Swedish Lakes and the (Vilhelm Irgens Pettersson), 945
Origin of the Solar System : Dirac's Cosmology and the (Prof. L. Egyed), 621
Origin of Tektites—Solar Furnace Glass (Dr Gerald S. Hawkins and Dr Sumner H Wolfson), 1027 ; High-Temperature Fusion of Possible Parent Materials for Tektites (J. F Lovering), 1028
Origin (Evolutionary), of Sexual Differentiation and the Sex-Ratio (Dr. H. Kalmus and Dr. C. A. B. Smith), 1004
Origin (Probable), by Mitotic Non-disjunction : A Mosaic of *Drosophila* consisting of 1X, 2X and 3X Tissue and its (Prof. Curt Stern), 179
Origin (Renal) Ultrastructure of the Clear Cells in Renal Carcinomas and its Importance for the Demonstration of their (Prof. Ch. Oberling, M. Rivière and Fr. Haguenau), 402
Original Strain and Sub-line of the Ascites Tumour resistant to Alkylating Reagents · Non-Protein Sulphydryl Group in the (Iwao Hirono), 1059
Orkand, Richard K. (Dudel, Dr Josef, and) : Spontaneous Potential Changes at Crayfish Neuromuscular Junctions, 476
Ornithology A Laboratory and Field Manual of (Olin Sewall Pettingill, Jr.), third edition, *review* by J. D. Macdonald, 65
Oró, Dr. J , and Guidry, C L : A Novel Synthesis of Polypeptides, 156
Orogens (Deutsche Geologische Vereiniging Discussion on), 206, 689
  Aspects of (J V. Harrison), 689
Orr, Jr , Dr Clyde : Between Earth and Space, *review* by B. R. Leaton, 68
Osborne, Dr. D V. : Appointed senior lecturer in the Department of Natural Philosophy, St. Salvator's College, St Andrews, 767
Oscillations (Potential), in the Lower Olfactory Pathway of the Toad (Dr. S. F. Takagi and Dr. T. Shibuya), 724
Osmotic Pressure : Gibberellic Acid and (J. van den Ende and P. Koornneef), 327
Osseous Chemistry in Lathyritic Rats : Aortic, Serum, Connective Tissue and (Dr. R. A. Grant, M. Hathorn and Prof. Theodore Gillman), 164
Ostertagia Species in Sheep : Retarded Development of (J. D. Dunsmore), 986
Oundle School Natural History Society : Report, 282
Outcrossing in the Groundnut Variety Mani Pintar : Genetic Instability and (J Smartt), 1070
Outer Secondary Wall on Unbleached Spruce Sulphite Fibres : Structure of the (O. Kallmes and J. A. S Newman), 566
Outline of Human Genetics (Prof. L. S. Penrose), *review* by Prof H. Gruneberg, 347
Ovariectomized Guinea Pigs : Normal Implantation in (Dr Ruth Deanesly), 327
Overseas Development . Assistance from the United Kingdom for (White Paper on), 501
Overseas Territories of the British Commonwealth : Scientific Research in the, 501
Overturning of Stearic Acid Molecules in Monolayers (George K. Gaines, Jun.), 384
Ovicides : Effect of Relative Humidity on Hatching and on Toxicity of, to Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina : Tetranychidae), (R. A. Harrison and A. G. Smith), 409
Ovomucoid . Amide Nitrogen Content of (Dr. R. D. Marshall and Prof. A. Neuberger), 311
Ovulating Hormone in the Merino Ewe : Seasonal Differences in (Dr. D. R. Lamond), 971
Owen, Dr. E. C. : Minor Elements in Nutrition (Biochemical Function of some of the Minor Elements), 939
Owens, Robert G. (Notovny, Helen M., and) : Localization of Amino-acids for Histochemical Estimation, 1057
Ox Spleen · Absence of Catecholamines in Cardioactive Acetone Extracts of (Dr. L B. Cobbin and Prof. R. H. Thorp), 473
Oxidase (Monoamine) : Inhibition of, by Benactyzine *in vitro* and *in vivo* (Dr V. Vítek and K. Ryšánek), 244
Oxidase (Monoamine) Inhibitors : Suppression of Increased Capillary Permeability in Injury by (W. G Spector and D. A. Willoughby), 162
Oxidation : Effect of Cathode Surface Roughness and, on Arc Movement (Dr. T. J. Lewis and Dr. P. E. Secker), 30
Oxidation of Beryllium in Carbon Dioxide and in Carbon Monoxide (Dr. S. J. Gregg, Dr. R J. Hussey and Dr. W. B. Jepson), 468
Oxidation of Catechol Amines, Dihydroxyphenylalanine and 5-Hydroxyindoles : Vanadium Catalysis of the (Dr. G. M. Martin, E. P. Benditt and N. Eriksen), 884
Oxidation of Hindered Phenols by Electron Spin Resonance : Study of the (Dr. J. E. Bennett), 385
Oxidation (Alkaline), of Cellulose : Catalytic Effects in the (Dr. W. A. Bell), 963
Oxidation (Enzymic), of Stilboestrol labelled with Carbon-14 (P. H. Jellinck), 157
Oxidation (α-Ketoglutarate and Succinate), in E-Deficient Liver Homogenates : Maintenance of, by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine (Dr. Laurence M. Corwin and Dr. Klaus Scharz), 1048
Oxidation and Reduction of Metal Ions by Hydrogen Atoms : Mechanism of the (Prof J. Halpern, G. Czapski, J Jortner and Dr. G. Stein), 629
Oxide (Nitric) : Effect of Oxygen and, on the Radiosensitivity of Human Cells in Tissue Culture (Dr. D. L. Dewey), 780
  Molecular Quadrupole Moment of (Dr D. V. G. L. Narasimha Rao), 881
Oxide (Nitrous) : Use of, to discriminate between the Forms of Hydrogen Atoms ($H^{\cdot}$ and H_2^+?) produced by γ-Irradiation of Aqueous Solutions (Prof. F. S. Dainton and Dr. D. B. Peterson), 878
  Use of, to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide irradiated with Ultra-violet Light (Prof. F. S. Dainton and S. A Sills), 879
Oxide Layers and Brittle Materials for Microdiffraction : A Technique for Sampling (A. M. Adams, M. A. Silva and Veronica M. Spiers), 147
N-Oxides of the Pyrrolizidine Alkaloids : Detection of (A. T. Dann), 1051
Oxycarboxylic Acids : Acidic Dissociation Constant of Alcoholic Hydroxyls of—Mandelic Acid (Dr M. T. Beck and M. Halmos), 388
Oxygen · Effect of, on the Inactivation of Trypsin by Ionizing Radiation (Prof. J A V Butler and Dr. A B Robins), 697
  Effect of, on the Radiosensitivity of Bacteriophage in the Presence of Sulphydryl Compounds (Dr. P. Howard-Flanders), 485
  Some Effects of Different Tensions of, on the Respiration and Growth of *L*-Strain Fibroblasts (A. R. Fisher), 315
  Flavin Dissociation and Inactivation of Cytochrome b_5 by (A New Type of Autoxidation Reaction), (J. McD Armstrong, Dr J. H. Coates and Prof. R. K. Morton), 1033
Oxygen Consumption in Cattle in relation to Rate of Increase in Environmental Temperature (Prof. H. H. Kibler), 972
Oxygen Consumption (Increased), in Rats during Irradiation : Significance of Adrenals for (Dr. A. Vacek), 90

Oxygen Equilibrium of Haemoglobin from *Thunnus thynnus* (Prof. A. Rossi-Fanelli and E. Antonini), 895
Oxygen Equilibrium of Myoglobin from *Thunnus thynnus* (Prof. A Rossi-Fanelli, E Antonini and R Giuffrè), 896
Oxygen and Nitric Oxide : Effect of, on the Radiosensitivity of Human Cells in Tissue Culture (Dr. D. L. Dewey), 780
Oxygen (Solid) (Copper and), condensed at Very Low Temperatures from a Gas Discharge : Reaction between (Jerome Kruger and William J. Ambs), 794
Oztan, Dr. Nezihe, and Gorbman, Dr. Aubrey : Responsiveness of the Neurosecretory System of Larval Lampreys (*Petromyzon marinus*) to Light, 167

PACIFIC Science Association Tenth Pacific Science Congress, 604
Pacific (Central) : On the Stratigraphy of some Bottom Sections from the (F. Brotzen and A. Dinesen), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 10, Special Investigations, No. 4), 609
Pacific (Central Equatorial) : X-Ray Determination of Phillipsite in a Sediment Core from the (F. Lippman), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 10, Special Investigations, No. 3), 609
Pacific (West) · Sediment Cores from the (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Nos 4-7), 609
Pacific (West-) Stratigraphic Correlation (Dr. M. F. Glaessner), 1039
Paddy Soils and Rice Production (Dr. H. Greene), 511
Page, D H. : Co-ordination of Light and Electron Microscopy, 672
Pagel, Dr. B. E. J. · The Lunar Surface, 826
Pai, Prof. Shih-I Introduction to the Theory of Compressible Flow, *review* by Dr. G. K. Batchelor, 1000
'Painted' Mouse Skin . Effect of Molecular Structure upon Concentration of Hydrocarbons in (Mary Burnham and Fred G. Bock), 323
Paintings · Scientific Techniques in the Conservation of, 437
Palmer, Dr. A. A. : Appointed director of the Department of Clinical Pathology in the Kanematsu Memorial Institute of Pathology, Sydney Hospital, 850 ; work of, 850
Palmer, Dr. H. P. (Davies, Dr. R. D., and) · Radio Studies of the Universe, *review* by Dr. J. S. Hey, 59
Palmer, R. C Appointed director of research to Griffin and George, Ltd., 206
Pandalai, Dr. K. M. Recent Advances in Coconut Research in India, 860
Pannekoek, Dr A. J. : Orogens (The Late History of the Orogen), 690
Panning in Ciné Micrography : An Apparatus for (Dr. W. H. Hughes and Dr. P. N. Cardew), 258
Pantin, Prof. C. F. A. : Elected president for 1960-61 of the Linnean Society of London, 766
Paoletti, P., and others : Heats and Entropies of Reaction of Transition Metal Ions with Ethylenediamine, 880
Paper Chromatograms : Specific Detection of Glucose on (Dr. M R. J. Salton), 966
Paper Chromatography—Multiple Spot Formation by Pure Substances (Dr. A H. Beckett, M. A. Beaven and Dr. Ann E. Robinson), 775
Papers (Medical and Technical), prepared by Research Workers (Cyanamid International, London, new list of), 523
Parabiotic Disease : Graft versus Host Reaction in (Dr. B. Nakič, Z. Nakič and J. Silobrčič), 322
Paracrinkle : Potato Virus *M* and (Dr. H. W. Howard and J. Wainwright), 993
n-Paraffin Molecules : Ionization of (W. M. Fairbairn), 151
Paragenesis of Minerals Physiochemical Basis of the Analysis of the (D. S. Korzhinskii), translated from the Russian, *review* by Dr. Bernard E. Leake, 745
Paragenesis (Mineral) : Russian Approach to, *review* by Dr. Bernard E. Leake, 745
Parakeratosis in Cattle . Zinc Sulphate Treatment of (S. P. Legg and L Sears), 1061
Paramecium aurelia . Genetical and Biochemical Studies of the Immobilization Antigens of (J O. Bishop and Dr. G. H. Beale), 734
Parametric Amplification : Experiments in the Field of (B Bollée and G. de Vries), 1019
Parasite (A Blood), from the California Yellow-legged Frog (Donald L. Lehmann), 765
Parasite (Parthenogenetic) · Environmental Determination of Sex in a (F. Wilson and L T Woolcock), 99
Parasites, Imaginary and Real, *review* by Dr. Ben Dawes, 46
Parasites and Parasitic Infections in Early Medicine and Science (Prof. R. Hoeppli), *review* by Dr Ben Dawes, 46
Parasitic Infections in Early Medicine and Science : Parasites and (Prof. R. Hoeppli), *review* by Dr. Ben Dawes, 46
Parenchymal Cells (Rat Pineal) . Effects of Injection of Bovine Pineal Extract on the Nuclei of (Dr. Uno Holmgren, Dr. Mark D. Altschule and Dr Richard J. Wurtman), 393
Parent Materials (Possible), for Tektites : High-Temperature Fision of (Origin of Tektites), (J. F. Lovering), 1028
Pargeter, Philip S. : The Reproduction of Catalogue Cards (Library Association, Pamphlet No. 20), 1020
Park, K. J F : *Obituary*, 595
Park · The Serengeti National (Dr A. S. Thomas), 605
Parker, C. A. (Lange, R T., and) : Nodulation Patterns on Legumes, 178
Parkinson, J., and others : Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methyl*iso*thiazole), a New Bacterial Sulphonamide, 221
Parks : Britain's National (edited by Harold M. Abrahams), *review*, 70
Parks Commission, National · Annual Report (1958-59), 281
Parotid Tumours (Mouse) : Virus Release from Single Cells of (Dr. Mathilde Krim and Dr. Leo Sachs), 262
Parr, Dr A. E : Mostly about Museums, *review* by Dr. F. S Wallis, 110
Parriss, J. R. (Moody, M. F., and) : The Visual System of *Octopus*—Discrimination of Polarized Light by *Octopus*, 839
Parrott, Dr. D. M V : Antigens, Transplantation and Tolerance, *review*, 51
Parry, E. (Todd, G , and) : Radiation-induced Changes in α-Lead Azide, 543
Parsons, D. S., and others · Biochemistry in relation to Medicine, third edition, *review* by Prof D. C Harrison, 422
Parsons, Dr. P A . Homeostasis of the Sex Ratio in *Drosophila*, 411
Parsons, Dr. P. A. (Kroman, Dr. R. A , and) : Genetic Basis of Two Melanin Inhibitors in *Drosophila melanogaster*, 411
Parthasarathy, Dr. S , and Bindal, V. N. : Ultrasonic Propagation Constants in Supercooled Salol, 145
Parthenogenetic Parasite · Environmental Determination of Sex in a (F. Wilson and L. T Woolcock), 99
Partial Hepatectomy : Histochemical and Biochemical Studies of Rat Liver in Experimental Cirrhosis after (I. Bartók, Gy. Domján, E. Horváth and Prof. B. Korpássy), 397
Particles (Autocatalytic), and Steady States (Dr. Allan Campbell), 256
Particles (Elementary) : Mass of (Dr. S. E Horning), 708
Particles (Mouse Encephalomyocarditis Virus) : Crystallization of Purified (P. Faulkner, E. M. Martin, S. Sved and Dr. T. S. Work), 908
Particles and Vapours : Inhaled (British Occupational Hygiene Society International Symposium on), 524
Patrick, Dr S. J. Medical Research in the British Caribbean (A Study of Liver Enzymes in Human Diabetes), 862
Partridge, Dr. Maurice William · Appointed to the Lord Trent chair of pharmaceutical chemistry in the University of Nottingham, 767 ; work of, 767
Passage : The Rites of (Arnold van Gennep), translated by Monika B. Vizedom and Gabrielle L. Caffee, *review* by Dr Kenneth Walker, 37
Passage of Immunologically Competent Cells in the Chick Embryo · Loss of Specificity on (Sir Macfarlane Burnet and Georgiana Boyer), 175
Passage of Insulin through the Wall of the Gastro-intestinal Tract of the Infant Mouse (W A. Kelly), 971
Pasteurella pestis : Enhanced Resistance of Mice to Infection with, following Vaccination with Fractions of Phenol-killed Tubercle Bacilli (Prof. David W. Weiss), 1060
Patel, Dr. C C , and Mohan, M S. : Nature of the Colour-forming Species in Peroxy Titanium Sulphate, 803
Patel, N. G., and others · Electrophoretic Components of the Proteins in Honeybee Larval Food, 633
Patella coerulea L. and *Aplysia depilans* L. : Yolk Formation in Oocytes of, as observed in the Electron Microscope (A. Bolognani), 490
Patents, Designs and Trade Marks (India) : Appointment of Dr S. Venkateswaran as first controller-general, 122
Pathogenesis and Immunology of Tumours (edited by G. V. Vygodchikov), translated from the Russian by R. Crawford, *review* by Dr. P. A. Gorer, 420
Pathogenic Specificity : An Enzymic Basis for (Elizabeth M. C. Turner), 325
Pathology : A Biochemical Approach to (M. J. R. Dawkins and Dr. K. R. Rees), *review* by Dr. R. W R. Baker, 921
  Preventive Aspects in the Teaching of (World Health Organization, Technical Report Series No. 175), 602
Pathology (Plant) : Progress in, *review* by W. C. Moore, 47
Pathology (Plant), an Advanced Treatise (edited by J. G. Horsfall and A. E. Dimond), Vol. I, The Diseased Plant, *review* by W. C. Moore, 47
Pathology (Plant), Problems and Progress, 1908-1958 (edited by C. S. Holton, G. W. Fischer, R W. Fulton, Helen Hart and S. E. A. McCallan), *review* by W. C. Moore, 47
Pathology (Social) : Social Science and (Barbara Wootton, assisted by Vera G. Seal and Rosalind Chambers), *review* by Prof. E. Stengel, 41
Paths Across the Earth (Lorus and Margery Milne), *review* by Sir Landsborough Thomson, 64
Patients (Carcinoma) ? Subnormal Level of Carbonic Anhydrase in Blood of (Dr. N. W. H. Addink), 253
Paton, J. : Results of the Royal Society's International Geophysical Year Expedition (Visual Work on Aurora), 192
Patrick, Dr. C. R , and others : Pentafluoropyridine, 231
Pattern (Unusual Web), made by an Unfertilized Female of the Spider *Uloborus walckenaerius* Latreille (Dr. Rasza Szlep), 94
Patterns (Micromosaic), in Single Crystals of Potassium Chloride containing Barium Chloride (J. Ewles and J. B Dawson), 381
Patterns (Nodulation), on Legumes (R T. Lange and C. A. Parker), 178
Paul Instrument Fund : Grant of £2,500 to Dr. J. H. Sanders, for the construction of an optical maser, 520
  Grant of £3,000 to H. W. Gosling, for the construction of an instrument for checking the stability of the standard ampere, 520
Paull, Prof. Wolfgang (the late) : Personal library transferred at the suggestion of Mrs. Paull to the European Organization for Nuclear Research (CERN) in Geneva, 1017
Pavlov Journal of Higher Nervous Activity (translated from the Russian), 935
Pawsey, Dr. J. L. : *Obituary* of C. A. Shain, 594
  Obituary of Dr. C. S. Gum, 932
Pawson, Prof. H. Cecil · *Obituary* of Prof. J A Hanley, 596
Payment of Scientific Civil Services, 436
Payne, Dr. W. J. A. (Williamson, G , and) : An Introduction to Animal Husbandry in the Tropics, *review* by Sir John Hammond, 49
Peaceful Purposes : Recent Developments in the Applications of Nuclear Science for (CENTO Institute of Nuclear Science Symposium on), 685
Peaceful Uses of Atomic Energy : Proceedings of the Second United Nations International Conference on the, held in Geneva, 1958, Vol 2, Survey of Raw Material Resources, *review* by Prof C. F. Davidson, 921
Peach treated with N-I-Naphthyl Phthalamic Acid : A Comparison of Adhering and Abscising Fruits of (Prof. Loyd E. Powell and Charlotte Pratt), 814
Peacock, Prof A. D. : *Obituary* of Prof K. W. Szarski, 679
Peak Sunspot Number in 1968 : An Estimate of the (C. M. Minnis), 462
Pearson, Dr. A. E. G. (Stewart, F. S., and) : Estimation of Mouse Tumour Blood Volumes employing a Radioactive Isotope Technique, 250
Pearson, Dr. A. E. G., and Atkin, N. B : Changes in the Deoxyribonucleic Acid Content of Mouse Sarcoma 37 Cells following Serial Irradiation, 647
Pearson, Prof. E. S. : Retirement from the chair of statistics in University College, London, 599 ; work of, 599
Pearson, I. G. (Boray, J. C., and) . Anthelmintic Efficiency of Tetrachlorodifluoroethane against *Fasciola hepatica* in Sheep, 252
Peirson, D. H., and others · Radioactivity of the Atmosphere due to Distant Nuclear Test Explosions, 224
Penicillin : Resistance of Gonococcus Strains to (Alice Reyn and M. W. Bentzon), 608
Penicillin-treated *Staphylococci* : Streptomycin-induced Lysis of (Dr. R. Hancock), 658

Penicillium griseofulvum Dierckx: Production of Shikimic Acid by (Prof Paul Simonart and Anselme Wiaux), 78
Penner, Prof. S. S: Explosions, Detonations, Flammability and Ignition, Part I, *review* by Dr. H F. Coward, 666
Pennock, J. F, and others: Dolichol, a Naturally Occurring Isoprenoid Alcohol, 470
Penrose, Prof. L S. Outline of Human Genetics, *review* by Prof. H. Gruneberg, 347
Pentafluoropyridine (Dr. J. Burdon, D. J. Gilman, Dr. C. R. Patrick, Prof. M. Stacey and Prof J. C. Tatlow), 231
Pepeu, Giancarlo, and Giarman, Prof Nicholas J.: Effect of Methylpentynol on Acetylcholine in the Rat's Brain, 638
Pepler, Dr. W. J.: Alkaline Phosphatase in the Meninges and in Meningiomas, 979
Pepper, Dr. K. W: The British Leather Manufacturers' Research Association—Open Days, 1024
Peptide: Urinary Excretion of a Ninhydrin-positive Compound, probably a, after Administration of β-Aminoisobutyric Acid to the Mouse (Dr James B Gilbert and Dr. Yuoh Ku), 160
Peptide containing Hydroxyproline Biological Significance of, during the Development of Carrageenin Granuloma (Dr. M. Chvapil and B. Cmuchalová), 806
Peptides (Synthetic), with only Slight Structural Resemblance to Natural Bradykinin · Bradykinin Activity of some (Dr. G. L Tritsch and Prof. D W. Woolley), 76
Perception The Problems of (R. J Hirst), *review* by Prof M. D. Vernon, 919
Perception (Person), and Interpersonal Behavior (edited by Renato Tagiuri and Luigi Petrullo), *review* by Prof M D. Vernon, 919
Perchlorate Solutions: Preparation of Pure Standard Metallic (E. P. Serjeant) 963
Pereira, Dr. H. G. Antigenic Structure of Non-Infectious Adenovirus Materials, 571
Perfect Stage of *Fusarium oxysporum* Schl. forma *pisi* (Lindf.) S. and H ?: Is *Nectria haematococca* Berk. and Br the (W L Gordon), 903
Perfect Stage of *Microsporum gypseum* (Dr. D. M. Griffin), 94
Perfect Stage of *Sclerotium rolfsii* Sacc. (Prof A. P. Misra and S Q. Haque), 567
Perforated Supporting Membranes for Electron Microscopy: A Simple Method for obtaining (V Drahoš and A. Delong), 104
Performance. Construct 'Reactive Inhibition' in the Interpretation of Age Changes in (Dr. S Griew and Dr. R. Lynn), 182
Periclinal Chromosomal Chimera of Apple Changes in Structure of a, following X-Irradiation (Charlotte Pratt), 255
Periodic Classification of Elements (W. P. Thistlethwaite), 153; (L. M Simmons), 154; (A. A Clifford), 154
Periodic Motions (Secular and), of the Node of an Artificial Earth Satellite (Prof Leon Blitzer), 874; (D. G. King-Hele), 875
Periodical Publications (Scientific): Cost of (K W. Humphreys and H D. Barry), 124
Periodicals in the Medical and Biological Sciences: Current Indexing and Abstracting (United Nations, World Health Organization, Library News, Vol 12, Supp. 2), 936
Peripheral Nerve Fibre Myelin Sheath · Neurokeratin Network of the, as a Centre of Metabolic Activity (Dr H. B. Tewari and Prof. Geoffrey H Bourne), 645
Perkins, Dr. D H.. Elected reader in physics in the Univesity of Bristol, 739
Perkins, H. J., and others Evidence of Concurrent Translocation, 205
Permanent Gases Self-Quenching Geiger Counters containing Mixtures of (Dr. Oswald Riedel), 876; (A. J L. Collinson, I. C. Demetsopoullos, J A. Dennis and J M Zarzycki), 876
Permeability (Delayed Potassium) Action Potentials in Active Tissue with (Dr E. P George), 889
Permeability (Increased Capillary), in Injury by Monoamine Oxidase Inhibitors: Suppression of (W G. Spector and D. A Willoughby), 162
Peroxidase Action Enhancement of, by Polysaccharides (Dr. B Z Siegel and Dr. S M Siegel), 391
Peroxide (Concentrated Sodium), or Potassium Hydroxide · Photo-stimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with (J Wawrzyniak and Dr B. Sujak), 467
Peroxide Reactions Mechanisms of (Office of Ordnance Research of the United States Army and Brown University Conference on), 127
Peroxy Titanium Sulphate: Nature of the Colour-forming Species in (Dr. C C Patel and M. S Mohan), 803
Perry, Prof. J. W. Scientific Russian without Tears, 359
Persijn, J. -P (van Duijn, P, and) · A New Technique for Studying the Quantitative Aspects of Cytochemical Reactions and its Application to the Fuelgen Reaction, 805
Person Perception and Interpersonal Behavior (edited by Renato Tagiuri and Luigi Petrullo), *review* by Prof M. D. Vernon, 919
Personnel (Research) Management of, *review* by E. S. Hiscocks, 579
Personnel Management, Institute of Occasional Papers No 15, Working Wives (Viola Klein), 365
Persson, Bengt H, and Melander, Stig E. J · Effect of *p*H on Biological Activity of Pregnant Mare Serum Gonadotropin, 163
Pesticides Research Committee (Colonial): Report for 1958-59, 501
Peters, Dr Walter. Inheritance of Asymmetry in a Water-boatman (*Krizousacorixa femorata*), 737
Peterson, Dr D B. (Dainton, Prof F S, and) · Use of Nitrous Oxide to discriminate between the Forms of Hydrogen Atoms (H· and H_2^+ ?) produced by γ-Irradiation of Aqueous Solutions, 878
Petrochemische Berechnungsmethoden auf Aquivalenter Grundlage (Prof. Conrad Burri), *review* by Prof. K. C Dunham, 56
Pétroles: Géologie des (Prof. Maurice Robert), *review* by H. B. Milner, 268
Petroleum: Geology of, *review* by H B. Milner, 268
Petroleum, Institute of, and others: Symposium on the Industrial Chemistry of the Lower Olefines, 285
Petroleum, Institute of (Gas Chromatography Discussion Group of the Hydrocarbon Research Group) · Annual General Meeting, 943
  Symposium on Gas Chromatography, 127, 943
Petroleum Industry Statistics (United Kingdom), relating to Consumption and Refinery Production, 1958 and 1959 (Petroleum Information Bureau), 851
Petroleum Information Bureau · United Kingdom Petroleum Industry Statistics relating to Consumption and Refinery Production (1958 and 1959), 851
Petromyzon marinus (Larval Lampreys): Responsiveness of the Neurosecretory System of, to Light (Dr. Nezihe Oztan and Dr. Aubrey Gorbman), 167
Petrullo, Luigi (edited by Renato Tagiuri and): Person Perception and Interpersonal Behavior, *review* by Prof. M. D Vernon, 919
Pettersson, Dr. Max. Intraspecific Differentiation—Biological and Social Aspects, 431
  Increase of Settlement Size and Population since the Inception of Agriculture, 870
Pettersson, Vilhelm Irgens: Surface Temperature of Swedish Lakes and the Origin of Rainfall, 945
Pettingill, Jr, Olin Sewall. A Laboratory and Field Manual of Ornithology, third edition, *review* by J D Macdonald, 65
*p*H Effect of, on Biological Activity of Pregnant Mare Serum Gonadotropin (Bengt H Persson and Stig E. J Melander), 163
*p*H of Myosin-5'-Nucleotidase: Activity in relation to (Darcy Gilmour), 295
Phage: A *Spirochaeta* (Dr. Ralph A Lewin), 901
T_1 and λ Phage Adsorption on Protoplast-like Bodies of *Escherichia coli* (Dr. P. H. Hofschneider), 568
Phage Sensitivity in *Erwinia amylovora* An Association between Capsulation and (Eve Billing), 819
Phagocytic Activity of the Reticulo-Endothelial System Duration of Stimulation of, after Cessation of Treatment with Diethylstilboestrol (C. C. Ware and Prof. T. Nicol), 974
Phagocytosis-inhibiting Substance from Culture Filtrates of an Encapsulated *Staphylococcus aureus*. Isolation of a (Dr. Stephen I. Morse), 102
Pharmacognosy · Indian Substitutes of Male Fern in (Prof. P. N. Mehra and T. C Mittal), 722
Pharmacology in Leeds, 121
Phase (Eclipse), of Vaccinia Virus (Dr. R. Postlethwaite and Prof. H. B Maitland), 335
Phase (Gas) · Analogy to the Kirkendall Effect in the (L. Miller and P. C Carman), 549
Phase (Metal), of Emstatite Chondrites · Silicon in the (A. E. Ringwood), 465
Phase (Viscous), of Liquid Sulphur: Structure of the (Dr. E. McLaughlin), 76
Phase Transformations (High-Pressure), in Laboratory Mechanical Mixers and Mortars (Frank Dachille and Prof Rustum Roy), 34
Phenol-killed Tubercle Bacilli: Enhanced Resistance of Mice to Infection with *Pasteurella pestis* following Vaccination with Fractions of (Prof. David W. Weiss), 1060
Phenol-treated T_2 Coli-Phage Preparations. Plaque-forming Ability of Urea- or (Dr. P H. Hofschneider), 330
Phenols (Hindered): Study of the Oxidation of, by Electron Spin Resonance (Dr. J E Bennett), 385
Phenols (Urinary), in Stress (R. Robinson and Dr P Smith), 240
Phenomena (Electromagnetic), in Cosmical Physics (edited by B. Lehnert), (International Astronomical Union Symposium No. 6, Stockholm 1956), *review* by Dr R H Garstang, 67
Phenomenon (Hosie) Pulsatile Flow through Tapered Distensible Vessels, Reflexions, and the (Robert L Evans), 290
Phenomena (Induction), in Photosynthesis of Isolated Spinach Chloroplasts (Dr. Knud Vejlby), 652
Phenomena (Nuclear), in *Trametes cingulata* Berk. (Pritindra Mohan Naha), 903
l-Phenyl-3,5-pyrazolidinedione Antipyretic Action of (Salah A. Tawab, Prof Ahmed Mustafa and Mohamed Kira), 165
Phenylthiocarbamide Test: A (André Leguebe), 970
Phillipsite in a Sediment Core from the Central Equatorial Pacific: X-Ray Determination of (F. Lippman), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 10, Special Investigations, No. 3), 609
Philosophical Society (American) Proceedings, Vol. 103, No. 4, A Blood Parasite from the California Yellow-legged Frog (Donald L. Lehmann), 765
  Yearbook for 1959, 850
Philosophy. Physics and (Prof. Werner Heisenberg), *review* by Prof. L. Rosenfeld, 830
Philosophy of Museums, *review* by Dr. F S Wallis, 110
Philosophy (Modern), of Science (Hans Reichenbach), translated and edited by Maria Reichenbach, *review* by Prof Herbert Dingle, 503
Phipps, I F.. Nitrogen in Tropical Agriculture (Manufacture and Use of Nitrogenous Fertilizers), 942
Phoca vitulina L. (Harbour Seal) Age Determination in the (A. W. Mansfield and H D Fisher), 92
Phosphatase (Alkaline), in the Meninges and in Meningiomas (Dr. W. J. Pepler), 979
Phosphate-^{32}P Heterogeneous Labelling of Acid-soluble Nucleoside 5'-Monophosphates during Short *in vivo* Incubation with (Dr T. D Price, K. K. Tsuboi, H. A Hinds and P B. Hudson), 158
Phosphate (Tri*para*ethylphenyl): Ataxia in Hens poisoned by (Ann Silver), 766
Phospholipids in Cytoplasmic Particulates Active Transport of γ-Aminobutyric Acid in Brain Cortex Slices, with special reference to Phosphorus-32 Turnover in (Yasuzo Tsukada, Yutaka Nagata and Shusuke Hirano), 474
Phosphorescence Spectra of Organic Compounds. Use of Solvents containing Ethyl Iodide in the Investigation of (Dr I. J Graham-Bryce and J. M Corkill), 965
Phosphorus-32: Heterogeneity of Lecithins labelled with (Dr. F. D. Collins), 366
Phosphorus-32 Turnover in Phospholipids in Cytoplasmic Particulates. Active Transport of γ-Aminobutyric Acid in Brain Cortex Slices, with special reference to (Yasuzo Tsukada, Yutaka Nagata and Shusuke Hirano), 474
^{32}P-Adenosine Triphosphate Exchange Reaction in Rat Liver Mitochondria: Effects of Fatty Acids on the (K. Ahmed and Dr P. G Scholefield), 1046
Phosphorus/Oxygen Ratios of Isolated Rat Liver Mitochondria: Effect of Pituitary Growth Hormone *in vivo* on the (C. N. Graymore, A. H. Melhuish and A. L Greenbaum), 392
Photobiology: (International Committee on Photobiology International Congress on), 523
Photobiology, International Committee on · International Congress on Photobiology, 523
Photochemie (Organische): Praparative (Prof. Alexander Schonberg), *review* by Prof. R. N. Haszaldine, 53

Photoelectric Spectrometry Group : Meeting on Spectrofluorimetry, 938

Photogrammetry : Aerial (École Nationale des Sciences Géographiques Theoretical and Technical Course on), 127

Photographic Emulsion Mosaics Spectroscopic Applications of (Prof. R W. Nicholls), 715

Photography : Insect, *review* by H. Oldroyd, 187

Photography (Astronomical), at the Telescope (Thomas Rackham), *review* by D. H. P. Jones, 190

Photomultiplier : Use of an Auxiliary Grid to stabilize the Gain of a (Dr. C. F G Delaney and Dr. A J Walton), 625

Photoperiodic Response of some Nigerian Plants (E Njoku), 438

Photoproducts (Low-Temperature) : Regeneration of Visual Pigments from their (Dr. C D B. Bridges), 292

Photoreduction of Chlorophyll : Role of the Triplet State in the (Prof. Robert Livingston and Dr. A C P. Pugh), 969

Photo-stimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide (J Wawrzyniak and Dr B Sujak), 467

Photosynthesis of Isolated Spinach Chloroplasts Induction Phenomena in (Dr. Knud Vejlby), 652

Photosynthesis (Bacterial) Equivalence of Light and Adenosine Triphosphate in (Dr M Losada, Dr A. V. Trebst, S. Ogata and Prof Daniel I Arnon), 753

Physical Chemistry, Russian Journal of : A translation to be issued by the Chemical Society in co-operation with the Department of Scientific and Industrial Research, 601

Physical Geography (Philip Lake), fourth edition, revised by Prof J. A. Steers, *review* by Prof L. Dudley Stamp, 190

Physical Sciences and Industry Use of Radioisotopes in the (International Atomic Energy Agency Conference on), 284

Physical Society (Institute of Physics and the) : Amalgamation of the, 681

Physical Society (Joint Committee appointed by the Institute of Physics and the) : The Postgraduate Training of Physicists in British Universities 915

Physical Society (Société Française de Physique and the) : Holweck Medal and Prize awarded to J. Brossel, 440

Physical Treatments : Heritable Changes in Lactic Streptococci induced by (B. S Gossling), 868

Physical and Chemical Constants : Tables of, and some Mathematical Functions (Dr G W. C Kaye and Dr. T. H. Laby), twelfth edition, *review* by T. M Yarwood, 67

Physical and Cultural Geography : Practical Field Techniques in (Geographical Association Course in), 1020

Physical and Structural Aspects of Non-destructive Testing of Metals (Non-destructive Testing Group of the Institute of Physics and the Société Française de Métallurgie Conference on), 284

Physicists in British Universities : The Postgraduate Training of—the Report of a Joint Committee appointed by the Institute of Physics and the Physical Society, 915

Physico-chemical Constants of Binary Systems in Concentrated Solutions (Prof. Jean Timmermans), Vol 1, Two Organic Compounds (without Hydroxyl Derivatives) ; Vol 2, Two Organic Compounds (at least one a Hydroxyl Derivative), *review* by Dr. E. F G. Herington, 918

Physics at Liverpool, 201

Physics at Southampton, 762

Physics : International School of (Societa Italiana di Fisica), 17

  Latin-American School of (Centro Brasileiro de Pesquisas Fisicas), 361

  Neutron, *review* by Dr. P A Egelstaff, 187

  Nuclear Reactor (Prof. Raymond L. Murray), *review* by J. Fell, 68

  Plasma (Danish Atomic Energy Commission International Summer Course on), 938

  A Student's Introduction to (Franklin Miller, Jr.), *review* by T. M Yarwood, 68

Physics, Institute of, and the Physical Society : Amalgamation of the, 681

Physics, Institute of, and the Physical Society (Joint Committee appointed by the) : The Postgraduate Training of Physicists in British Universities, 915

Physics, Institute of (Electron Microscopy Group), (Royal Microscopical Society and the) : Symposium on the Co-ordination of Light and Electron Microscopy, 672

Physics, Institute of (Non-destructive Testing Group), and the Société Française de Métallurgie : Conference on Physical and Structural Aspects of Non-destructive Testing of Metals, 284

Physics (Atomic), in Norway, 850

Physics (Cosmical) : Electromagnetic Phenomena in (edited by B. Lehnert), (International Astronomical Union Symposium No. 6, Stockholm 1956), *review* by Dr R H. Garstang, 67

Physics (Experimental), at Cambridge, 762

Physics (Metal) Progress in (edited by Dr. Bruce Chalmers and Dr. R. King), Vol. 7 (1958), Vol. 8 (1959), *review* by Prof. F. C Thompson, 666

Physics (Neutron) : Introduction to (Dr. L. F. Curtiss), *review* by Dr. P. A. Egelstaff, 187

Physics (Nuclear) : Low-Energy, *review* by Dr. E Bretscher, 58

  Proceedings of the International Conference on—Low-Energy Nuclear Interactions and Nuclear Structure, Paris 1958 (presented by P. Gugenberger), *review* by Dr. E. Bretscher, 58

Physics (Plasma), and Magnetohydrodynamics and their Applications to Controlled Thermonuclear Reactions : Bibliography on (J. D. Ramer), 522

Physics (Solid State) : Russian–English Glossary of (edited by I. Emin), *review* by Prof. S. I. Tomkeieff, 347

Physics (Twentieth Century) : A Forerunner of—a Re-view of Larmor's 'Aether and Matter' (Lancelot Law Whyte), 1010

Physics and Astronomy : From Nucleus to Universe—a Course of Selected Lectures in (University of Sydney, 1960), (edited by Prof. S. T. Butler and Prof. H. Messel), *review* by G. R. Noakes, 748

Physics and Chemistry of Glass, Vol. 1, No. 1 (Society of Glass Technology), 601

Physics and Mathematics (edited by Donald J. Hughes, J. E. Sanders and J. Horowitz), Vol 3 (Progress in Nuclear Energy, Series 1), *review* by Dr. E. R Rae, 68

Physics and Philosophy (Prof. Werner Heisenberg), *review* by Prof L. Rosenfeld, 830

Physiochemical Basis of the Analysis of the Paragenesis of Minerals (D S. Korzhinskii), translated from the Russian, *review* by Dr. Bernard E. Leake, 745

Physiological Age for Female *Glossina morsitans* Determination of (D. S. Saunders), 651

Physiology at the London Hospital Medical College, 598

Physiology : Comparative Biochemistry and, Vol. 1, No. 1, 764

Physiology : General, *review* by Prof. A. St. G. Huggett, 52, 284

Physiology of D-Glutamic Acid-requiring Mutants of *Bacillus subtilis* (Haruo Momose and Prof. Yônosuke Ikeda), 818

Physiology (Bacterial) : An Introduction to (E. L. Oginsky and Wayne W. Umbreit), second edition, *review* by Dr. R. H. Gorrill, 111

Physiology (General) : Principles of (W. M Bayliss), fifth edition, by Dr. L E. Bayliss, *review* by Prof A. St. G. Huggett, 52, 284

  A Textbook of (Dr. Hugh Davson), second edition, *review* by Prof. A St. G. Huggett, 52

Physiology (Plant) : Advances in, *review* by Prof W Stiles, 747

  Annual Review of (edited by Leonard Machlis, in association with John G. Torrey), Vol. 10, *review* by Prof. W Stiles, 757

Physique, Société Française de, and the Physical Society : Holweck Medal and Prize awarded to J. Brossel, 440

Phytopathological Society (American) : Plant Pathology, Problems and Progress, 1908-1958 (edited by C. S. Holton, G. W. Fischer, R. W. Fulton, Helen Hart and S E. A. McCallan), *review* by W. C. Moore, 47

Phytophthora palmivora (Butl) Butl. : Variation in, on *Theobroma cacao* L. in West Africa (P. D. Turner), 495

Picard-Ami, Luis, and others : Serotonin Content of the Pineal Glands of Man and Monkey, 480

Picciotto, Prof. E E : Geological Reconnaissance of the Sor-Rondane Mountains (Queen Maud Land), 740

Pickavance, Dr. T. G. : *Obituary* of Prof. H. W. B. Skinner, 354

Picken, Dr. Lawrence Ernest Rowland : Presented with the Trail Award and Medal of the Linnean Society of London, 766

Pickering, Sir George : Elected a Fellow of the Royal Society, 11

Pickman, D. O. : Reactor Fuel Element Technology (Design and Manufacture of Calder-type Fuel Elements), 1026

Picou, Dr D. I. M. : Medical Research in the British Caribbean, 862

Pig (Young) : Body-Weight and Age in relation to the Metabolic-Rate of the (Dr. L. E Mount and J G. Rowell), 1054

Piggott, W. R. (Bellchambers, W. H., and) : Results of the Royal Society's International Geophysical Year Expedition (Ionospheric Measurements), 191

Pigment (Visual), of the Horseshoe Crab, *Limulus polyphemus* (Dr Ruth Hubbard and Prof George Wald), 212

Pigment-producing Strains of *Acetobacter aceti* (J. G. Carr and J. L Shimwell), 331

Pigments (Visual) : Regeneration of, from their Low-Temperature Photoproducts (Dr C. D. B. Bridges), 292

Pigs : Thread Protein and β-Globulin Polymorphism in the Serum Proteins of (G. C. Ashton), 991

Piko, L , and Bomsel-Helmreich, O. : Triploid Rat Embryos and other Chromosomal Deviants after Colchicine Treatment and Polyspermy, 737

Piling-up of Dislocations beneath a Surface Film (A. R. C. Westwood and L. J. Demer), 146

Pilkington, Dr Roger : Robert Boyle, Father of Chemistry, *review* by Dr. W. A. Smeaton, 63

Pillai, G B. : Recent Advances in Coconut Research in India, 861

Pillai, N. G. : Recent Advances in Coconut Research in India, 861

Pillai, R V., and Satyabalan, K. : Recent Advances in Coconut Research in India, 861

Pinch ('Theta') : 'Price' a Pre-ionized (R. D. Medford, A. L. T. Powell, J. D. Herbert, R. C. Pottinger and J K. Wright), 706

Pinched Discharge (Linear) : Growth of Surface Instabilities in a (Dr. R. Latham, J. A. Nation, F. L. Curzon and Dr. A Folkierski,) 624

Pine Weevil (*Hylobius abietis*) : The Large (Forestry Commission, Leaflet No 1), revised edition, 521

Pineal Extract (Bovine) : Effects of Injection of, on the Nuclei of Rat Pineal Parenchymal Cells (Dr. Uno Holmgren, Dr Mark D Altschule and Dr. Richard J. Wurtman), 393

Pineal Glands of Man and Monkey : Serotonin Content of the (Prof. Nicholas J. Giarman, Daniel X. Freedman and Luis Picard-Ami), 480

Pineal Parenchymal Cells (Rat) Effects of Injection of Bovine Pineal Extract on the Nuclei of (Dr. Uno Holmgren, Dr. Mark D. Altschule and Dr. Richard J. Wurtman), 393

Pinus : Effects of *Gibberella fujikuroi* on Fungal Root-Infections of (Dr. Ida Levisohn), 987

Pippard, Prof. A. B. : Elected to the John Humphrey Plummer professorship of experimental physics in the University of Cambridge, 762 ; work of, 762

Pippard, Prof. A. J. S. : A Treatise on Statically Indeterminate Structures, *review*, 582

Pirie, Dr. Antionette : The Biochemistry of the Eye, 352

Pirone, Prof Thomas P., and others : Purification and Properties of Cauliflower Mosaic Virus, 656

Pistons (Rigid), in an Array : Measurements of the Total Acoustic Radiation Impedance of (J S. M. Rusby), 144

Pitt, Frances : The Buzzard, *review*, 65

Pituitary of the Minnow : Distribution of Chromactivating Hormones in the (A. K. Kent), 395

Pituitary Growth Hormone *in vivo* : Effect of, on the Phosphorus/Oxygen Ratios of Isolated Rat Liver Mitochondria (C. N. Graymore, A. H. Melhuish and A. L. Greenbaum), 392

Pituitary Stalk Section : Influence of Cervical Sympathectomy and, upon Milk Secretion in Goats (G. B. Tverskoy), 782

Plack, Dr P. A. : Vitamin A_1 Aldehyde in Hen's Eggs, 234

Planetary Dynamics, *review* by Dr. R. H. Garstang, 60

Plans d'Expérience : Analyse de Variance et (Prof. Daniel Dugué et Prof. Maurice Girault), *review* by Dr. D J. Finney, 68

Plant : The Diseased (Plant Pathology, an Advanced Treatise, edited by J. G. Horsfall and A. E. Dimond, Vol. 1), *review* by W. C. Moore, 47

Plant Cell-Wall : The (Prof. Pieter A Roelofsen), *review* by Prof. R. D. Preston, 920

Plant Cell-Walls : Structure and Growth of, *review* by Prof. R. D. Preston, 920

Plant Cells : Life-like Preservation of Cytoplasmic Detail in (Dr J. Chayen, Prof. G. J. Cunningham, P. B. Gahan and A. A. Silcox), 1068
Plant Extracts : Treatment of Injured and Regenerating Muscles with (S. Hoja and J. Vittek), 283
Plant Extracts (Alcoholic) : An Ion-Exchange Resin Method for the Fractionation of (Dr. Dalton Wang), 326
Plant Pathology : Progress in, *review* by W. C. Moore, 47
Plant Pathology, an Advanced Treatise (edited by J. G. Horsfall and A. E. Dimond), Vol. I, The Diseased Plant, *review* by W. C. Moore, 47
Plant Pathology, Problems and Progress, 1908-1958 (edited by C. S. Holton, G. W. Fischer, R. W. Fulton, Helen Hart and S. E. A. McCallan), *review* by W. C. Moore, 47
Plant Physiology : Advances in, *review* by Prof. W. Stiles, 747
  Annual Review of (edited by Leonard Machlis, in association with John G. Torrey), Vol. 10, *review* by Prof. W. Stiles, 747
Plant Population and Crop Yield (R. Holliday), 22
Plant (Crop) Resistance to Disease : Nature and Exploitation of (Association of Applied Biologists and the British Mycological Society Symposium on), 857
Plants : Bio-electric Potentials of (D. S. Fensom), 853
  Degradation of γ-Methyleneglutamic Acid by (Dr. L. Fowden), 897
  Detoxication during Secondary Growth in (C. M. Stewart), 374
Plants Recorded as Resistant to Root-Knot Nematodes (*Meloidogyne* spp.), (Mary T. Franklin and D. J. Hooper), 684
Plants (Fossil), of the Carboniferous Rocks of Great Britain (Dr. Robert Crookall), second edition, *review* by T. M. Harris, 66
Plants (Nigerian) : The Photoperiodic Response of some (E. Njoku), 438
Plants (Rice) : Stimulating Effects of Nuclear Radiations on Development and Productivity of (Dr. Maung Mya Thaung), 982
Plants (Tropical) : Photoperiodic Response of some, 438
Plaque-forming Ability of Urea- or Phenol-treated T_2 Coli-Phage Preparations (Dr. P. H. Hofschneider), 330
Plaque-forming System (An Indicator), for Demonstration of Interference by Non-cytocidal Strains of Rabies Virus (Dr. Martin M. Kaplan, Dr. Eberhard Wecker, Dr. Zlatko Forsek and Dr Hilary Koprowski) 821
Plasma (Human Serum and) : Antithromboplastin in (Dr. T. G. Scott, Dr. C. Symons and R. L. Markham), 248
Plasma (Normal and Hageman) : Initiation of Clotting in, by Glass (Dr Preben Ollendorff), 173
Plasma Physics (Danish Atomic Energy Commission International Summer Course on), 938
Plasma Physics and Magnetohydrodynamics and their Applications to Controlled Thermonuclear Reactions : Bibliography on (J. D. Ramer), 522
Plasminogen (Profibrinolysin) : Rivanol in the Preparation of (Dr. M. Steinbuch and Dr. S. Niewiarowski), 87
Plastics Institute : Swinburne Award, 126
  Conference on Polymeric Progress, 441
Plateau (Columbia) : Miocene Floras of the, Part I, Composition and Interpretation (Ralph W. Chaney) ; Part 2, Systematic Considerations (Ralph W. Chaney and Daniel I. Axelrod), *review* by Prof. J. Walton, 66
Platelets (Human White Cells and) : Microelectrophoresis of (Dr. William P Creger and Phyllis Menna Thomas), 171
Plating (Nickel) : Brighteners for, and Polarographic Maxima (Hideya Okada and Takeo Ishida), 152
Pleistocene Period—its Climate, Chronology and Faunal Successions (Prof. Frederick E. Zeuner), *review* by D. F. W. Baden-Powell, 833
Pleural Fluid : Mucopolysaccharides of Serum and (Prof C. W. Fishel), 804
Plutonium : Allotropic Transformations in (J. D. Hill), 304
δ-Plutonium Transition Temperature (Dr. R. G. Cope), 539
Pochin, Dr. E. E. : Thyroid Radioiodine Uptake Measurement, *review*, 424
Poisonous Amphibians and Reptiles (Prof. Floyd Boys and Prof. Hobart M. Smith), *review* by A. G. C. Grandison, 269
Poisonous Substances in Agriculture and Food Storage, Advisory Committee on : Appointment of Sir Charles Dodds as chairman, 934
Polansky, T. S , and others : Structure of High-Rank Coals deduced from Helium Densities, 792
Polanyi, Prof. Michael : The Study of Man (Lindsay Memorial Lectures, 1958), *review* by F. I G. Rawlins, 347
Polar Cap Absorption of Cosmic Noise . A Relation between Solar Radio Emission and (Dr. M. R. Kundu and Prof. F. T. Haddock), 610
Polarimetric Method . Rate of Ligand Exchange with its Metal Complex by a (B. Bosnich, Dr. F. P. Dwyer and Dr. A. M. Sargeson), 966
Polarizability (Solvent) : Effect of, on the Ultra-violet Spectral Shifts of Aromatic Compounds (Dr. F A. Bovey and S. S. Yanari), 1042
Polarized Light : Discrimination of, by *Octopus* (The Visual System of *Octopus*), (M. F. Moody and J R. Parriss), 839
Polarographic Maxima : Brighteners for Nickel Plating and (Hideya Okada and Takeo Ishida), 152
'Polarons' (Self-trapped Electrons) : Primary Processes in the Action of Ionizing Radiations on Water—Formation and Reactivity of (Prof. Joseph Weiss), 751
Policy for School Science (Organization for European Economic Co-operation Seminar on), 850
Political and Economic Planning : European Organizations, 830
Political and Economic Science, British Library of : Annual Report for 1958-59, 520
Polley, Margaret J , and others : Role of C'_4 in the Antiglobulin Reaction, 482
Polli, E E., and others · Infra-Red Spectra of Deoxyribonucleic Acids from Human Leucocytes, 964
Pollution (Water), by Trade Effluents, 210
Polmear, I. J. · A Trace Element Effect in Alloys based on the Aluminium–Zinc–Magnesium System, 303
Polonovski, M., et autres : Traité de Biochimie Générale, Vol I, Composition Chimique des Organismes, *review* by Prof. F G. Young, 51
Polycytidylic Acid : Polyinosinic plus—a Crystalline Polynucleotide Complex (Dr David R. Davies), 1030
Polyelectrolytes (Synthetic), as Tumour Inhibitors (Dr. William Regelson, Stephan Kuhar, Marvin Tunis, Joseph Fields, John Johnson and Earl Gluesenkamp), 778
Polyethylene : Effect of a Second Crystalline Modification in, on X-Ray Crystallinity Measurements (Dr. C. G Vonk), 962
  Reaction of Active Nitrogen with (Dr. J. L. Weininger), 546
Polyinosinic plus Polycytidylic Acid—a Crystalline Polynucleotide Complex (Dr. David R. Davies), 1030
Polymer Formation in Irradiated *p*-Xylene (Francis van Hecke), 382
Polymeric Progress (Plastics Institute Conference on), 441
Polymerization of Crystalline Methacrylic Acid initiated by Ultra-violet Radiation (Dr. C. H. Bamford, A. D. Jenkins and J. C. Ward), 713
Polymers : Analytical Chemistry of (edited by Gordon M. Kline), Part I, Analysis of Monomers and Polymeric Materials—Plastics, Resins, Rubbers, Fibres, *review* by Prof. C. E. H. Bawn, 52
  Complexes of Calcium–Montmorillonite with (W. W. Emerson), 573
Polymers (Dimethyl Siloxane) : Proton Magnetic Resonance in a Series of—a Specific Long-Chain Effect? (Dr. J. G. Powles and A. Hartland), 26
Polymers (Hydrocarbon) : Mode of Radiation-induced Cross-Linking in (T. F Williams), 544
Polymorphism (β-Globulin), in the Serum Proteins of Pigs · Thread Protein and (G. C. Ashton), 991
Polynucleotide Complex : Polyinosinic plus Polycytidylic Acid—a Crystalline (Dr. David R Davies), 1030
Polyoma Virus (*S E*) : Development of Resistance in Mice to Tumour Induction by (Sarah E. Stewart, Bernice E. Eddy, Marjean Irwin and Stephanie Lee), 615
Polypeptides : A Novel Synthesis of (Dr. J. Oró and C. L Guidry), 156
Polysaccharides : Enhancement of Peroxidase Action by (Dr. B. Z. Siegel and Dr. S. M. Siegel), 391
  Synovial Proliferation induced by (D. P. Page Thomas, J. T. Dingle and E. R. Cook), 251
Polyspermy : Triploid Rat Embryos and other Chromosomal Deviants after Colchicine Treatment and (L. Piko and O. Bomsel-Helmreich), 737
Polystyrene Resin (Sulphonated) : Behaviour of some Aldehydes on a (Dr. S. A. Barker, K. Murray and Prof. M. Stacey), 469
Polyvinyl Benzoate Monolayers (Herman E. Ries, jun., Nicky Beredjick and Joseph Gabor), 883
Pond Animals : Suffolk Ponds and (J. E. Marston), 771
Ponder, Dr Eric, and Ponder, Ruth V. . Interaction between Albumin, Lecithin and Cephalin, 235
Ponder, Ruth V. (Ponder, Dr. Eric, and) : Interaction between Albumin, Lecithin and Cephalin, 235
Ponds and Pond Animals : Suffolk (J. E. Marston), 771
Pontén, Dr. J : Awarded a grant from the Tata Memorial Trust, for research on leukaemia and allied diseases, 1020
Pool, W. A. (edited by) : The Veterinary Annual, 1959, *review* by G. N. Gould, 667
Poon-King, Dr. T. . Medical Research in the British Caribbean (Treatment of Diabetes mellitus with Chlorpropamide), 862
Pope, Dr. M. (Kallmann, Dr. H., and) : Bulk Conductivity in Organic Crystals, 31
Population in 1958, 765
Population : Increase of Settlement Size and, since the Inception of Agriculture (Dr Max Pettersson), 870
Population (Japanese) : Haptoglobin Types in a (Prof. E. Matsunaga and Kyoko Murai), 320
Population (Plant), and Crop Yield (R. Holliday), 22
Population Bulletin, Vol. 15, No. 6, Fertility of College Graduates (Population Reference Bureau, Inc.), 22
Population Genetics : Electronic Computers in (W. F. Bodmer), 851 ; (J. L. Crosby), 851
Population Reference Bureau, Inc. : *Population Bulletin*, Vol. 15, No. 6, Fertility of College Graduates, 22
Population and Progress in the Far East (Prof. Warren S. Thompson), *review* by Prof. W. D. Borrie, 664
Porphyra tenera–Cytochrome 553 : Crystallization of an Algal Cytochrome (Dr. Sakae Katoh), 138
Porter, Prof. G. : Elected a Fellow of the Royal Society, 11
Position of the Gene determining the Diploid-like Meiotic Behaviour of Wheat (Dr. Ralph Riley, Victor Chapman and Gordon Kimber), 259
Position of the Proximal Centriole in Flagellate Spermatozoa (Prof. Vishwa Nath, Brij L. Gupta and L. C. Mittal), 899 ; (Dr. J. Bronté Gatenby and R. S Mathur), 900
Position (Electrophoretic), of Haptoglobin Mixtures : Variations in, in Agar-gel Electrophoresis (Dr. Jan Hirschfeld), 894
Position (Electrophoretic), of an Indoxylacetate Splitting Component in the α_2-Globulin Region of Normal Human Sera : Agar-gel Electrophoretic Demonstration of Individual Variations in (Dr. Jan Hirschfeld), 321
Possibility of a Self-sustaining Corbino Disk (Dr. D. Midgley), 377
Possible Basis for Immunological Tolerance (Dr. D. T. Denhardt), 728
Possible Factor in Sympatric Speciation : Selective Visits of Butterflies to Flowers—a (K. R. Dronamraju), 178
Possible Fundamental in the Behaviour of Young Nidifugous Birds (Dr. Peter M. Driver), 416
Possible Mechanism for the Anti-Inflammatory Action of Corticosteroids : Accumulation of Substrate by Isolated Rat Diaphragm—a (Prof. Ira G Wool), 728
Possible Parent Materials for Tektites : High-Temperature Fusion of (Origin of Tektites), (J. F. Lovering), 1028
Possible Relation to the Circulation of Amniotic Fluid : Ultra-Structure of Human Amnion and its (Dr. Gordon L. Bourne and Dr. Dennis Lacy), 952
Possible Role of Excited Dimers in Energy Transfer Processes : Radiative Life-time of the Pyrene Dimer and the (Dr. B. Stevens and E. Hutton), 1045
Postgraduate Courses, 1960-61 (Imperial College of Science and Technology, London), 206
Postgraduate Students : The Training of, 915
Postgraduate Training of Physicists in British Universities—the Report of a Joint Committee appointed by the Institute of Physics and the Physical Society, 915
Postgraduate Training Grants in Fishery Research (Development Commissioners, the Ministry of Agriculture, Fisheries and Food, and the Scottish Home Department), 360
Post-yield Region . Supercontraction of Wool Fibres and Creep in the (Dr. K. J Whiteley), 473
Postlethwaite, Dr. R., and Maitland, Prof. H. B. : Eclipse Phase of Vaccinia Virus, 335
Postural Changes in Chlorpromazine Hypothermia (Dr. D. Svorad), 240

Potamopyrgus jenkinsi Smith (Snail) : Effect of a Sewage Effluent Discharge on the Deposition of Calcium Carbonate on Shells of the (R. W. Edwards and J. Heywood), 492
Potassium : Isotopic Composition of (B. R. F. Kendall), 225
Potassium Chloride (Single Crystals of), containing Barium Chloride : Micromosaic Patterns in (J. Ewles and J. B. Dawson), 381
Potassium Hydroxide : Photo-stimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or (J. Wawrzyniak and Dr B Sujak), 467
Potassium Iodide irradiated with Ultra-violet Light : Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of (Prof. F. S. Dainton and S A Sills), 879
Potassium-Level (Supernatant) . Effect of, on Cardiac Activity in Quantitative Tissue Culture (Prof A. W. B Cunningham, K. Kleutch and W. Herbst), 241
Potassium Permeability (Delayed) : Action Potentials in Active Tissue with (Dr. E. P. George), 889
Potassium Trivanadate : Crystal Structure of (Dr. Stanley Block), 540
Potassium-40 in Norwegian-produced Milk : Radiocaesium and (K. Madshus and J Baarli), 527
Potassium-42 Uptake by the Rat Muscle *in vitro* : Effect of Denervation on (Dr. Z. Drahota and O. Hudlická), 396
Potassium-42 and Iodine-131 (Sodium-24,) Clearance Rates of, in Normal Dog Hip Joints (Prof Patrick G. Laing and Dr. Ik Dong Kim), 898
Potato Virus *M* and Paracrinkle (Dr. H. W. Howard and J. Wainwright), 993
Potential' ('Equivalent Redox) : Significance of the, in Aqueous Solutions under Ionizing Radiation (Dr. G. H. Cartledge), 370
Potential Changes (Membrane), associated with Stimulation of Smooth Muscle by Adrenalin (G Burnstock), 727
Potential Changes (Spontaneous), at Crayfish Neuromuscular Junctions (Dr. Josef Dudel and Richard K. Orkand), 476
Potential Oscillations in the Lower Olfactory Pathway of the Toad (Dr. S. F Takagi and Dr. T. Shibuya), 724
Potential Theory of Unsteady Supersonic Flow (Prof. John W Miles), *review* by L E. Fraenkel, 505
Potentials (Action), in Active Tissue with Delayed Potassium Permeability (Dr E. P. George), 889
Potentials (Bio-electric), of Plants (D. S Fensom), 853
Potentials (Extracellular Unit Action), from the Central Nervous System : 'Weightless' Micro-electrodes for Recording (Prof. B. Delisle Burns and Dr. J. G. Robson), 246
Potentials (Intracellular), in Rat Atria during and after Vagal Stimulation or Acetylcholine Administration (P. A. Biersteker, J. Th. F. Boeles and L. N. Bouman), 637
Potentials (Spontaneous), from Explants of Brain Tissue in Culture (Prof. A. W. B. Cunningham, Marshall Dougherty and B J Rylander), 477
Pottinger, R. C., and others : 'Prize', a Pre-ionized 'Theta' Pinch, 706
Pound, Glenn S , and others : Purification and Properties of Cauliflower Mosaic Virus, 656
Powder Metallurgy (Metal Powder Industries Federation International Conference on), 361
Powell, A L. T., and others : 'Prize' a Pre-Ionized 'Theta' Pinch, 706
Powell, Prof. Loyd E , and Pratt, Charlotte : A Comparison of Adhering and Abscising Fruits of Peach treated with N-1-Naphthyl Phthalamic Acid, 814
Power Output 1960-65 : Estimated United Kingdom, 122
Power Reactors (Nuclear Energy and) : Fundamentals of (Henry Jacobowitz), *review* by Dr. T. E Allibone, 917
Powles, Dr J G , and Hartland, A : Proton Magnetic Resonance in a Series of Dimethyl Siloxane Polymers—a Specific Long-Chain Effect?, 26
Poxviruses Reactivation of, by a Non-Genetic Mechanism (Dr. W. K. Joklik, Pamela Abel and I H Holmes), 992
Practical Field Techniques in Physical and Cultural Geography (Geographical Association Course in), 1020
Practice : Heat Treatment (British Iron and Steel Research Association Conference on), 523
Practice of Sedimentation : Theory and, *review* by Dr K. V. Shooter, 56
Prasannakumari, T. O. : Recent Advances in Coconut Research in India, 861
Pratt, Charlotte : Changes in Structure of a Periclinal Chromosomal Chimera of Apple following X-Irradiation, 255
Pratt, Charlotte (Powell, Prof. Loyd E., and) : A Comparison of Adhering and Abscising Fruits of Peach treated with N-1-Naphthyl Phthalamic Acid, 814
Precambrian (Late) Fauna in South Australia (M F Glaessner and B. Daily), 205
Precipitate (Benzidine Sulphate) : A Modification for Washing the, in the Determination of Sulphate (Dr. I P. T. Hakkinen), 232
Precipitating Antibody in Trypanosomiasis of Cattle and other Animals (A. R. Gray), 1058
Precursor of Antigen 34 in *Salmonella* : Somatic Antigen 15 as a (Hisao Uetake and Shin Hagiwara), 261
Predehydroxylation State of Kaolinite (Dr. J. J. Fripiat and F. Toussaint), 627
Predissociation (A New), in Nitrogen (Alf Lofthus), 302
Pregnant Mare Serum Gonadotropin : Effect of *p*H on Biological Activity of (Bengt H. Persson and Stig E. J. Melander), 163
Pre-Ionized 'Theta' Pinch : 'Prize', a (R. D Medford, A. L. T. Powell, J. D. Herbert, R. C. Pottinger and J. K. Wright), 706
Preliminary Flight Tests of an Atomic Clock in Preparation of Long-range Clock Synchronization Experiments (Friedrich H. Reder and Gernot M R. Winkler), 592
Preparation for Direct Entry into First Degree Courses in the Faculty of Science : Report of an Enquiry into the Suitability of the General Certificate of Education Advanced Level Syllabuses in Science as a (University of Birmingham), 687
Preparation of Long-range Clock Synchronization Experiments : Preliminary Flight Tests of an Atomic Clock in (Friedrich H. Reder and Gernot M. R. Winkler), 592
Preparation of Plasminogen (Profibrinolysin) : Rivanol in the (Dr. M. Steinbuch and Dr. S Niewiarowski), 87
Preparation of Pure Standard Métallic Perchlorate Solutions (E. P. Serjeant), 963
Preparation of Tritiated Water Samples by Distillation (J. D. Simpson and Dr. J. R. Greening), 467
Preparation of Ultra-Thin Sections : Water-Soluble Methacrylates as Embedding Media for (Dr. O. Wichterle, Dr. P. Bartl and Dr. M. Rosenberg), 494
Preparation for University Work : Sixth-Form Science as a (Dr W. L. Sumner), 686
Preparations (*T_2* Coli-Phage) : Plaque-forming Ability of Urea- or Phenol-treated (Dr P H. Hofschneider), 330
Presence of Adenosine Triphosphate : Effect of Electrical Stimulation on a Muscle Fibre Model in the (Prof. Masahiro Fujino, Tatsuaki Matsushima, Tomizo Muroya, Hideyo Yabu, Saburo Yamaguchi and Masaki Takahashi), 318
Presence of Chicken Tumour Virus in the Sarcoma of the Adult Rat inoculated after Birth with Rous Sarcoma Tissue (Dr. Jan Svoboda), 980
Presence of Gibberellin-like Substances in Lettuce Seed (Dr. S. Blumenthal-Goldschmidt and Prof. A. Lang), 815
Presence of Protein in some Serum Filtrates (Dr. F. J. Scandrett), 558
Present Problems in World Affairs (Le Play Society Conference on), 606
Preservation of Documents (W K. Wilson and B. W. Forshee), 124
Preservation of North Devon Countryside, 935
Preservation (Life-like), of Cytoplasmic Detail in Plant Cells (Dr. J. Chayen, Prof G J Cunningham, P. B Gahan and A A Silcox), 1068
Press Arrangements for Scientific, Medical and Technical Conferences : Guide to (edited by Ronald Bedford), 437
Pressman, Dr David, and Radzimski, Dr Gerald : Iodination of Specific Sites on Bovine Serum Albumin, 1049
Pressure (High-) Phase Transformations in Laboratory Mechanical Mixers and Mortars (Frank Dachille and Prof Rustum Roy), 34
Pressure (Osmotic) : Gibberellic Acid and (J. van den Ende and P. Koornneef), 327
Pressure (Rock), in Mines : The Measurement of (Nils Hast), 936
Preston, Prof. R. D. . Structure and Growth of Plant Cell-Walls, *review*, 920
Preston, Prof R. D. (Aronson, J M., and) : Cell Wall Formation in Spores of the Fungus *Allomyces*, 95
Preuss, Dr. H. : Die Methoden der Molekulphysik und ihre Anwendungsbereiche, *review* by Prof C A. Coulson, 54
Prevalence (Distribution and), of *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw.) Wr) producing Substances with Gibberellin-like Biological Properties (Prof. W. L. Gordon), 698
Prevention (The Chemical), of Cardiac Neuroses (Prof. Hans Selye), *review* by Dr D C. Deuchar, 423
Preventive Aspects in the Teaching of Pathology (World Health Organization, Technical Report Series No. 175), 602
Priapulus caudatus Lamarck, 853
Price, Dr. Derek J. de Solla, and others : Heavenly Clockwork—the Great Astronomical Clocks of Medieval China, *review* by Dr. F. A. B. Ward, 834
Price, Dr. T. D., and others : Heterogeneous Labelling of Acid-soluble Nucleoside 5'-Monophosphates during Short *in vivo* Incubation with Phosphate-^{32}P, 158
Primary Neoplastic Growth : Chromosomes in (Dr. K. Bayreuther), 6
Primary Processes in the Action of Ionizing Radiations on Water—Formation and Reactivity of Self-trapped Electrons ('Polarons'), (Prof. Joseph Weiss), 751
Primary Source of Sulphate in Tidal Swamp Soils from Sierra Leone : Sea-Water as the (J C. D. Watts), 308
Primary Structure of the Protein of Tobacco Mosaic Virus (F. A. Anderer, H. Uhlig, E. Weber and Prof. G. Schramm), 922
Primates : Man among the, *review* by Dr. G. G. Simpson, 665
Primates (Laboratory) : Diseases of (Prof. Theodore C. Ruch), *review* by Dr C. R. Cold, 506
Prince, Dr. Herbert N. : Specific Inhibition of Obligate Anaerobes, 816
Principal Works of Simon Stevin (edited by Prof. D J Struik), Vol. 2A, Mathematics ; Vol. 2B, Mathematics, *review* by Dr. J. F. Scott, 60
Principles : Chemical Process (Prof. Olaf A. Hougen, Prof Kenneth M. Watson and Prof Roland A. Ragatz), Part 2, Thermodynamics, second edition, *review* by L. E Marc de Chazal, 1003
Principles of the Extraction of Metals (Dr D. J. G Ives), 765
Principles of General Physiology (W M. Bayliss), fifth edition, by Dr. L. E. Bayliss, *review* by Prof. A St. G. Huggett, 52, 284
Principles of Geology (James Gilluly, A. C. Waters and A O. Woodford), second edition, *review* by Dr. J. V. Harrison, 57, 440
Principles of Organic Chemistry (T. A. Geissman), now available in England, 17
Principles of Quantum Electrodynamics (Walter E. Thirring), translated from the German by J. Bernstein, *review* by Prof. N. Kemmer, 999
Pringle, Ross B., and others Purification of a Specific Inducer of the Male Sex Organ in certain Fern Species, 1066
Prior, J. R. (Male, J. C , and) : Intrinsic Recombination Radiation in Diamond, 1037
'Prize', a Pre-ionized 'Theta' Pinch (R. D Medford, A. L. T. Powell, J. D. Herbert, R. C. Pottinger and J. K. Wright), 706
Prizes (Nobel) . Tenth Annual Meeting of Holders of, 938
Probability and Statistics (Prof Walter L. Smith), 338
Probable Origin by Mitotic Non-disjunction : A Mosaic of *Drosophila* consisting of 1*X*, 2*X* and 3*X* Tissue and its (Prof. Curt Stern), 179
Probert-Jones, J. R. : Meteorological Use of Pulsed Doppler Radar, 271
Problem : The Nucleolus (Dr. J. L. Sirlin), 275
Problem of Language in Publications of Works in Scientific and other Fields of Learning (Prof. D. Keilin), 912
Problem of Noise, Committee on the : Ready to receive evidence, 1020
Problem der Tiefseesande im westlichen Teil des aquatorialen Atlantiks : Ein Beitrag zum (F W. Locher), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Sediment Cores from the North Atlantic Ocean, No. 5), 609
Problem (Human Fertility). Modern Science and the (Dr Richard Meier), *review* by Dr. Kenneth Walker, 188
Problem (Mullite) : A New Interpretation of the (J. H. Welch), 545
Problems : Arid Zone (Unesco Symposium on), 284
Problems of Human Fertility, *review* by Dr. Kenneth Walker, 188
Problems of Motion of Artificial Satellites : Figures of Equilibrium of Celestial Bodies, with Emphasis on (Prof. Zdenek Kopal), *review* by D. G. King-Hele, 747
Problems of Perception (R. J. Hirst), *review* by Prof. M. D. Vernon, 919

Problems of Progress in Industry : No. 5, Human Problems of Innovation (Based on a Study of some Scottish Firms by Tom Burns and G M. Stalker), (Department of Scientific and Industrial Research), 419
Problems of Space Flight, *review* by D. G. King-Hele, 59
Problems (Biological), of Grafting—a Symposium sponsored by the Commission Administrative du Patrimoine Universitaire de Liège and the Council for International Organizations of Medical Sciences), *review* by Dr. D. M. V. Parrott, 51
Problems (Human), of Innovation (Based on a Study of some Scottish Firms by Tom Burns and G. M. Stalker), (Department of Scientific and Industrial Research, Problems of Progress in Industry, No 5), 419
Problems (Human), of Innovation in Industry, 419
Problems (Mental Health), of Automation : Study Group on the (World Health Organization, Report Series No. 183), 364
Problems (Present), in World Affairs (Le Play Society Conference on), 606
Problems (Scientific), of Crop Protection (Hungarian Academy of Sciences International Conference on), 523
Processes : Textile Engineering (edited by Prof A H Nissan), *review* by Prof C. S Whewell, 189
Processes (Energy Transfer) : Radiative Life-time of the Pyrene Dimer and the Possible Role of Excited Dimers in (Dr. B Stevens and E. Hutton), 1045
Processes (Primary), in the Action of Ionizing Radiations on Water—Formation and Reactivity of Self-trapped Electrons ('Polarons'), (Prof Joseph Weiss), 751
Producing Free Radicals from Solids The Tesla-coil Method for (Dr C. H. Bamford, A D Jenkins and J C. Ward), 712
Product (Condensation), of Ethylenediamine with Noradrenaline or 3,4-Dihydroxymandelic Acid (Kunio Yagi, Toshiharu Nagatsu and Ikuko Nagatsu), 310
Production of Calcium-47 : International Co-operation and the, 1018
Production of Shikimic Acid by *Penicillium griseofulvum* Dierckx (Prof. Paul Simonart and Anselme Wiaux), 78
Production of Vibrationally Hot Molecules in Free-Radical Reactions . A Model to account for the (Dr. J. P. Simons), 551
Production (Erythropoietine), in the Dog (Dr. F. W Kinard, F F. Griffin, jun., and F. W. Kinard, jun.), 561
Production (Ethylene), by Tomato and Apple Fruits (D. F Meigh, K. H. Norris, C. C. Craft and M. Lieberman), 902
Production (Experimental), of Liver Cancer : Effect of 3-Amino-1,2,4-triazole on the (Munemitsu Hoshino), 174
Production (Rice) : Paddy Soils and (Dr. H. Greene), 511
Productivity of Rice Plants : Stimulating Effects of Nuclear Radiations on Development and (Dr. Maung Mya Thaung), 982
Products Council (Colonial) : Report for 1958-59, 501
Products (Fission) : An Assessment of the Quantities of, likely to be found in Milk in the Event of Aerial Contamination of Agricultural Land (Dr R. J Garner), 1063
Professional Civil Servants, Institution of . Fifteenth Annual Report (1959), 436, 1017
Professional Status : Higher National Certificates and, 123
Profibrinolysin (Plasminogen) : Rivanol in the Preparation of (Dr. M. Steinbuch and Dr. S. Niewiarowski), 87
Profile of Upper-Atmosphere Air Density at the Height of 180-212 km. derived from the Orbit of *Sputnik* III (Z. V. Bochníček), 460
Profile (Wind), in Thermally Stratified Flow (W. C. Swinbank), 463
Profitable Farming : Fertilizers and (Dr. G. W. Cooke), *review* by G. V. Jacks, 424
Progress : Polymeric (Plastics Institute Conference on), 441
Progress in the Far East : Population and (Prof. Warren S. Thompson), *review* by Prof. W D. Borrie, 664
Progress of Geology in the U.S.S R. (Prof. S. I. Tomkeieff), 438
Progress in Industry : Problems of, No. 5, Human Problems of Innovation (Based on a Study of some Scottish Firms by Tom Burns and G. M. Stalker), (Department of Scientific and Industrial Research), 419
Progress in Metal Physics (edited by Dr. Bruce Chalmers and Dr. R. King), Vol. 7 (1958), Vol. 8 (1959), *review* by Prof. F. C. Thompson, 666
Progress in Nuclear Energy : Series I, Physics and Mathematics, Vol. 3 (edited by Donald J Hughes, J E. Sanders and J Horowitz), *review* by Dr. E. R. Rae, 68
Progress in Plant Pathology, *review* by W C. Moore, 47
Progressive Development in *Habrobracon* Females : Divergence between Lethal Doses and Sterilizing Doses of X-Rays with (Dr. Howard E. Erdman), 254
Proliferation (Synovial), induced by Polysaccharides (D. P. Page Thomas, J. T. Dingle and E. R. Cook), 251
Proneness of Drivers to Road Accidents (Dr R. J. Smeed), 273
Proof : Godel's (Ernest Nagel and James R. Newman), *review* by F. I. G. Rawlins, 61
Propagation of Clones of *Hevea brasiliensis* by Cuttings : Developments in the (G H. Tinley and R. J. Garner), 407
Propagation Constants (Ultrasonic), in Supercooled Salol (Dr. S Parthasarathy and V N Bindal), 145
Propellants : Rocket (Francis A. Warren), *review* by Dr. W. B Littler, 58
Properties of Cauliflower Mosaic Virus : Purification and (Prof. Thomas P. Pirone, Glenn S Pound and Robert J. Shepherd), 656
Properties of the Iridium–Platinum Alloys : Constitution and (Dr. A. S. Darling), 211
Properties (Antimalarial), of some Guanidine Derivatives (Y. Ch. Chin, Y. Y. Wu, B. Skowrońska-Serafin, Prof. T. Urbański and J. Venulet), 170
Properties (Coherence), of Electromagnetic Radiation (United States Air Force, the Optical Society of America and the University of Rochester Conference on), 127
Properties (Electrical and Magnetic), of β-Carotene Triiodide (Dr. Charles M. Huggins and Dr. Oliver H LeBlanc, jun), 552
Properties (Gibberellin-like Biological) . Distribution and Prevalence of *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw.) Wr.) producing Substances with (Prof. W. L Gordon), 698
Properties (Mechanical), of Solids : Lattice Defects and the (International Union of Crystallography Symposium on), 1020
Properties (Optical), of Bismuth (H. D Mallon and I. G Runciman), 709
Properties (Optical), of the $\alpha\omega$-Dimethanesulphonoxyalkanes (Dr. A. C. Bishop and Dr. R. D. Marshall), 74
Properties (Rheological), of Barytes Suspensions (A. W Earnshaw and J. C. Sproson), 378
Properties (Rheological), of Dough made from Wheaten Flour : A Role for Thiol and Disulphide Groups in Determining the (R. Frater, Dr. F J. R Hird, H. J. Moss and J. R. Yates), 451
Properties (Wetting), of Insect Cuticle (J. W. L. Beament), 408
Property (Industrial), International Association for the Protection of : Twenty-fourth Congress, 440
Propulsion : Rocket (Marcel Barrère, Prof André Jaumotte, Prof. Baudouin Fraeijs de Veubeke and Jean Vandenkerckhove), *review* by J E P. Dunning, 186
Propulsion (Marine Nuclear), for the United Kingdom, 122
Protection of Industrial Property, International Association for the . Twenty-fourth Congress, 440
Protection (Crop) : Scientific Problems of (Hungarian Academy of Sciences International Conference on), 523
Protein in some Serum Filtrates : Presence of (Dr. F. J. Scandrett), 558
Protein of Tobacco Mosaic Virus Primary Structure of the (F A. Anderer, H. Uhlig, E Weber and Prof G Schramm), 922
Protein (Iodinated), in the Young Mouse : Selection of (W. A. Hemmings), 399
Protein (Native), and Inorganic Salts : Specific Interaction of (Folke Rønnike), 88
Protein (A New Copper), from *Chlorella ellipsoidea* (Dr Sakae Katoh), 533
Protein (Thread), and β-Globulin Polymorphism in the Serum Proteins of Pigs (G C Ashton), 991
Protein Administration . Changes in the Levels of Adenosine Triphosphate and Glycogen in the Liver caused by (Dr. Catherine M. Clark, Dr. G A. J. Goodlad, Dr. J. Chisholm and Dr. H. N. Munro), 719
Protein Components from Turnip Yellow Mosaic Virus (Dr. J. M. Kaper), 219
Protein Structure and Function (Brookhaven National Laboratory thirteenth Symposium in Biology), 361
Proteins (Chemical Research Committee of the Indian Council of Scientific and Industrial Research Symposium on), 767
Proteins . Diffusion of, through Lipophilic Agar Cells (Dr. Ch. Wunderly), 885
Proteins labelled with various Fluorescent Dyes : Depolarization of the Fluorescence of (C. S. Chadwick, Dr. P. Johnson and E. G. Richards), 239
Proteins in Honeybee Larval Food : Electrophoretic Components of the (N G. Patel, M H. Haydak and T A Gochnauer), 633
Proteins from Surface Tissue of the Tongue . Amino-Acid Composition of (Dr C J. Barnes and Dr L. N. Ferguson), 617
Proteins (Aggregating), in the Ultracentrifuge Concentration-Dependent Sedimentation of (Dr. G A. Gilbert), 882
Proteins (Cellular) : Ribonucleic Acids and the Synthesis of (Prof. J. Brachet), 194
Proteins (Contractile), in the X-Irradiated Embryo : Synthesis of (Dr. Yoshito Ogawa), 77
Proteins (Serum), of Pigs . Thread Protein and β-Globulin Polymorphism in the (G. C. Ashton), 991
Protists : Nonulosaminic Acid (Sialic Acid) in (Dr. S. Aaronson and T. Lessie), 719
Proton and Neutron : Comparison of the Charges of the Electron, (A M. Hillas and T. E. Cranshaw), 459
Proton (Water) Line : Broadening of the, in High-Resolution Nuclear Magnetic Resonance Spectra of Starch Gels (Dr. Roger Collison and Dr M. P. McDonald), 548
Proton Magnetic Resonance in a Series of Dimethyl Siloxane Polymers—a Specific Long-Chain Effect ? (Dr J G. Powles and A. Hartland), 26
Protoplast-like Bodies of *Escherichia coli* : T_1 and λ Phage Adsorption on (Dr P. H. Hofschneider), 568
Provan, A L. : Milk Testing, *review*, 835
Proximal Centriole in Flagellate Spermatozoa : Position of the (Prof. Vishwa Nath, Brij L. Gupta and L. C. Mittal), 899 ; (Dr. J. Bronte Gatenby and R S Mathur), 900
Przibram, Prof. K : Do Meteorites exist consisting Predominantly of Feldspar ?, 300
Psaronius (Genus) . The Morphology and Anatomy of American Species of the (Jeanne Morgan), *review* by Prof John Walton, 190
Pseudomonas solanacearum : A Method for Characterizing (A. C. Hayward), 405
Psychiatric Services and Architecture (A. Baker, R Llewelyn Davies and P Sivadon), (United Nations, World Health Organization, Public Health Papers No. 1), 936
Psychiatry : Social Science, Criminology and, *review* by Prof. E. Stengel, 41
Psychiatry (Child Psychology and), and Allied Disciplines, Journal of, Vol. 1, No. 1, 935
Psychology of Gifted Children (Dr. W. D. Wall), 692
Psychology (Industrial), National Institute of : Vernon Prize for 1960 awarded to Dr R. B Buzzard, 938
Psychology and Psychiatry (Child), and Allied Disciplines, Journal of, Vol 1, No. 1, 935
Psychotomimetic Agent (New) : Blocking Effect of Tetrahydroaminacrin on a (Dr. Samuel Gershon), 1072
Public Health Authority (United States) : Grant of 152,517 dollars to the Department of Biomolecular Structure in the University of Leeds, 767
Public Health Service (United States) : Senior Research Fellowships, 439
Public Libraries (Manchester) : One hundred and seventh Annual Report (1958-59), 437
Public Welfare Medal of the United States National Academy of Sciences awarded to Dr Alan T. Waterman, 686
Publication : Microtexts as Media for (Hertfordshire County Council Technical Information Service), 602
Publications of Works in Scientific and other Fields of Learning : The Problem of Language in (Prof. D. Keilin), 912
Publications (Scientific Periodical) : Cost of (K. W. Humphreys and H. D. Barry), 124
Puchtler, Holde, and others . Structures corresponding to Terminal Bars and Terminal Web in Many Types of Cells, 784
Puck, Prof. T. T : Elected a member of the United States National Academy of Sciences, 773
Pugh, Dr A. C P. (Livingston, Prof. Robert, and) . Role of the Triplet State in the Photoreduction of Chlorophyll, 969

Pugh, Sir William : Elected to Fellowship of the Imperial College of Science and Technology, London, 522
Pulsatile Flow through Tapered Distensible Vessels, Reflexions, and the Hosie Phenomenon (Robert L Evans), 290
Pulsed Doppler Radar Meteorological Use of (J. R. Probert-Jones), 271
Pumphrey, Prof R J : Sensory Specialization in Response to Environmental Demands, 688
Punnett, S W. Title of senior lecturer in electronics in the University of Southampton conferred on, 284
Punsar, Sven, and others : Haemorrhagic Lipaemia in the Rat, 888
Pure Culture of the Trichomycete, *Amoebidium parasiticum* (Dr. Howard C. Whistler), 732
Pure Standard Metallic Perchlorate Solutions Preparation of (E. P. Serjeant), 963
Pure Substances : Paper Chromatography—Multiple Spot Formation by (Dr A H Beckett, M A. Beaven and Dr Ann E. Robinson), 775
Puri, Dr G S Appointed director of the Central Botanical Laboratory, Allahabad, 519 , work of, 519
Purification of a Specific Inducer of the Male Sex Organ in certain Fern Species (Ross B. Pringle, Ulrich Naf and Armin C Braun), 1066
Purification (Sewage), Institute of Annual Conference, 127, 938
Purification and Properties of Cauliflower Mosaic Virus (Prof Thomas P. Pirone, Glenn S. Pound and Robert J. Shepherd), 656
Purified Mouse Encephalomyocarditis Virus Particles Crystallization of (P Faulkner, E M Martin, S. Sved and Dr T. S. Work), 908
Purine Riboside (New), isolated from *Fusarium* Species : Characterization of a (Dr Alessandro Ballio, Dr Carlo Delfini and Dr Serena Russi), 968
Purnell, Dr J H . Gas Chromatography (Modification of Solid Supports), 943
Purposes (The Social), of Education (K G Collier), *review* by Prof H. L. Elvin, 420
Pye, *Sir* David . *Obituary* by Sir Ben Lockspeiser, 433
Pye, Ltd., W. G. (Cambridge) Scientific Instrument Catalogue 'N', 852
Pyramidone : Application of, to Detection of Nitrous Acid (Dr. Wiktor Wawrzyczek), 883
Pyrene Dimer Radiative Life-time of the, and the Possible Role of Excited Dimers in Energy Transfer Processes (Dr B Stevens and E. Hutton), 1045
Pyrolytic Graphite : Tensile Behaviour of, at 2,750°C. (H E Martens and W V Kotlensky), 960
Pyrophosphatase Activity in Reticulocytes Glutathione Stability and—Direct Evidence for the Importance of Glutathione for the Enzyme Status in Intact Cells (Prof S Rapoport and D Scheuch), 967
Pyrrolizidine Alkaloids : Detection of N-Oxides of the (A. T Dann), 1051

QUADRUPOLE Moment (Molecular), of Nitric Oxide (Dr D V G L. Narasimha Rao), 881
Quagliariello, E , and others : Interrelation of Tryptophan and Nicotinic Acid in Man during the First Month of Life, 639
Qualitative Analysis of Volatile Mercaptan Mixtures A Rapid Method for (John F Carson, William J Weston and Jack W. Ralls), 801
Quantique : Mécanique (Prof. Albert Messiah), *review* by Prof. N Kemmer, 999
Quantitative Aspects of Cytochemical Reactions : A New Technique for Studying the, and its Application to the Feulgen Reaction (P. van Duijn and J -P. Persijn), 805
Quantitative Biology Cold Spring Harbor Symposia on, Vol 23, Exchange of Genetic Material—Mechanisms and Consequences, *review* by Prof Kenneth Mather, 832
Quantitative Cytochemical Observations on a Specific Nucleoprotein Reaction in Cell Nuclei (Dr. E A. Barnard), 447
Quantitative Tissue Culture : Effect of Supernatant Potassium-Level on Cardiac Activity in (Prof. A. W B Cunningham, K. Kleutch and W. Herbst), 241
Quantities of Fission Products likely to be found in Milk in the Event of Aerial Contamination of Agricultural Land : An Assessment of the (Dr R J Garner), 1063
Quantum Effects on a Macroscopic Scale, *review* by Dr J. G. Valatin, 345
Quantum Electrodynamics Principles of (Walter E Thirring), translated from the German by J Bernstein, *review* by Prof N. Kemmer, 999
Quantum Theory for the Scholar, *review* by Prof. N Kemmer, 999
Quarter Century in the Natural Sciences (Dr Warren Weaver), 20
Queen, H M. the . To open the tercentenary celebrations of the Royal Society, 206
  Birthday Honours List, 933
Queen Elizabeth the Queen Mother, H M To open the Brunswick Square building of the School of Pharmacy, University of London, 284
Queen Mary College, London : Appointment of Dr B. C. L Weedon to the University of London chair of organic chemistry 522, 762
  Appointment of Prof. M J. S. Dewar to the chair of organic chemistry in the University of Chicago, 762
Queen's College, St. Andrews : Appointment of Dr. Ann R Sanderson as senior lecturer in the Department of Zoology, 767
Queen's University, Belfast Appointment of Dr S M Nelson as lecturer in organic chemistry, 767
  Appointment of Dr. A. R. Johnston as lecturer in physics, 767
  Appointment of Dr L. T. Threadgold as lecturer in zoology, 767
  Appointment of T. J. Black and D McCloy as lecturers in mechanical engineering, 767
Querido, A., and others : A New Class of Hormonally Active Steroids, 168
4-Quinazolone Acetylation of (R. Mirza), 716

RABBIT Antiglobin Serum : Observations on Globin, Haemoglobin and Haptoglobin using a (D. S. Rowe and J F Soothill), 975
Rabbits Blood Groups in (Dr D Nelken, Debora Birnbaum and J. Gurevitch), 321
  Cirrhosis of the Liver induced in, by Gastric Instillation of 3-Monohydroxycholanic Acid (Dr. Paul Holsti), 250
  Elevation of Serum Haptoglobin in, in Response to Experimental Inflammation (R K Murray and G E Connell), 86
Rabies Virus : An Indicator Plaque-forming System for Demonstration of Interference by Non-cytocidal Strains of (Dr. Martin M. Kaplan, Dr. Eberhard Wecker, Dr Zlatko Forsek and Dr. Hilary Koprowski), 821
Rabinovitch, Dr. M , and others : Increase in 'Alkaline' Ribonuclease of Rat Kidney Cortex after Lysozyme and Egg-White Administration, 158
Race, Dr R R , and others : An Rh Antibody Specific for V and R'^{s}, 171
  M_1, a Subdivision of the Human Blood-Group Antigen M, 642
Rackham, Thomas . Astronomical Photography at the Telescope, *review* by D. H P Jones, 190
Radar (Pulsed Doppler) . Meteorological Use of (J R Probert-Jones), 271
Radar Reflector : Roughness of the Moon as a (V. A. Hughes), 873
Radar 'Ring Angels' and the Roosting Movements of Starlings (E. Eastwood, G. A. Isted and G C Rider), 112
Radden, Dr B G A Specific Stain for Mast Cell Granules, 400
Radha, Dr K. (Nair, U K., and) Recent Advances in Coconut Research in India, 861
Radiation Effects of, on Human Heredity, 125
  Technological Use of (Australian Atomic Energy Commission Conference on), 126
Radiation of a Dry Enzyme : A Connexion between S–S Bond Breakage and Inactivation by (Dilip K Ray, Dr. Franklin Hutchinson and H J Morowitz), 312
Radiation Biology (Australasian Conference on), 938
Radiation Labelling with Carbon-14 of Aliphatic Hydrocarbons (Fulvio Cacace and Angelo Guarino), 632
Radiation (Apparent Radio), at 11-m Wave-Length from Venus (Dr. J. D. Kraus), 462
Radiation (Electromagnetic) . Coherence Properties of (United States Air Force, the Optical Society of America and the University of Rochester Conference on), 127
Radiation (Electromagnetic), from Cylindrical Structures (James R. Wait), *review* by W. Brown, 583
Radiation (Infra-red), over the United States : A Synoptic Study of (Dr John L. Gergen and Dr. William F Huch), 426, *erratum*, 604
Radiation (Intrinsic Recombination), in Diamond (J C. Male and J. R. Prior), 1037
Radiation (Ionizing) : Chemical Effects of, on Deoxyribonucleic Acid in Dilute Aqueous Solution (G Hems), 710
  Effect of Oxygen on the Inactivation of Trypsin by (Prof J. A V. Butler and Dr. A B. Robins), 697
  Inability of Thiotaurine to protect Mice against (Dr. D Cavallini and L Tentori), 254
  Significance of the 'Equivalent Redox Potential' in Aqueous Solutions under (Dr G H. Cartledge), 370
  Use of, in Spot Tests for Nitrogenous Compounds (H. J. M Bowen, E Arter and P. A. Cawse), 383
Radiation (Solar Extreme Ultra-violet), as a Source of Interplanetary Ionization (Dr Hans E. Hinteregger), 523
Radiation (Ultra-violet) Polymerization of Crystalline Methacrylic Acid initiated by (Dr C. H Bamford, A D Jenkins and J. C Ward), 713
Radiation, Genes and Man (Prof Bruce Wallace and Prof. Th. Dobzhansky), *review* by Dr. A. G. Searle, 109
Radiation Chemistry : Applied, *review* by Prof F. S. Dainton, 344
Radiation Effect : Mechanism of the, on the Synthesis of Deoxyribonucleic Acid (Dr. R J. Berry, E. Hell, Dr L G. Lajtha and Dr. M. Ebert), 563
Radiation Hazards : Genetic, *review* by Dr. A G Searle, 109
Radiation Impedance (Total Acoustic), of Rigid Pistons in an Array : Measurements of the (J S M Rusby), 144
Radiation Synthesis of Urea (S. Dilli and J H. Green), 383
Radiation-induced Changes in α-Lead Azide (G Todd and E. Parry), 543
Radiation-induced Cross-linking in Hydrocarbon Polymers . Mode of (T F. Williams,) 544
Radiations (Ionizing), on Water Primary Processes in the Action of—Formation and Reactivity of Self-trapped Electrons ('Polarons'), (Prof Joseph Weiss), 751
Radiations (Nuclear) Stimulating Effects of, on Development and Productivity of Rice Plants (Dr. Maung Mya Thaung), 982
Radiative Life-time of the Pyrene Dimer and the Possible Role of Excited Dimers in Energy Transfer Processes (Dr B. Stevens and E. Hutton), 1045
Radical (Benzyloxyl Free), in Solution Disproportionation and Dimerization of the (Dr. J. B. de Sousa and S. K Ho), 776
Radical (Free-) Reactions : A Model to account for the Production of Vibrationally Hot Molecules in (Dr. J. P Simons), 561
Radicals (Diatomic), containing Boron or Silicon : Absorption Spectra of (Dr B A. Thrush), 1044
Radicals (Free), from Solids . The Tesla-coil Method for producing (Dr. C. H Bamford, A. D Jenkins and J. C. Ward), 712
Radio Astronomy An Easy Guide to, *review* by Dr J S. Hey, 59
Radio Emission (Solar), and Polar Cap Absorption of Cosmic Noise : A Relation between (Dr M. R. Kundu and Prof F. T Haddock), 610
Radio Noise (Atmospheric) : Observations of (G. R. A. Ellis), 229
Radio Radiation (Apparent), at 11-m. Wave-Length from Venus (Dr. J. D. Kraus), 462
Radio Research in Britain, 357
Radio Research Station, Slough : Appointment of Dr J. A. Saxton as deputy director, 357
Radio Signals from Artificial Satellites : Electron Density Measurements in the Upper Ionosphere using the Faraday Rotation of (Dr D. McL. A. Wilson), 623
Radio Studies of the Universe (Dr R. D. Davies and Dr. H P. Palmer), *review* by Dr J. S Hey, 59
Radio Telescope at Jodrell Bank : Cost of the, 13
Radioactive Counting : An Inexpensive Castle and Sample Holder for (Dr. Howard Boroughs), 145
Radioactive Fallout during 1959 (W. Anderson, R. E. Bentley, L. K. Burton, J. O. Crookall and C A Greatorex), 925
Radioactive 7-Iodo-6-Deoxytetracycline in Tumour Tissue (Dr Joseph J. Hlavka and Donald A. Buyske), 1064
Radioactive Isotope Technique Estimation of Mouse Tumour Blood Volumes employing a (F. S Stewart and Dr. A E G Pearson), 250
Radioactivity of the Atmosphere due to Distant Nuclear Test Explosions (D H Peirson, R N. Crooks and E. M. R Fisher), 224

Radioactivity (Fall-out), in Southern Sweden (Prof Pontus Ljunggren), 655
Radioactivity (Long-lived Natural): Use of, as an Atmospheric Tracer (W. M. Burton and N G. Stewart), 584
Radioassay by Gas Chromatography of Compounds labelled with Carbon-14 (Dr. Arthur Karmen and Harold R. Tritch), 150
Radiobiology: The Sigmoid Survival Curve in (Dr. Tikvah Alper, Dr. N. E. Gillies and Dr. M M. Elkind), 1062
Radiocaesium and Potassium-40 in Norwegian-produced Milk (K. Madshus and J. Baarli), 527
Radiocarbon Dating System using Scintillation Techniques (C. F. G. Delaney and I. R. McAulay), 204
Radiochemistry of Arsenic (Harold C Beard), 602
Radiochemistry of Cadmium (James R. DeVoe), 602
Radiochemistry of Francium (Earl J Hyde), 602
Radioiodine Uptake Measurement: Thyroid (Dr. Marshall Brucer), *review* by Dr E. E Pochin, 424
Radioisotopes: International Directory of, Vol. 1, Unprocessed and Processed Radioactive Preparations and Special Radiation Sources; Vol. 2, Compounds of Carbon-14, Hydrogen-3, Iodine-131, Phosphorus-32 and Sulphur-35 (International Atomic Energy Agency), 282
Radioisotopes in the Physical Sciences and Industry: Use of (International Atomic Energy Agency Conference on), 284
Radiologie (Medizinische) Sechzig Jahre (Prof Hans R. Schinz), *review* by Dr. R E. Steiner, 921
Radiosensitivity of Bacteriophage in the Presence of Sulphydryl Compounds: Effect of Oxygen on the (Dr. P. Howard-Flanders), 485
Radiosensitivity of Human Cells in Tissue Culture Effect of Oxygen and Nitric Oxide on the (Dr. D. L Dewey), 780
Radnor, Lord: Appointed a Knight of the Order of the Garter, 361
Radzimski, Dr. Gerald (Pressman, Dr. David, and): Iodination of Specific Sites on Bovine Serum Albumin, 1049
Rae, Dr. E. R: Physics and Mathematics, *review*, 68
Raffel, Sidney, and others (edited by) · Annual Review of Microbiology, Vol. 13, *review* by Dr. B. A. Newton, 49
Ragatz, Prof. Roland A, and others: Chemical Process Principles, Part 2, Thermodynamics, second edition, *review* by L. E. Marc de Chazal, 1003
Rain-Water: Sodium/Potassium Ratio in (Dr. A. T. Wilson), 705
Raine, H. C. · Polymeric Progress (Polyolefins), 442
Rainfall: Surface Temperature of Swedish Lakes and the Origin of (Vilhelm Irgens Pettersson), 945
Ralls, Jack W., and others · A Rapid Method for Qualitative Analysis of Volatile Mercaptan Mixtures, 801
Ramachandran, C. P. · Recent Advances in Coconut Research in India, 862
Ramanandan, P L.: Recent Advances in Coconut Research in India, 861
Ramer, J. D. Bibliography on Plasma Physics and Magnetohydrodynamics and their Applications to Controlled Thermonuclear Reactions, 522
Rana temporaria · Endocrine Control of Sexual Reproduction in *Opalina ranarum* Parasitic in (Dr M. El Mofty and Prof. J D Smyth), 559
Randall, H. M., and others · Mycosides, a New Class of Type-Specific Glycolipids of *Mycobacteria*, 887
Range (Home), in a Feral Goat Herd (Thane Riney and Graeme Caughley), 125
Rannoch Moor Nature Reserve: Additions to the, 358
Rao, C. Seshagiri: Recent Advances in Coconut Research in India, 861
Rao, K. R. Mohan · Recent Advances in Coconut Research in India, 861
Rao, T. Kailas, and Rao, T. Srirama: Recent Advances in Coconut Research in India, 860
Rao, T. Srirama (Rao, T. Kailas, and): Recent Advances in Coconut Research in India, 860
Rapid Method for Qualitative Analysis of Volatile Mercaptan Mixtures (John F. Carson, William J Weston and Jack W. Ralls), 801
Rapid Volume Changes in a Muscle during Activity Determination of Small (Prof. B. C. Abbott and R. J. Baskin), 1055
Rapoport, Prof. S., and Scheuch, D.: Glutathione Stability and Pyrophosphatase Activity in Reticulocytes—Direct Evidence for the Importance of Glutathione for the Enzyme Status in Intact Cells, 967
Rare-Earth Elements, Lanthanum to Lutetium, in Chondritic Meteorites: Abundances of the (Dr. R. S. Schmitt, A. W Mosen, C. S. Suffredini, J. E. Lasch, Dr. R. A. Sharp and D. A. Olehy), 863
Rat: Effect of Severing the Olfactory Bulbs on the Intake and Excretion of Water in the (V. Nováková and H. Dlouhá), 638
  Effect of Thyroxine and 2,4-Dinitrophenol on Levels of Ubiquinone and Ubichromenol in the (E. E. Edwin, J. Green, A. T. Diplock and J Bunyan), 725
  Exploratory Behaviour in the (Roger G. A. Stretch), 454
  Haemorrhagic Lipaemia in the (Sven Punsar, Gottfried Hartel, Antti Louhija and Olli P. Heinonen), 888
  Induction of a Chorion-epitheliomatous Tumour in the (R. Stein-Werblowsky), 980
  Œstrogen–Insulin Interaction on the Uterus of the (Dr. R. Michel Zilberstein), 635
  Ubiquinones and Ubichromenols in the (A. T. Diplock, E. E. Edwin, J. Green, J. Bunyan and S. Marcinkiewicz), 554
  Whole-Body Turnover of Selenium in the (Clifton Blincoe), 398
Rat (Adult): Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the (S. L. Liu), 475
Rat (Adult), inoculated after Birth with Rous Sarcoma Tissue: Presence of Chicken Tumour Virus in the Sarcoma of the (Dr. Jan Svoboda), 980
Rat Atria: Intracellular Potentials in, during and after Vagal Stimulation or Acetylcholine Administration (P. A. Biersteker, J. Th. F. Boeles and L. N Bouman), 637
Rat Diaphragm: Release of Acetylcholine in (K. Krnjević and J F. Mitchell), 241
Rat Diaphragm (Isolated): Accumulation of Substrate by—a Possible Mechanism for the Anti-Inflammatory Action of Corticosteroids (Prof. Ira G. Wool), 728
Rat Embryos (Triploid), and other Chromosomal Deviants after Colchicine Treatment and Polyspermy (L. Piko and O. Bomsel-Helmreich), 737
Rat Kidney: Development of 5-Hydroxytryptophan Decarboxylase Activity in (Dr. Irene Huang, Sheila Tannenbaum and Dr. David Yi-Yung Hsia), 717
Rat Kidney Cortex · Increase in 'Alkaline' Ribonuclease of, after Lysozyme and Egg-White Administration (Dr. T. Maack, Dr. R Brentani and Dr. M. Rabinovitch), 158
Rat Liver: Binding of a Hepatocarcinogen to the Structural Lipoprotein of—Its Bearing on the Immunological Theory of Cancer (J. W. Westrop and Prof. H. N. Green), 350
  Level of Sulphydryl Compounds in, following Feeding with Goitrogenous and Non-goitrogenous Cabbage (Jozef Sedlák), 892
Rat Liver in Experimental Cirrhosis: Histochemical and Biochemical Studies of, after Partial Hepatectomy (I. Bartók, Gy. Domján, E. Horváth and Prof. B. Korpássy), 397
Rat Liver Mitochondria: Effect of Pituitary Growth Hormone *in vivo* on the Phosphorus/Oxygen Ratios of Isolated (C. N. Graymore, A H Melhuish and A. L. Greenbaum), 392
  Effects of Fatty Acids on the ^{32}P-Adenosine Triphosphate Exchange Reaction in (K Ahmed and Dr. P. G Scholefield), 1046
Rat Muscle *in vitro* · Effect of Denervation on Potassium-42 Uptake by the (Dr. Z. Drahota and O Hudlická), 396
Rat Pineal Parenchymal Cells. Effects of Injection of Bovine Pineal Extract on the Nuclei of (Dr. Uno Holmgren, Dr. Mark D. Altschule and Dr Richard J. Wurtman), 393
Rat's Brain. Effect of Methylpentynol on Acetylcholine in the (Giancarlo Pepeu and Prof Nicholas J. Giarman), 638
Rate of Increase in Environmental Temperature · Oxygen Consumption in Cattle in relation to (Prof. H. H Kibler), 972
Rate of Ligand Exchange with its Metal Complex by a Polarimetric Method (B Bosnich, Dr. F. P. Dwyer and Dr A. M Sargeson), 966
Rates (Clearance), of Sodium-24, Potassium-42 and Iodine-131 in Normal Dog Hip Joints (Prof. Patrick G. Laing and Dr. Ik Dong Kim), 898
Ratio (Sex-): Evolutionary Origin of Sexual Differentiation and the (Dr. H Kalmus and Dr. C. A B Smith), 1004
Ratio (Sex), of Ammocoetes (M. W. Hardisty), 988
Ratio (Sex) at Birth Dependence of the, on the Age of the Father (Dr. Leo Szilard), 649; (Dr. A. Comfort), 1065
Ratio (Sex), in *Drosophila*: Homeostasis of the (Dr. P A Parsons), 411
Ratio (Sodium/Potassium), in Rain-Water (Dr. A. T. Wilson), 705
Ratios (Saliva–Serum), of Tritium after the Administration of Tritiated Water (Dr. A J. Coppen and Dr. J L. Gibbons), 724
Rats · Effect of Manganese Edetate on Blood Formation in (T J. Sullivan), 87
  Effect of Vitamin A on the Cystine Content in Skin of (Prof. Tatsuo Koyanagi and Satoru Odagiri), 809
Rats receiving an Acute Whole-Body Dose of X-Rays: Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in (Prof J. Maisin, P Dumont and A. Dunjic), 487
Rats during Irradiation: Significance of Adrenals for Increased Oxygen Consumption in (Dr. A. Vacek), 90
Rats exposed to X-Rays: Inability of Methionine to affect Lethality in Mice and (Prof. Zenon M Bacq and Dr. Marie L Beaumariage), 1064
Rats (Lathyritic): Aortic, Serum, Connective Tissue and Osseous Chemistry in (Dr. R. A Grant, M. Hathorn and Prof. Theodore Gillman), 164
Rats and Chicks · Vitamin A Isomers in the Liver of (O R. Braekkan, H Myklestad, L. R. Njaa and F Utne), 312
Rawlins, F. I. G.. Godel's Theorem, *review*, 61
  The Study of Man, *review*, 347
  Scientific Methods in the Care of Works of Art, 437
  The Reach of Science, *review*, 1003
Rawther, T S. S: Recent Advances in Coconut Research in India, 861
Ray, Dilik K, and others: A Connexion between S–S Bond Breakage and Inactivation by Radiation of a Dry Enzyme, 312
Ray, Prof. Ramesh Chandra. *Obituary*, 679
γ-Ray Resonance (Ultra-High Resolution), in Zinc-67 (D. E. Nagle, P. P. Craig and W. E Keller), 707
Rayon Research Association, British: Open Days, 284
Rays (Ionizing): Combined Application of Hydrogen Peroxide and, in Animal Experiments (E. Fleischmann, H. Werkgartner and K. Karrer), 324
Reach of Science (Prof. Henryk Mehlberg), *review* by F. I G. Rawlins, 1003
Reaction of Active Nitrogen with Polyethylene (Dr. J. L Weininger), 546
Reaction between Copper and Solid Oxygen condensed at Very Low Temperatures from a Gas Discharge (Jerome Kruger and William J. Ambs), 794
Reaction of *p-n*-Decyloxybenzenediazonium Fluoborate with Sodium Iodide in Benzene (Prof W. Bradley and J. D Thompson), 631
Reaction of Transition Metal Ions with Ethylenediamine · Heats and Entropies of (M. Ciampolini, P. Paoletti and Prof. L. Sacconi), 880
Reaction (Antiglobulin): Role of C'_4 in the (G. C. Jenkins, Margaret J. Polley and Dr. P. L Mollison), 482
Reaction (Autoxidation): A New Type of—Cause of the Instability of Cytochrome c Reductase (Dr. Malcolm Dixon, J. M. Maynard and P. F. W. Morrow), 1032; Flavin Dissociation and Inactivation of Cytochrome b_5 by Oxygen (J. McD. Armstrong, Dr. J H. Coates and Prof. R. K. Morton), 1033
Reaction (Feulgen). A New Technique for Studying the Quantitative Aspects of Cytochemical Reactions and its Application to the (P. van Duijn and J.-P. Persijn), 805
Reaction (Graft versus Host), in Parabiotic Disease (Dr. B. Nakič, Z. Nakič and V. Silobrčič), 322
Reaction (Malonaldehyde–Thiobarbituric Acid): Estimation of 3-Deoxy Sugars by means of the (Dr. Morris A. Cynkin and Dr. Gilbert Ashwell), 155
Reaction (^{32}P-Adenosine Triphosphate Exchange), in Rat Liver Mitochondria: Effects of Fatty Acids on the (K. Ahmed and Dr. P. G. Scholefield), 1046
Reaction (Specific Nucleoprotein), in Cell Nuclei: Quantitative Cytochemical Observations on a (Dr. E. A. Barnard), 447
Reactions: Structure of Graphite and the Kinetics of its (Société de Chimie Physique Conference on), 284
Reactions (Bacterially Mediated False-Positive), in Lytic Blood-Typing Tests (Prof Clyde Stormont, Yoshiko Suzuki and W. J Miller), 247
Reactions (Controlled Thermonuclear): Bibliography on Plasma Physics and Magnetohydrodynamics and their Applications to (J. D. Ramer), 522
Reactions (Cytochemical): A New Technique for Studying the Quantitative Aspects of, and its Application to the Feulgen Reaction (P. van Duijn and J.-P. Persijn), 805

Reactions (Electron Transfer), involving *s*-Trinitrobenzene (Dr. R. E. Miller and Prof W. F. K. Wynne-Jones), 149
Reactions (Free-Radical) : A Model to account for the Production of Vibrationally Hot Molecules in (Dr. J. P. Simons), 551
Reactions (Microbiological) Steric Course of (edited by G E. W. Wolstenholme and Cecilia M. O'Connor), *review* by Prof D. C. Harrison, 835
Reactions (Non-Enzymic), of Indoles with Coenzyme I (Prof. S. G A. Alivisatos, G A Mourkides and A Jibril), 718
Reactions (Peroxide) : Mechanisms of (Office of Ordnance Research of the United States Army and Brown University Conference on), 127
Reactivation of Poxviruses by a Non-Genetic Mechanism (Dr. W K Joklik, Pamela Abel and I H. Holmes), 992
'Reactive Inhibition' (Construct), in the Interpretation of Age Changes in Performance (Dr. S. Griew and Dr. R. Lynn), 182
Reactivity of Self-trapped Electrons ('Polarons') . Primary Processes in the Action of Ionizing Radiations on Water—Formation and (Prof. Joseph Weiss), 751
Reactor Fuel Element Technology (Imperial College of Science and Technology Course of Lectures in), 1025
Reactor Physics : Nuclear (Prof. Raymond L Murray), *review* by J Fell, 68
Reactor Shielding : Fundamental Aspects of (Dr. Herbert Goldstein), *review* by Dr. T E Allibone, 917
Reactors (Nuclear Energy and Power) . Fundamentals of (Henry Jacobowitz), *review* by Dr T. E Allibone, 917
Read, Prof. H H : Awarded the Steinmann Medal of the Deutsche Geologische Vereinigung, 206, 690
Read, Prof John : Organic Syntheses, *review*, 669
Reading, H W., and others Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methylisothiazole), a New Antibacterial Sulphonamide, 221
Reagent (Thiobarbituric Acid Spray), for Deoxy Sugars and Sialic Acids (Dr Leonard Warren), 237
Reagents (Alkylating) : Non-Protein Sulphydryl Group in the Original Strain and Sub-line of the Ascites Tumour resistant to (Iwao Hirono), 1059
Reaktionen (Chemische), Ionisierender Strahlen (Radiation Chemistry), (herausgegeben von Prof. Hermann Mohler), *review* by Prof F. S. Dainton, 344
Recently Produced Fission Products in the Atmosphere : Detection of (Dr. W. Anderson, Dr. R. E Bentley, L. K Burton and Dr. C. A. Greatorex), 223
Receptors (Muscle), in the Kitten : Activity of (Dr. Sten Skoglund), 478
Recombination Genetic, *review* by Prof Kenneth Mather, 832
Recombination Radiation (Intrinsic), in Diamond (J C. Male and J. R. Prior), 1037
Reconnaissance (Geological), of the Sor-Rondane Mountains (Queen Maud Land), (Prof E. E. Picciotto), 740
Reconstruction of the Foot of the 'Abominable Snowman' (W. Tschernezky), 496
Record Low Sea-Level Air Pressure : New (C L. Jordan), 283
Recording Extracellular Unit Action Potentials from the Central Nervous System : 'Weightless' Micro-electrodes for (Prof. B. Delisle Burns and Dr. J. G. Robson), 246
Recording Material for X-Ray Microscopy . Silver-activated Nitrocellulose as (Saara K. Asunmaa), 1036
Recourt, J. H. (Beerthuis, R. K., and) : Sterol Analysis by Gas Chromatography, 372
Recovery of Adult *Amoeba lescherae* from Dried Cultures (Monica Taylor), 329
Recovery of Ultra-violet-Irradiated *Escherichia coli B* Effects of Chloramphenicol on the (H. Okagaki and Prof. A. Sibatani), 818
Recovery Factors in Rats receiving an Acute Whole-Body Dose of X-Rays : Yeast Ribonucleic Acid and its Nucleotides as (Prof. J. Maisin, P. Dumont and A. Dunjic), 487
Recruitment of Teachers in Britain, 600
Red, Roe and Fallow, *review* by R. S. R. Fitter, 45
Red Blood Cells of East Africans : Glucose-6-Phosphate Dehydrogenase Deficiency in (Dr. A C. Allison), 531
Red Sea : Sediment Cores from the Mediterranean Sea and the (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 8, No. 1), 609
Red Spider Mite, *Tetranychus telarius* (L.) (Acarina:Tetranychidae) : Effect of Relative Humidity on Hatching and on Toxicity of Ovicides to Eggs of the (R. A. Harrison and A. G Smith), 409
Red Water Bloom of Rotifers in Cook Strait, New Zealand (Vivienne Cassie), 328
Reder, Friedrich H , and Winkler, Gernot M. R. : Preliminary Flight Tests of an Atomic Clock in Preparation of Long-range Synchronization Experiments, 592
Redistribution (Inter-bivalent), of Chiasmata in *Delphinium* : Experimentally Induced (H K. Jain and A. K. Bose), 260
Redman, Prof. R. O. : *Obituary* of Dr. Andrew McKellar, 1014
Redmond, Dr. J. P., and Walker, jun., Dr. P. L : Gas Content of Graphites, 72
Redox Potential' ('Equivalent) : Significance of the, in Aqueous Solutions under Ionizing Radiation (Dr. G. H. Cartledge), 370
Redpoll in New Zealand—Interbreeding Sub-species (David Stenhouse), 488
Reduced Temperatures for Nucleation in Supercooled Liquids (Dr. E. R. Buckle), 875
Reductase (Cytochrome *c*) : Cause of the Instability of (A New Type of Autoxidation Reaction), (Dr. Malcolm Dixon, J. M. Maynard and P. F. W. Morrow), 1032
Reduction of Metal Ions by Hydrogen Atoms : Mechanism of the Oxidation and (Prof. J. Halpern, G. Czapski, J. Jortner and Dr. G. Stein), 629
Reerink, Dr. E. H., and others : A New Class of Hormonally Active Steroids, 168
Rees, Dr. K. R. (Dawkins, M. J. R., and) : A Biochemical Approach to Pathology, *review* by Dr. R. W. R Baker, 921
Rees, Dr. Linford : Treatment of Depression by Drugs and other Means, 114
Re-Evaluation of the Clotting Time of Chicken Blood (Dr. C. H. Bigland and Dr. D. C. Triantophyllopoulos), 644
Reeve, P. (Hurst, Dr. E. Weston, and) : Transmission of the Viruses of Trachoma, Inclusion Blennorrhoea and Lymphogranuloma to Mice, 336
Reeves, Dr. C. M : Appointed lecturer in electronic computing at the University of Leeds, 767
Reference Books on Mineralogy in the U S.S.R. (Academy of Sciences of the U S.S R), 203
Reference Library (National), of Science and Invention, 934
Refinery Production (Consumption and), 1958 and 1959 : United Kingdom Petroleum Industry Statistics relating to (Petroleum Information Bureau), 851
Reflectance of Coal Vitrains in the Visible and Ultra-Violet compared with that of Graphite (L. A. Gilbert), 143
Reflector (Radar) . Roughness of the Moon as a (V A Hughes), 873
Reflex (Giant-Fibre), of the Earthworm (Dr. M. B. V. Roberts), 167
Reflexions, and the Hosie Phenomenon : Pulsatile Flow through Tapered Distensible Vessels, (Robert L. Evans), 290
Regelson, Dr. William, and others : Synthetic Polyelectrolytes as Tumour Inhibitors, 778
Regenerating Muscles (Injured and) : Treatment of, with Plant Extracts (S. Hoja and J. Vittek), 283
Regeneration of Visual Pigments from their Low-Temperature Photoproducts (Dr. C. D. B Bridges), 292
Region (The Mesopause), of the Ionosphere (Dr. J. D Whitehead), 461
Regional Council for Further Education (Southern) : Twelfth Annual Report, 123
Registrar General : Statistical Review, Part 2, Tables, Population, 765
Regular Micropulsations of the Earth's Field at the Equator (Rosemary Hutton), 955
Regular Mixed-Layer Chlorite–Vermiculite Mineral (Dr. M Nakahira and S. Sugiura), 877
Regularities in the Retina and Optic Lobes of *Octopus* in relation to Form Discrimination (The Visual System of *Octopus*), (Prof. J. Z. Young), 836
Regulation (Self-) for Children, *review* by Prof. M. D Vernon, 38, 912 ; (Paul Ritter), 911
Regulator : The Brain as (Dr. W. Ross Ashby), 413
Reichenbach, Hans : Modern Philosophy of Science (translated and edited by Maria Reichenbach), *review* by Prof Herbert Dingle, 503
Reid, K. J : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Reisenauer, Prof H. M : Cobalt in Nitrogen Fixation by a Legume, 375
Reiser, Prof Oliver L. : The Integration of Human Knowledge, *review* by Dr. John Tucker, 37
Relation between Solar Radio Emission and Polar Cap Absorption of Cosmic Noise (Dr. M. R. Kundu and Prof F. T. Haddock), 610
Relation (Possible), to the Circulation of Amniotic Fluid : Ultra-Structure of Human Amnion and its (Dr. Gordon L. Bourne and Dr. Dennis Lacy), 952
Relations (Thermodynamical), in Two-Component Two-Phase Systems (Prof. H. Kaufman), 299
Relationships : Solar Terrestrial (K. D. Cole), 874
Relationships to Human Anatomy : The Teaching of Veterinary Anatomy as a Branch of Biology—its (Dr. R. A. Green), 192
Relative Humidity : Effect of, on Hatching and on Toxicity of Ovicides to Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina : Tetranychidae), (R. A. Harrison and A G. Smith), 409
Relativity : Analysis of Accelerated Motion in the Theory of (Robert T. Jones), 790
Relativity (General) : Gravitational Waves in (Dr. H. Bondi), 535
Release of Acetylcholine in Rat Diaphragm (K. Krnjević and J. F. Mitchell), 241
Release of Methionine labelled with Sulphur-35 from Muscle Tissue and Mitochondria (Dr. R Zák and Dr Z. Drahota), 973
Release (Anaphylactic), of Histamine from Chopped Guinea Pig Lung : Inhibition of the, by Chymotrypsin Substrates and Inhibitors (Dr. K. F. Austen and Dr. W. E. Brocklehurst), 866
Release (Virus), from Single Cells of Mouse Parotid Tumours (Dr. Mathilde Krim and Dr Leo Sachs), 262
Remanent Magnetization (Natural), of some Welsh Slates : Anisotropy of Susceptibility and the (M D. Fuller), 791
Removal of Strontium from Milk (Dr. Leon Singer and Dr. W. D. Armstrong), 484
Renal Carcinomas : Ultrastructure of the Clear Cells in, and its Importance for the Demonstration of their Renal Origin (Prof. Ch. Oberling, M. Rivière and Fr. Haguenau), 402
Renal Origin : Ultrastructure of the Clear Cells in Renal Carcinomas and its Importance for the Demonstration of their (Prof. Ch. Oberling, M. Rivière and Fr. Haguenau), 402
Rendel, D. G. A : Promoted to Deputy Chief Scientific Officer and appointed head of the Mechanical Engineering Department of the Royal Aircraft Establishment, 12 ; work of, 12
Rendel, Jan, and others : Inheritance of β-Globulins in Serum and Milk from Cattle, 907
Rendel, Dr. J. M. : Elected a Fellow of the Australian Academy of Science, 519
Rensselaer Polytechnic Institute, Troy, N.Y. : Report on Gifts, Grants and Bequests (1958-59), 766
Repercussions (Human) : Automation and its, 364
Replica Method : Size Distribution of Tobacco Smoke Droplets by a (W. J. Harris), 537
Reproduction of Catalogue Cards (Philip S. Pargeter), 1020
Reproduction (Animal) : Ford Research Fellowships in (Zoological Society of London), 519
Reproduction (Sexual), in *Opalina ranarum* Parasitic in *Rana temporaria* : Endocrine Control of (Dr. M. El Mofty and Prof. J. D. Smyth), 559
Reptiles : Poisonous Amphibians and (Prof. Floyd Boys and Prof. Hobart M. Smith), *review* by A. G. C. Grandison, 269
Requirements for Stereospecificity in Hydrolysis by Chymotrypsin—Diethyl β-Acetamidoglutarate (Prof. Saul G. Cohen and Ezra Khedouri), 75
Research at the Imperial College of Science and Technology, London, 123
Research in British Universities, 1959 : The Use of Film in Teaching and (British Universities Film Council), 444
Research at the Ministry of Aviation, 518
Research : Waverley Gold Medal Essay Competition, 937

Research : Ageing and, 852
  Boundary Layer (NATO Advisory Group for Aeronautical Research and Development Discussion on), 1022
  Colonial, 1958-59—Reports of the Colonial Research Council, Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Economic Research Committee, Colonial Fisheries Advisory Committee, Colonial Medical Research Committee, Colonial Pesticides Research Committee, Colonial Products Council, Colonial Road Research Committee, Colonial Social Sciences Research Council, Tsetse Fly and Trypanosomiasis Committee, Director of the Anti-Locust Research Centre, and Research Matters not covered by the above Reports of the Specialist Advisory Bodies (Colonial Office), 501
  Ionospheric (NATO Meeting on), 685
  Natural Rubber (Rubber Research Institute of Malaya, the Government of the Federation of Malaya and the Rubber Producers' Council International Conference on), 767
Research into Griseofulvin (Dr. P W. Brian), 853
Research on Leukaemia and Allied Diseases (Tata Memorial Trust Awards), 1020
Research in Marine Biology or Oceanography · Grants for (Challenger Society), 854
Research in Nuclear Science, National Institute for . Grant of £10,450 to the University of Oxford for an investigation of the alignment of nuclei for the proton linear accelerator, to be carried out in the Clarendon Laboratory, 126
Research in Optical Design at the Imperial College, London, 934
Research in Veterinary Science, Vol I, No I (British Veterinary Association), 16
Research and Development in Colleges and Universities in the Fiscal Year 1958 (United States National Science Foundation Report on), 1016
Research and Development (Academic) . United States Expenditure on, 1016
Research and Development (Aeronautical), Advisory Group for (NATO) : AGARDograph No 31, Explosions, Detonations, Flammability and Ignition, Part I (Prof S S Penner) ; Part 2 (B. P Mullins), *review* by Dr H. F. Coward, 666
  Meeting on Ionospheric Research, 685
  Discussion on Boundary Layer Research, 1022
Research and Development Expenditure · Industrial, 1958 (Department of Scientific and Industrial Research), 997
Research (Biochemical) · Data for (edited by R. M. C Dawson, Daphne C. Elliott, W H. Elliott and K. M. Jones), *review* by Dr K S Dodgson, 50
Research (Biochemical and Biophysical), Communications, Vol I, No. I, 124
Research (Cancer), in the U S S R., *review* by Dr. P. A. Gorer, 420
Research (Coconut), in India Recent Advances in (Indian Central Coconut Committee Conference on), 860
Research (Communication), at Keele, 599
Research (Co-operative), in Europe, 520
Research (Dental), in Britain, 600
Research (Economic and Social), National Institute of · Economic and Social Studies, Vol 18, British Industrialists—Steel and Hosiery, 1850-1950 (Charlotte Erickson), *review* by R. Brightman, 347
Research (Fisheries), in Australia, 280
Research (Fishery) : Postgraduate Training Grants in (Development Commissioners, the Ministry of Agriculture, Fisheries and Food, and the Scottish Home Department), 360
Research (Food) Advisory Committee, 519
Research (Fundamental and Applied) : The Balance of, 341
Research (Genetical), No. 1, 16
Research (Industrial), in the United States, 763
Research (Low-Temperature) : Fritz London Award for, 205
Research (Medical), in Malaya, 944
Research (Medical) . Fellowships for (Beit Memorial Trust Elections), 520
  Grants for (Wellcome Trust), 439
  Significant Trends in (Ciba Foundation Symposium on), (edited by G. E. W. Wolstenholme, Cecilia O'Connor and Maeve O'Connor), *review* by Prof L. J. Witts, 42
Research (Medical), Institute for (Federation of Malaya · Annual Report for 1958, 944
Research (Nuclear), European Organization for : Appointment of J. B. Adams as interim director-general, 523
Research (Radio), in Britain, 357
Research (Scientific), in Antarctica, 212
Research (Scientific), in the Overseas Territories of the British Commonwealth, 501
Research (Scientific), at South African Universities, 1959 : Register of Current (edited by D. Ryle Masson), (South African Council for Scientific and Industrial Research), 854
Research (Scientific), and Development : A Bibliography on the Economic and Social Implications of (United States National Science Foundation), 14
  Projects in Colleges and Universities on the Economic and other Impacts of (United States National Science Foundation), 14
Research (Scientific), and Technical Services in the Federation of Rhodesia and Nyasaland · Government Organizations and Statutory Bodies concerned with, 202
Research (Scientific and Industrial) : The Balance of, 997
Research (Scientific and Technical) . Co-operation in the Field of (Organization for European Economic Co-operation), 998
Research (Thermonuclear) · An Introduction to (Albert Simon), *review* by Dr. T. E. Allibone, 917
Research Association of British Flour Millers—New Laboratories (Dr. T. Moran), 856
Research Committees : Colonial, 280
Research Conferences 1960 : Gordon, 283
Research Corporation of the United States, 126
Research Council (Colonial) : Report for 1958-59, 501
Research Defence Society · Pamphlet on Vivisection, 125
  Pamphlet No 10, The Use of Laboratory Animals in the Standardization of Drugs, 438
Research Development Corporation of India (National) : Fifth Annual Report (1958-59), 202
Research Fellowship (Royal Geographical Society), 684
Research Fellowships : Carlsberg–Wellcome Travelling (Wellcome Trust), 283
  Lederle Medical Student (American Cyanamid Company), 283
  Senior (United States Public Health Service), 439
Research Fellowships in Animal Reproduction : Ford (Zoological Society of London), 519
Research Management The Human Element in (Dr. B. E. Noltingk), *review* by E. S. Hiscocks, 579
Research Medal of the Royal Agricultural Society of England awarded to Prof R L Wain, 685
Research Personnel Management of, *review* by E S Hiscocks, 579
Research Programmes in Ageing (United States Department of Health), 852
Resemblance (Slight Structural), to Natural Bradykinin Bradykinin Activity of some Synthetic Peptides with only (Dr. G L Tritsch and Prof D. W Woolley), 76
Residential Short Courses (National Institute of Adult Education), 685
Resin (Sulphonated Polystyrene) Behaviour of some Aldehydes on a (Dr. S. A Barker, K. Murray and Prof M Stacey), 469
Resin Method (An Ion-Exchange), for the Fractionation of Alcoholic Plant Extracts (Dr Dalton Wang), 326
Resins (Ion Exchange) : Trace Analysis by X-Ray Fluorescence using (J N. van Niekerk and J F de Wet), 380
Resistance of the Adult Housefly (*Musca domestica*) to 'Cyclodiene' Insecticides : Mechanisms of (Dr G T Brooks), 96
Resistance to Dieldrin Genetics of, in *Lucilia cuprina* Wied. (G J. Shanahan), 181
Resistance to Disease (Crop Plant) Nature and Exploitation of (Association of Applied Biologists and the British Mycological Society Symposium on), 857
Resistance of Gonococcus Strains to Penicillin (Alice Reyn and M. W. Bentzon), 608
Resistance in Mice to Tumour Induction by *S E* Polyoma Virus : Development of (Sarah E. Stewart, Bernice E. Eddy, Marjean Irwin and Stephanie Lee), 615
Resistance (Enhanced), of Mice to Infection with *Pasteurella pestis* following Vaccination with Fractions of Phenol-killed Tubercle Bacilli (Prof. David W Weiss), 1060
Resistance (High-Order), to 'Dieldrin' in *Lucilia cuprina* Wied. : Selection for (G J Shanahan), 100
Resistant to Root-Knot Nematodes (*Meloidogyne* spp,) : Plants Recorded as (Mary T Franklin and D J Hooper), 684
Resolution of Human Haemoglobin Variants : A New Electrophoretic Medium and its Application to the (Dr. E R. Huehns and Dr. A. O. Jakubovic), 729
Resolution (Ultra-High) γ-Ray Resonance in Zinc-67 (D. E. Nagle, P. P. Craig and W. E. Keller), 707
Resonance · Nuclear Magnetic—Applications to Organic Chemistry (Prof. J D Roberts), *review* by Prof E R. Andrew, 55
Resonance (Electron Spin) : Study of the Oxidation of Hindered Phenols by (Dr J E. Bennett), 385
Resonance (Electron Spin), in Hydrogen Peroxide–Water Solutions at 90°K. Irradiated with Ultra-Violet Light (Robert C. Smith and S J. Wyatt), 226
Resonance (Nuclear Magnetic) Optical Detection of (J. Brossel), 440
Resonance (Proton Magnetic), in a Series of Dimethyl Siloxane Polymers—a Specific Long-Chain Effect ? (Dr J. G. Powles and A. Hartland), 26
Resonance (Ultra-High Resolution γ-Ray), in Zinc-67 (D. E. Nagle, P P. Craig and W. E. Keller), 707
Resonance Spectra (High-Resolution Nuclear Magnetic), of Starch Gels : Broadening of the Water Proton Line in (Dr. Roger Collison and Dr M P. McDonald), 548
Resources : Water, *review* by E. Miller, 423
Respiration and Growth of L-Strain Fibroblasts : Some Effects of Different Tensions of Oxygen on the (A. R Fisher), 315
Respiratory Dead Space of the Giraffe (Prof. Eugene D. Robin, Dr. Joseph M. Corson and Prof Gustave J. Dammin), 24
Response . The Brain in, *review* by Prof M. D. Vernon, 919
Response to Environmental Demands : Sensory Specialization in (Zoological Society of London Symposium on), 688
Response to Experimental Inflammation . Elevation of Serum Haptoglobin in Rabbits in (R. K. Murray and G. E. Connell), 86
Response of Larvae of *Calyptraea chinensis* (L) to Light (H. V. Wyatt), 328
Response (The Photoperiodic), of some Nigerian Plants (E. Njoku), 438
Responsiveness of the Neurosecretory System of Larval Lampreys (*Petromyzon marinus*) to Light (Dr Nezihe Oztan and Dr. Aubrey Gorbman), 167
Results of the Royal Society's International Geophysical Year Expedition (Royal Society Discussion on), 191
Retarded Development of *Ostertagia* Species in Sheep (J. D. Dunsmore), 986
Reticulo-Endothelial System : Duration of Stimulation of Phagocytic Activity of the, after Cessation of Treatment with Diethylstilboestrol (C C Ware and Prof. T. Nicol), 974
Reticulocytes · Glutathione Stability and Pyrophosphatase Activity in—Direct Evidence for the Importance of Glutathione for the Enzyme Status in Intact Cells (Prof. S. Rapoport and D Scheuch), 967
Retina and Optic Lobes of *Octopus* in relation to Form Discrimination : Regularities in the (The Visual System of *Octopus*), (Prof. J. Z. Young), 836
Reversible Nitrate Electrode (P H. T Beckett), 879
Reversible Transformation of Gelatin to the Collagen Structure (Dr. Arthur Veis and Dr. Jerome Cohen), 720
Reversion of *c*-Mutations . Induction and, by Irradiation of the Extracellular χ-Phage of *Serratia* (Prof. R. W. Kaplan, U. Winkler and H. Wolf-Ellmauer), 330
Reversions induced by Base Analogues in *Salmonella typhimurium* (Rivka Rudner and Elias Balbinder), 180
Revolution : The Neolithic (Sonia Cole), 360
Revolution (October) Soviet Reviews of Nuclear Science on the 40th Anniversary of the, *review* by Dr. T. E. Allibone, 917
Reyers, I. H M , and others : Swelling of Fresh and Aged Liver Mitochondria as affected by Succinate, Adenine Nucleotides and Thyroxine, 556
Reyment, R. A. · A Note on the Foraminifera in a Sediment Core from the Mindanao Trough (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No. 6), 609
Reyn, Alice, and Bentzon, M. W. : Resistance of Gonococcus Strains to Penicillin, 608
Rh Antibody Specific for V and R's (Dr. Ruth Sanger, Jean Noades, Patricia Tippett, Dr R R Race J. A. Jack and Dr C A. Cunningham), 171

Rhenium : Some New Complexes of (R Colton, R. Levitus and Prof. G. Wilkinson), 233
Rheological Properties of Barytes Suspensions (A W. Earnshaw and J. C. Sproson), 378
Rheological Properties of Dough made from Wheaten Flour : A Role for Thiol and Disulphide Groups in Determining the (R. Frater, Dr. F. J. R Hird, H. J. Moss and J R. Yates), 451
Rheology in Australia (Dr P. U. A. Grossman), 941
Rhesus Monkey Development of Learning in the (Harry F. Harlow and colleagues), 211
  Diurnal Temperature Variation in the, under Normal and Experimental Conditions (Dr. Lloyd B. Erikson), 83
Rhodesia and Nyasaland (Federation of) : Government Organizations and Statutory Bodies concerned with Scientific Research and Technical Services in the, 202
Rhythm (Biological), Society for, and the International Basimetric Society : Seventh International Conference, 604
Riboflavin Antimetabolite ? : Ackee Toxin, a (H. C. Fox and D. S Miller), 561
Ribonuclease ('Alkaline'), of Rat Kidney Cortex Increase in, after Lysozyme and Egg-White Administration (Dr T. Maack, Dr R Brentani and Dr M. Rabinovitch), 158
Ribonucleic Acid of *Anacystis nidulans* : A Methyl Cytidine from the (Dr. B. B Biswas and J. Myers), 238
Ribonucleic Acid (Tumour) Heterogeneity of, and the Effect of 'Degranol' on it (F. Antoni, E J. Hidvégi and K Lapis), 81
Ribonucleic Acid (Yeast), and its Nucleotides as Recovery Factors in Rats receiving an Acute Whole-Body Dose of X-Rays (Prof. J. Maisin, P. Dumont and A Dunjic), 487
Ribonucleic Acids in Animal Cells Fractionation of Two Metabolically Distinct Classes of, and its Bearings on Cancer (Prof. A. Sibatani, K. Yamana, K. Kimura and T. Takahashi), 215
Ribonucleic Acids and the Synthesis of Cellular Proteins (Prof. J. Brachet), 194
Riboside (Purine), isolated from *Fusarium* Species . Characterization of a New (Dr Alessandro Ballio, Dr. Carlo Delfini and Dr Serena Russi), 968
Rice (D H. Girst), third edition, *review* by Dr H. Greene, 507
Rice Plants . Stimulating Effects of Nuclear Radiations on Development and Productivity of (Dr Maung Mya Thaung), 982
Rice Production · Paddy Soils and (Dr. H Greene), 511
Richards, Dr. A. N. : *Obituary* of Dr. Abraham Flexner, 278
Richards, E. G., and others Depolarization of the Fluorescence of Proteins labelled with various Fluorescent Dyes, 239
Richardson, Prof. E G. *Obituary* by Prof. W. E. Curtis, 678
Richerche Nucleari, Comitato Nazionale per le . Fifth Nuclear Congress, 127
Richter, Dr. D. : How Many More New Journals ?, 18
Rider, G. C., and others Radar 'Ring Angels' and the Roosting Movements of Starlings, 112
Riedel, Dr Oswald · Self-Quenching Geiger Counters containing Mixtures of Permanent Gases, 876
Riegel, Dr. J. A. . Blood Glucose in Crayfishes in relation to Moult and Handling, 727
Riek, R. F., and Keith, R. K. · Effect of X-Rays on the Development of the Infective Larvae of *Oesophagostomum radiatum* (Rud. 1803) (Strongylidae : Nematoda), 981
Ries, jun., Herman E , and others . Polyvinyl Benzoate Monolayers, 883
Rigby, B. J . Visco-Elastic Systems (Theories of Rate Processes), 942
Rigid Pistons in an Array : Measurements of the Total Acoustic Radiation Impedance of (J. S M. Rusby), 144
Riley, G. H., and others . Age of Emplacement of Granites, 702
Riley, Dr. Ralph, and others : Position of the Gene determining the Diploid-like Meiotic Behaviour of Wheat, 259
Rinderbesamung Lehrbuch der (Dr. Karl Eibl), *review* by Sir John Hammond, 667
Rinderknecht, Dr. H : Chemical Degradation of Canavanine to Canaline, 1047
Riney, Thane, and Caughley, Graeme Home Range in a Feral Goat Herd, 125
'Ring Angels' (Radar), and the Roosting Movements of Starlings (E. Eastwood, G. A. Isted and G. C. Rider), 112
Ringwood, A. E. : Silicon in the Metal Phase of Enstatite Chondrites, 465
Rites : Human, *review* by Dr. Kenneth Walker, 37
Rites of Passage (Arnold van Gennep), translated by Monika B Vizedom and Gabrielle L Caffee, *review* by Dr Kenneth Walker, 37
Ritter, Paul : Self-Regulation for Children, 911
Ritter, Paul and Jean : The Free Family, *review* by Prof. M. D. Vernon, 38
Rivanol in the Preparation of Plasminogen (Profibrinolysin), (Dr. M. Steinbuch and Dr. S. Niewiarowski), 87
Rivett, K., and others : Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methyl*iso*thiazole), a New Bacterial Sulphonamide, 221
Rivière, M , and others : Ultrastructure of the Clear Cells in Renal Carcinomas and its Importance for the Demonstration of their Renal Origin, 402
Road Accidents Proneness of Drivers to (Dr R. J Smeed), 273
Road Research Committee (Colonial) : Report for 1958-59, 501
Robbins, Dr A B. . Appointed lecturer in physics at the University of Birmingham, 937
Robert, Prof Maurice · Géologie des Pétroles. *review* by H. B. Milner, 268
Roberts, Dr. D. F. : Human Growth (Effects of Race and Climate on Growth), 20
Roberts, E. P. S. : Appointed a member of the Executive of the Australian Commonwealth Scientific and Industrial Research Organization, 12
Roberts, Dr. J. A. Fraser : An Introduction to Medical Genetics, second edition, *review* by R. H. Mole, 1003
Roberts, Prof. J. D. : Nuclear Magnetic Resonance—Applications to Organic Chemistry, *review* by Prof. E. R. Andrew, 55
Roberts, Dr. M. B. V. : Giant-Fibre Reflex of the Earthworm, 167
Roberts, Dr. M. B. V. (Horridge, Dr. G. A , and) : Neuro-Muscular Transmission in the Earthworm, 650
Robertson, Dr. D. M. : Awarded the Portsmouth fellowship for research in multiple sclerosis, at the University of Leeds, 767
Robertson, Dr. P. A. : Calcium and Contractility in Depolarized Smooth Muscle, 316
Robertson, Dr. W. B. : Medical Research in the British Caribbean (Association of Aortic and Coronary Atheroma with Essential Hypertension, Diabetes, Age and Sex), 862
Robin, Prof. Eugene D., and others . The Respiratory Dead Space of the Giraffe, 24
Robins, Rt. Hon. Lord : Honorary membership of the Institute of Mining and Metallurgy conferred on, 854
Robins, Dr A. B. (Butler, Prof J. A. V., and) : Effect of Oxygen on the Inactivation of Trypsin by Ionizing Radiation, 697
Robinson, Dr. Ann E., and others : Paper Chromatography—Multiple Spot Formation by Pure Substances, 775
Robinson, Dr J T. : The Affinities of the New Olduvai Australopithecine, 456
Robinson, R., and Smith, Dr P. · Urinary Phenols in Stress, 240
Roblin, Dr Richard O. . Elected president and director of the Cyanamid European Research Institute, Geneva, 361
Robson, Dr. J. G (Burns, Prof. B Delisle, and) · 'Weightless' Microelectrodes for Recording Extracellular Unit Action Potentials from the Central Nervous System, 246
Roche, J , et autres Traité de Biochimie Générale, Vol. I, Composition Chimique des Organismes, *review* by Prof. F G. Young, 51
Roche Products, Ltd · Grant of £1,250 per annum for two years to the Department of Organic Chemistry, University of Bristol, for the establishment of a Roche fellowship for research work, 284
Rock Pressure in Mines : The Measurement of (Nils Hast), 936
Rockefeller Foundation . President's Review, 20
  Grant of 30,000 dollars to the Marine Biological Association of the United Kingdom, for the purchase of research equipment for use in the Plymouth laboratory, 361
  Appointment of Dr. A. H. Moseman as director for the agricultural sciences, 681
Rockefeller Institute Press (Biophysical Society and the) : To publish the *Biophysical Journal*, 282
Rocket Propellants (Francis A Warren), *review* by Dr. W B. Littler, 58
Rocket Propulsion (Marcel Barrère, Prof. André Jaumotte, Prof. Baudouin Fraeijs de Veubeke and Jean Vandenkerckhove), *review* by J. E. P. Dunning, 186
Rocket and Satellite Observations of the Solar Ultra-violet Spectrum (R. Grant Athay), 1036
Rockets . Sounding (Homer E. Newell, jun), *review* by W. H. Stephens, 269
Rocks Chemical Analyses of, *review* by Prof. K. C. Dunham, 56
Rocks (Carboniferous), of Great Britain . Fossil Plants of the (Dr. Robert Crookall), second edition, *review* by T. M. Harris, 66
Rocks (Grooved), at Apoje, Nigeria (William Fagg), 205
Roddie, I. C. : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Rodger, Prof. F C : Blindness in West Africa, *review* by R. C. Davenport, 64
Rodgers, Dr. P. E. (Cruickshank, Prof. E. K , and) · Medical Research in the British Caribbean (Spinal Arachnoiditis in Jamaica), 863
Roe and Fallow Red, *review* by R. S. R. Fitter, 45
Roe Deer · The (Forestry Commission, Leaflet No. 45), 936
Roelofsen, Prof Pieter A. : The Plant Cell-Wall, *review* by Prof. R. D. Preston, 920
Roger, R. S., and Thomson, J H : Faraday Effect in the Transmissions from Fast Spinning Satellites, 622
Role of C'₄ in the Antiglobulin Reaction (G. C. Jenkins, Margaret J Polley and Dr. P L. Mollison), 482
Role of Hospitals in Ambulatory and Domiciliary Medical Care—Second Report of the Expert Committee on Organization of Medical Care (United Nations, World Health Organization, Technical Report Series No. 176), 202
Role for Thiol and Disulphide Groups in Determining the Rheological Properties of Dough made from Wheaten Flour (R. Frater, Dr. F J. R. Hird, H. J Moss and J R. Yates), 451
Role of the Triplet State in the Photoreduction of Chlorophyll (Prof. Robert Livingston and Dr. A. C. P. Pugh), 969
Role (Possible), of Excited Dimers in Energy Transfer Processes · Radiative Life-time of the Pyrene Dimer and the (Dr. B. Stevens and E Hutton), 1045
Rønnike, Folke : Specific Interaction of Native Protein and Inorganic Salts, 88
Roof Designs : Snow Loads and, 603
Roosting Movements of Starlings : Radar 'Ring Angels' and the (E. Eastwood, G. A. Isted and G. C Rider), 112
Root Formation : Foliar Abnormalities, including Repeated Branching and, induced by Kinetin in Attached Leaves of *Marsilea* (Dr. A. Allsopp and Alicja Szweykowska), 813
Root-Infections (Fungal), of *Pinus* : Effects of *Gibberella fujikuroi* on (Dr. Ida Levisohn), 987
Root-Knot Nematodes (*Meloidogyne* spp.) · Plants recorded as Resistant to (Mary T. Franklin and D. J Hooper), 684
Root Nodules of *Casuarina cunninghamiana* Haemoglobin in the (Dr. H E. Davenport), 653
Roots · Influence of Light on Bacterial Flora of (J. W. Rouatt and Dr H Katznelson), 659
Roots (Tomato) : Organic Acid Synthesis in (J. van Die), 603
Rose, Dr. Anthony H. : Excretion of Nicotinic Acid and Nicotinic Acid Adenine Dinucleotide by Biotin-deficient Yeast, 139
Rose, Dr. A. J. (edited by) . Index of Crystallographic Supplies, second edition, 1019
Rose-Innes, A. C : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Rosenberg, Dr. M., and others : Water-Soluble Methacrylates as Embedding Media for Preparation of Ultra-Thin Sections, 494
Rosenfeld, Prof. L : Heisenberg, Physics and Philosophy, *review*, 830
Rossi, Prof. Bruno : *Obituary* of Prof. Marcel Schein, 355
Rossi-Fanelli, Prof A., and Antonini, E. : Oxygen Equilibrium of Haemoglobin from *Thunnus thynnus*, 895
Rossi-Fanelli, Prof. A., and others : Oxygen Equilibrium of Myoglobin from *Thunnus thynnus*, 896
Rotating Fluid Masses, *review* by D G. King-Hele, 747
Rotation (Faraday), of Radio Signals from Artificial Satellites : Electron Density Measurements in the Upper Ionosphere using the (Dr. D McL. A. Wilson), 623
Roth, Dr. K. F. Elected a Fellow of the Royal Society, 11

Rotifers in Cook Strait, New Zealand : A Red Water Bloom of (Vivienne Cassie), 328
Rouatt, J. W , and Katznelson, Dr. H. . Influence of Light on Bacterial Flora of Roots, 659
Roughness of the Moon as a Radar Reflector (V. A Hughes), 873
Roughness (Cathode Surface), and Oxidation · Effect of, on Arc Movement (Dr. T. J. Lewis and Dr. P. E. Secker), 30
Roulston, W. J., and Schuntner, C. A : Sulphydryl Content of the Embryos of the Australian Cattle Tick, 1069
Rous Sarcoma Tissue : Presence of Chicken Tumour Virus in the Sarcoma of the Adult Rat inoculated after Birth with (Dr. Jan Svoboda), 980
Rousseau, Pierre . Man's Conquest of the Stars, *review* by D. H. P. Jones, 69
Route of Inoculation and Strain of Mouse Influence of, on Infectivity Titrations of the Virus of Foot-and-Mouth Disease (Wendy Heatley, H. H. Skinner and H Subak-Sharpe), 909
Rowe, A. J : Elected to a Beit Memorial Junior Fellowship for Medical Research, 520
Rowe, D. S , and Soothill, J. F. : Observations on Globin, Haemoglobin and Haptoglobin using a Rabbit Antiglobin Serum, 975
Rowell, J G. (Mount, Dr L. E., and) Body-Weight and Age in relation to the Metabolic Rate of the Young Pig, 1054
Roy, M , and others (edited by) : Advances in Aeronautical Sciences—Proceedings of the First International Congress on the Aeronautical Sciences (Madrid 1958), *review* by Prof. A R. Collar, 665
Roy, Prof. Rustum (Dachille, Frank, and) : High-Pressure Phase Transformations in Laboratory Mechanical Mixers and Mortars, 34
Royal Aeronautical Society : Honorary Fellowships conferred on Prof. W. J Duncan and Sir George Edwards, 685
  Financial grants from the Man Powered Aircraft Group for promising projects designed to further the achievements of man-powered flight, 1020
Royal Agricultural Society of England : Research Medal awarded to Prof R L. Wain, 685
Royal Aircraft Establishment Promotion of D. G A. Rendel to Deputy Chief Scientific Officer and appointment as head of the Mechanical Engineering Department, 12
Royal Aircraft Establishment, and Semiconductors, Ltd. : The *Corsair*, a Digital Differential Analyser, 201
Royal Anthropological Institute . Occasional Publication No. 13, The ABO Blood Groups (Dr. A. E Mourant, Ada C. Kopeć and Kazimiera Domaniewska-Sobczak), *review* by Dr F. Stratton, 581
Royal College of Science · Research Report of the (1956-59), 123
Royal College of Surgeons of England—a History (Sir Zachary Cope), *review* by Prof. Charles Singer, 35
Royal Commonwealth Society for the Blind Blindness in West Africa (Prof F C. Rodger), *review* by R. C. Davenport, 64
Royal Dental Hospital of London School of Dental Surgery : Appointment of Dr H. J J. Blackwood as reader in oral anatomy, 938
Royal Geographical Society : Research Fellowship for work on the geography and topography of the Roman Fenland awarded to Dr. P. Salway, 684
Royal Geological and Mining Society of the Netherlands Geological Nomenclature (English–Dutch–French–German), (edited by A. A. G. Schieferdecker), *review* by Dr. V. A. Eyles, 57
Royal Horticultural Society : Bowles Memorial Travel Scholarship, 206
Royal Institute of Chemistry Lectures, Monographs and Reports, 1959, No 5, Modern Explosives (the late Dr. Wilfrid Taylor), 204
  Monographs for Teachers No 3, Principles of the Extraction of Metals (Dr D. J. G. Ives), 765
Royal Institute of Chemistry, and others · Symposium on the Industrial Chemistry of the Lower Olefines, 285
Royal Institution Election of Officers, 440
  Christmas Lectures, 1951, How Animals Move (Sir James Gray), *review* by Dr. N. B. Marshall, 921
Royal Meteorological Institute of Belgium : Ionospheric Observations over Belgium during the International Geophysical Year, 203
Royal Meteorological Society · Buchan Prize for 1955-59 awarded to Dr. R J. Murgatroyd, 440
  Hugh Robert Mill Medal and Prize for 1959 awarded to Dr. B. J. Mason 440
  Darton Prizes—(*a*) Home Awards, first prize to Dr. C. J Adkins, and second prize to Dr. J. A. Funk ; (*b*) Canadian Awards, first prize jointly to R. H Douglas and Dr W. Hitschfeld, and second prize to D. K. A. Gilles, 440
  Symposium on Convection, 604
  Symposium on Agricultural Meteorology, 604
Royal Microscopical Society and the Electron Microscopy Group of the Institute of Physics : Symposium on the Co-ordination of Light and Electron Microscopy, 672
Royal Scottish Geographical Society : Seventy-fifth Anniversary Exhibition (Mapping Britain), 523
Royal Society of Arts : Report on the Industrial Arts Bursaries Competition for 1959, 684
Royal Society of London : Election of new Fellows, 11
  Appointment of I. E. Efford to a John Murray Travelling Studentship in Oceanography and Limnology, 127
  Discussion on the Results of the Royal Society's International Geophysical Year Expedition, 191
  Tercentenary celebrations at the Royal Albert Hall to be opened by H.M. the Queen, 206
  New Foreign Members of the, 435
  Philosophical Transactions, Series B, Biological Sciences, No. 695, Vol. 242, The Growth in Weight and Tail Length of Inbred and Hybrid Mice reared at Two Different Temperatures (Prof. G. A. Harrison, R. J. Morton and Dr. J. S. Weiner), 446
  Tercentenary Exhibition, 1016
Royal Society of South Africa : Election of Officers and Council for 1960, 766
Royal Statistical Society : Election of Officers, 1020
Ruanda-Urundi : Flore du Congo Belge et du (Institut National pour l'Etude Agronomique du Congo Belge), Vol. 9, 764
Rubber Producers' Council, and others : International Conference on Natural Rubber Research, 767
Rubber Research : Natural (Rubber Research Institute of Malaya, the Government of the Federation of Malaya and the Rubber Producers' Council International Conference on), 767
Rubber Research Institute of Malaya, and others International Conference on Natural Rubber Research, 767
Rubber and Metal : Bonds between, *review* by Dr W. C. Wake, 189
Rubber to Metal Bonding (Dr. S. Buchan), second edition, *review* by Dr. W. C. Wake, 189
Rubino, A., and others : Interrelation of Tryptophan and Nicotinic Acid in Man during the First Month of Life, 639
Ruch, Prof. Theodore C : Diseases of Laboratory Primates, *review* by Dr. C. R. Coid, 506
Ruckkoppelung als Urprinzip der Lebensvorgange (Bayerische Akademie der Wissenschaften Prize of 8,000 D marks for an Essay on), 938
Rudall, Dr. K. M. · Co-ordination of Light and Electron Microscopy, 672
Rudner, Rivka, and Balbinder, Elias : Reversions induced by Base Analogues in *Salmonella typhimurium*, 180
Rugby School Natural History Society : Report for 1959, 765
Rumley, Marilynn K , and others Dipeptidase Activity of Brain, 559
Runciman, I. G. (Mallon, H. D., and) Optical Properties of Bismuth, 709
Rusby, J S. M. . Measurements of the Total Acoustic Radiation Impedance of Rigid Pistons in an Array, 144
Russell, Dr. F. S : *Obituary* of W. H. Searle, 518
Russell, G. R . Detection and Estimation of a Facial Eczema Toxin, Sporidesmin, 788
Russell, Dr. W. Ritchie Brain—Memory—Learning— a Neurologist's View, *review* by Dr. Gilbert Hall, 39
Russi, Dr. Serena, and others : Characterization of a New Purine Riboside isolated from *Fusarium* Species, 968
Russian for Scientists, 359
Russian Approach to Mineral Paragenesis, *review* by Dr. Bernard E. Leake, 745
Russian Journals (North Western Group, Library Association), 683
Russian Machine Translation Dictionary (H. S. H. Massey), 852
Russian (Scientific), without Tears (Prof J. W. Perry), 359
Russian–English Glossary of Optics and Spectroscopy, *review* by Prof. S. I. Tomkeieff, 347
Russian–English Glossary of Solid State Physics (edited by I. Emin), *review* by Prof. S. I Tomkeieff, 347
Russian Journal of Physical Chemistry : A translation to be issued by the Chemical Society in co-operation with the Department of Scientific and Industrial Research, 601
Russian Language : Bibliographical Index of Literature in, for 1958 (Academy of Sciences of the U.S.S.R.), 359
Rutgers State University : Annual Ciba Lectures in Microbial Biochemistry (Microbial Cell Walls), (Dr. M. R. J. Salton), 284
Rutherford, Dr. D. E. : Fluid Dynamics, *review* by Dr. G. K Batchelor, 1000
Rylander, B. J., and others · Spontaneous Potentials from Explants of Brain Tissue in Culture, 477
Ryšánek, K. (Vítek, Dr. V , and) : Inhibition of Monoamine Oxidase by Benactyzine *in vitro* and *in vivo*, 244

SABATINI, A. (Sacconi, Prof. L., and) : The 'Irving–Williams' Order in the Metal-ligand Stretching Frequencies of some Metal Hydrazine Complexes, 549
Sacconi, Prof L., and Sabatini, A. : The 'Irving–Williams' Order in the Metal-ligand Stretching Frequencies of some Metal Hydrazine Complexes, 549
Sacconi, Prof. L , and others : Heats and Entropies of Reaction of Transition Metal Ions with Ethylenediamine, 880
Sachs, Dr. Leo (Krim, Dr. Mathilde, and) : Virus Release from Single Cells of Mouse Parotid Tumours, 262
Sagana, Kenya : The Inland Fishery Research Station (Dr. Vernon D. van Someren), 425
'Sage', a Colour Modifier in *Aspergillus nidulans* (B. J. Kilbey), 906
Sahara (Africa South of the) . Inventory of Economic Studies concerning—an Annotated Reading List of Books, Articles and Official Publications (edited by Peter Ady), (Commission for Technical Co-operation in Africa South of the Sahara, CSA/CCTA Publication No. 30, Joint Project No 4), 202
Sahara (Africa South of the), Scientific Council for Publication No. 37, Tenth Meeting of the Science Council, Kampala (1959), 502
Salisbury, Sir Edward : A Nineteenth-Century Botanist, *review*, 44
  Obituary of Dr Paul Haas, 595
Saliva–Serum Ratios of Tritium after the Administration of Tritiated Water (Dr. A. J. Coppen and Dr. J. L. Gibbons), 724
Salivary Mucoprotein : Correlation between Composition, Structure, Shape and Function of a (Dr. Alfred Gottschalk), 949
Salmon Culture · Trout and—Hatchery Methods (Earl Leitritz), 204
Salmon Kelts . Furunculosis in (Dr. Isabel W. Smith), 733
Salmonella · Somatic Antigen 15 as a Precursor of Antigen 34 in (Hisao Uetake and Shin Hagiwara), 261
Salmonella typhimurium : Reversions induced by Base Analogues in (Rivka Rudner and Elias Balbinder), 180
Salmonella Antigens · The *a-z-z*$_{53}$ Group of (Leonard Schrire), 569
Salol (Supercooled) . Ultrasonic Propagation Constants in (Dr. S. Parthasarathy and V. N. Bindal), 145
Salt (Tetrazolium), in Ascites Tumours : Viability and (Dr. Gustav Dallner), 176
Salton, Dr. M. R. J. : Annual Ciba Lectures in Microbial Biochemistry (Microbial Cell Walls), 284
  Specific Detection of Glucose on Paper Chromatograms, 966
Salts (Inorganic) : Specific Interaction of Native Protein and (Folke Rønnike), 88
Salvetti, Prof. C. . Appointed director of the Division of Research and Laboratories of the International Atomic Energy Agency, 17
Salway, Dr. P. : Awarded a Royal Geographical Society Research Fellowship for work on the geography and topography of the Roman Fenland, 684
Sample Holder for Radioactive Counting : An Inexpensive Castle and (Dr. Howard Boroughs), 145
Samples (Tritiated Water) : Preparation of, by Distillation (J. D. Simpson and Dr. J. R. Greening), 467
Sampling Oxide Layers and Brittle Materials for Microdiffraction : A Technique for (A. M. Adams, M. A. Silva and Veronica M. Spiers), 147
Sanders, J. E., and others (edited by) : Physics and Mathematics, Vol. 3 (Progress in Nuclear Energy, Series 1), *review* by Dr. E. R. Rae, 68

Sanders, Dr. J H. : Awarded a grant of £2,500 from the Paul Instrument Fund, for the construction of an optical maser, 520
Sanderson, Dr. Ann R. : Appointed senior lecturer in the Department of Zoology, Queen's College, St. Andrews, 767
Sandia Corporation : Civilian Application Releases through 1959, 854
Sanger, Dr. Ruth, and others : An Rh Antibody Specific for V and R' , 171
  M₁, a Subdivision of the Human Blood-Group Antigen M, 642
Sankaranarayanan, M. P. : Recent Advances in Coconut Research in India, 861
Saponaria Basic Chromosome Numbers in *Silene* and (Dr. T. N. Khoshoo), 412
Saponin (*Dioscorea*) : Smilagenone and *Epi*-Smilagenin from (D. Chakravarti, Prof. R. N Chakravarti and M. N. Mitra), 236
Sarcoma of the Adult Rat inoculated after Birth with Rous Sarcoma Tissue : Presence of Chicken Tumour Virus in the (Dr. Jan Svoboda), 980
Sarcoma 37 Cells (Mouse) : Changes in the Deoxyribonucleic Acid Content of, following Serial Irradiation (Dr. A. E. G. Pearson and N. B. Atkin), 647
Sarcoma Tissue (Rous) : Presence of Chicken Tumour Virus in the Sarcoma of the Adult Rat inoculated after Birth with (Dr. Jan Svoboda), 980
Sargeson, Dr. A M , and others . Rate of Ligand Exchange with its Metal Complex by a Polarimetric Method, 966
Sasaki, Prof Nobuji, and others A Micro Gas Chromatograph, 309
Sastry, P. V. (Bahadur, K., and) : Thin Films of Silver–Cadmium Alloy, 467
Satellite 1960*s* : Earth, 598
Satellite (Artificial Earth) : Secular and Periodic Motions of the Node of an (Prof. Leon Blitzer), 874 , (D. G. King-Hele), 875
Satellite Observations (Rocket and), of the Solar Ultra-violet Spectrum (R Grant Athay), 1036
Satellite Orbits . Density of the Upper Atmosphere and its Dependence on the Sun, as revealed by (D. G. King-Hele and D. M. C. Walker), 928
Satellite Project : Joint United States–Canadian, 13
Satellites (Artificial) : Electron Density Measurements in the Upper Ionosphere using the Faraday Rotation of Radio Signals from (Dr. D. McL. A Wilson), 623
  Figures of Equilibrium of Celestial Bodies, with Emphasis on Problems of Motion of (Prof Zdeněk Kopal), *review* by D. G. King-Hele, 747
Satellites (Fast Spinning) . Faraday Effect in the Transmissions from (R. S. Roger and J. H. Thomson), 622
Saturated Fats (Differently), for Three Years . Essential Fatty Acids of Normal and Atherosclerotic Aortas from Chickens receiving (Prof. H. Fisher and A. S. Feigenbaum), 85
Satyabalan, K. (Pillai, R. V , and) : Recent Advances in Coconut Research in India, 861
Saunders, D S . Determination of Physiological Age for Female *Glossina morsitans*, 651
Saunders, Harold N : A Handbook of West African Flowers, *review* by J. P. M Brenan, 65
Savanes de l'Afrique Centrale (Roger Sillans), *review* by J. P. M. Brenan, 505
Savannahs : Central African, *review* by J P. M. Brenan, 505
Sawyer, Prof W. W. A Concrete Approach to Abstract Algebra, *review*, 69, 440
Saxena, H. C., and others : Influence of Dietary Intake of certain Insecticides on the Haemoglobin and Erythrocyte Contents of Chick Blood, 172
Saxton, Dr. J. A : Appointed deputy director of the Radio Research Station (Department of Scientific and Industrial Research), Slough, 357 ; work of, 357
Scale : The Extragalactic Distance (Paul W Hodge), 622
Scalera, Dr Mario : Elected a vice-president of the Cyanamid European Research Institute, Geneva, 361
Scandrett, Dr F. J. : Presence of Protein in some Serum Filtrates, 558
Scaramelli, N., and others : Non-Identity of Triosephosphate Dehydrogenase of Adult Male and Nymph Development Stages of *Triatoma infestans*, 1052
Scarano, Dr. Eduardo, and others : Enzymatic Deamination of 5-Deoxycytidylic Acid and of 5-Methyl-5'-deoxycytidylic Acid in Growing and in Non-growing Tissues, 237
Schachman, Dr. Howard K. Ultracentrifugation in Biochemistry, *review* by Dr. K. V. Shooter, 56
Schaeffer, A. J , and others (edited by) . Documenta Ophthalmologica (Advances in Ophthalmology, Vol. 13), *review* by R. C. Davenport, 42
Schaeffer, Oliver A., and Fisher, David E. . Exposure Ages for Iron Meteorites, 1040
Schein, Prof. Marcel : *Obituary* by Prof. Bruno Rossi, 355
Schenck, Prof Hermann . Awarded the Bessemer Gold Medal for 1960 of the Iron and Steel Institute, 13
Scheuch, D. (Rapoport, Prof. S., and) Glutathione Stability and Pyrophosphatase Activity in Reticulocytes—Direct Evidence for the Importance of Glutathione for the Enzyme Status in Intact Cells, 967
Schieferdecker, A A. G. (edited by) : Geological Nomenclature (English–Dutch–French–German), *review* by Dr V A. Eyles, 57
Schiller, Claire H. (translated and edited by) : Instinctive Behaviour, the Development of a Modern Concept, *review* by Dr. R. A. Hinde, 43
Schindler, Dr Otto : *Obituary* by Dr. E Trewavas, 434
Schinz, Prof Hans R. : Sechzig Jahre Medizinische Radiologie, *review* by Dr R. E. Steiner, 921
Schistocerca gregaria Forsk. : Nervous Control of Movements in the Foregut of (Dr. K. U. Clarke and H. Grenville), 98
Schmitt, Dr R. A , and others : Abundances of the Rare-Earth Elements, Lanthanum to Lutetium, in Chondritic Meteorites, 863
Schneider, Gy , and others : Effect of Diphenylamine on the Synthesis of Carotene, 235
Schneierson, Dr S. Stanley (Amsterdam, Dr. Daniel, and) : Enhancement of Staphylococcal Virulence for Mice by Intraperitoneal Cortisone Acetate, Cholesterol and Lecithin, 101
Schnell, H. Polymeric Progress (Polycarbonates), 442
Schoeller, L., and others : Frequencies of the Haptoglobin Serum Groups among Blood Donors from Austria and Germany, 976
Schofield, R., and Thomason, D. : Calcium Binding in Homogenates of Ehrlich Ascites Tumour Cells, 656
Scholar Quantum Theory for the, *review* by Prof. N. Kemmer, 999
Scholarship . Bowles Memorial Travel (Royal Horticultural Society), 206
  Bursaries and a (Institution of Agricultural Engineers), 284
Scholarship Awards for 1960-61 (National Research Council of Canada), 854
Scholarships in Chemical Engineering (John Brown, Ltd , and the Institution of Chemical Engineers), 522
Scholarships (State), and Commonwealth Co-operation, 935
Scholefield, Dr P. G. (Ahmed, K., and) : Effects of Fatty Acids on the ^{32}P-Adenosine Triphosphate Exchange Reaction in Rat Liver Mitochondria, 1046
Scholer, H. F. L., and others : A New Class of Hormonally Active Steroids, 168
Schomaker, Dr. V. (Dodge, R. P , and) : Crystal Structure of Tetraphenyl*cyclo*butadiene Iron Tricarbonyl, 798
Schonberg, Prof. Alexander . Praparative Organische Photochemie, *review* by Prof. R. N. Haszeldine, 53
School of Physics : International (Societa Italiana di Fisica), 17
School (Summer), in Modern Methods of Crystal Structure Determination (Manchester College of Science and Technology), 766
School Natural History Societies, 282
School Science : Policy for (Organization for European Economic Co-operation Seminar on), 850
Schools (Secondary) : Science in (Ministry of Education, Pamphlet No. 38), 663
Schrader, M. E , and Kalinsky, J. L. : Effect of Moisture on Carboxylic Acid Adsorption to Steel, 710
Schramm, Prof. G., and others : Primary Structure of the Protein of Tobacco Mosaic Virus, 922
Schrire, Leonard : The *a*-*z*-z_{33} Group of *Salmonella* Antigens, 569
Schultz, Prof Adolph : Human Growth (Comparison of Changes during Growth in Man, Apes and Monkeys), 19
Schumacher, Prof. E (Meyer, Dr. B., and) : Coloured Sulphur Deposits at Low Temperatures, 801
Schuntner, C. A (Roulston, W. J., and) : Sulphydryl Content of the Embryos of the Australian Cattle Tick, 1069
Schwabe, P. H., and others : Adsorption of Helium on Carbons—Influence on Measurement of Density, 956
Schwartz, Dr. Klaus (Corwin, Dr. Laurence M., and) : Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine, 1048
Schwarzschild, Prof. Martin Elected a member of the Astronomy Section of the Leopoldina Academy of Natural Sciences, 766
Science Classification and Indexing in (B. C. Vickery and D J. Foskett), second edition, *review* by R Brightman, 190
  European Co-operation for, 600
  Fibre (Textile Institute Conference on), 360
  Modern Philosophy of (Hans Reichenbach), translated and edited by Maria Reichenbach, *review* by Prof. Herbert Dingle, 503
  The Reach of (Prof Henryk Mehlberg), *review* by F. I G. Rawlins, 1003
  Report of an Enquiry into the Suitability of the General Certificate of Education Advanced Level Syllabuses in, as a Preparation for Direct Entry into First Degree Courses in the Faculty of Science (University of Birmingham), 687
  Senior Visiting Fellowships in (Organization for European Economic Co-operation and the United States National Science Foundation Awards), 1019
  Space (Dr. R. L. F. Boyd), 749
  Space (Committee on Space Research of the International Council of Scientific Unions first International Symposium on), 749
  Tenth International Congress of the History of, 767
Science in Secondary Schools (Ministry of Education, Pamphlet No. 38), 663
Science in South-East Asia . The Development of (Unesco South-East Asia Science Co-operation Office and the Indonesian Council of Sciences Discussion on), 859
Science, Australian Academy of . Election of new Fellows, 519
Science, Indian Institute of (Bangalore) : Golden Jubilee Symposia (Prof. R. L. Datta), 691
  Symposium on Hydrocarbon Synthesis and Hydrocarbon Conversion, 691
  Symposium on Mass Transfer, 691
Science, Royal College of : Research Report of the (1956-59), 123
Science, Weizmann Institute of : International Conference on Science in the Advancement of New States, 604
Science in the Advancement of New States (Weizmann Institute of Science International Conference on), 604
Science of Glass Making : Journals and the, 601
Science Association of Nigeria (Dr. B. Hopkins), 442
  Second Annual Conference, 442
Science Information News : Title to be changed to *Scientific Information Notes* (United States National Science Foundation), 437
Science Museum, London : Appointment of Dr. D. H. Follett as director, 206, 518
  Appointment of D. Chilton as keeper of the Department of Electrical Engineering and Communications, 206
Science Teachers : Competition for (*Teaching Science*), 126
Science Writers (British), Association of . Guide to Press Arrangements for Scientific, Medical and Technical Conferences (edited by Ronald Bedford), 437
Science and Civilization in China (Dr. Joseph Needham with the collaboration of Dr Wang Ling), Vol. 3, Mathematics and the Sciences of the Heavens and the Earth, *review* by Prof W. M Smart, 36
Science and Economics in the United States, 14
Science and Engineering in American Industry—Report of a 1956 Survey (United States National Science Foundation), 763
Science and Invention : National Reference Library of, 934
Science and Mathematics Teaching, 850
Science and Technology, Manchester College of : Summer School in Modern Methods of Crystal Structure Determination, 766
  Retirement of Prof. H. Wright Baker from the chair of mechanical engineering in the Faculty of Technology of the University of Manchester, 1015
  Appointment of W Johnson to the chair of mechanical engineering in the Faculty of Technology of the University of Manchester, 1015
Science (Early), in China, *review* by Prof W. M. Smart, 36
Science (Early Medicine and) : Parasites and Parasitic Infections in (Prof. R. Hoeppli), *review* by Dr. Ben Dawes, 46
Science (Greek) : A Source Book in (Prof Morris R. Cohen and Dr. I. E. Drabkin), second printing, with corrections, *review*, 63

Science (Modern), and the Human Fertility Problem (Dr. Richard L. Meier), *review* by Dr. Kenneth Walker, 188
Science (Nuclear) : Soviet Reviews of, on the 40th Anniversary of the October Revolution, *review* by Dr. T. E. Allibone, 917
Science (Nuclear), CENTO Institute of, In Tehran (H. A. C. McKay), 513
  Symposium on Recent Developments in the Applications of Nuclear Science for Peaceful Purposes, 685
Science (Nuclear), National Institute for Research in : Grant of £10,450 to the Universisy of Oxford, for an investigation of the alignment of nuclei for the proton linear accelerator, to be carried out in the Clarendon Laboratory, 126
Science (Nuclear), for Peaceful Purposes · Recent Developments In the Applications of (CENTO Institute of Nuclear Science Symposium on), 685
Science (Political and Economic), British Library of : Annual Report for 1958-59, 520
Science (School) . Policy for (Organization for European Economic Co-operation Seminar on), 850
Science (Sixth-Form), as a Preparation for University Work (Dr. W. L. Sumner), 686
Science (Social), Criminology and Psychiatry, *review* by Prof E. Stengel, 41
Science (Social), and Social Pathology (Barbara Wootton, assisted by Vera G. Seal and Rosalind Chambers), *review* by Prof. E. Stengel, 41
Science (Veterinary), Research in, Vol. 1, No 1 (British Veterinary Association), 16
Sciences, Hungarian Academy of : International Conference on Scientific Problems of Crop Protection, 523
Sciences, Indonesian Council of (Unesco South-East Asia Science Co-operation Office and the) : Discussion on the Development of Science in South-East Asia, 859
Sciences, New York Academy of : Symposium on Cardiovascular Effects of Nicotine and of Smoking, 525
  Conference on the Actinomycins and their Importance In the Treatment of Tumours In Animals and Man, 771
Sciences of the Heavens and the Earth : Mathematics and the (Dr. Joseph Needham, with the collaboration of Dr. Wang Ling), (Science and Civilization In China, Vol. 3), *review* by Prof W M. Smart, 36
Sciences (Aeronautical) : Advances in—Proceedings of the First International Congress on the Aeronautical Sciences, Madrid 1958 (edited by Th von Kármán, A. M. Ballantyne, R. R. Dexter, H. Blenk, H. L. Dryden and M Roy), *review* by Prof A. R. Collar, 665
  Aspects of, *review* by Prof. A. R. Collar, 665
Sciences (Aeronautical), Institute of (United States Air Force Office of Scientific Research and the) : Second Annual Astronautics Symposium—Vistas in Astronautics, Vol. 2 (edited by Morton Alperin and Hollingsworth F. Gregory), *review* by D. G. King-Hele, 59
Sciences (Agricultural), in the Rockefeller Foundation, 681
Sciences (Biological) : Elementary Statistics with Applications in Medicine and the (Prof. Frederick E. Croxton), *review* by R. M. Cormack, 746
Sciences (Biological and Medical) : Statistical Methods In, *review* by R. M. Cormack, 746
Sciences (Medical), Council for Interational Organizations of (Commission Administrative du Patrimoine Universitaire de Liège and the) : Symposium on Biological Problems of Grafting, *review* by Dr. D. M. V. Parrott, 51
Sciences (Medical and Biological) · Current Indexing and Abstracting Periodicals in the (United Nations, World Health Organization, Library News, Vol. 12, Supp. 2), 936
Sciences (Natural) : A Quarter Century in the (Dr. Warren Weaver), 20
Sciences (Physical), and Industry : Use of Radioisotopes in the (International Atomic Energy Agency Conference on), 284
Sciences Géographiques, École Nationale des · Theoretical and Technical Course on Aerial Photogrammetry, 127
Scientific Bibliography of Latin America, 203
Scientific Cinematography A Central Institute for, 444
Scientific Civil Services : Payment of, 436
Scientific Council for Africa South of the Sahara : Publication No. 37, Tenth Meeting of the Science Council, Kampala (1959), 502
Scientific Film Association (International) Fourteenth Congress, 767
Scientific Future : Organization for European Economic Co-operation and the, 520
Scientific Ideas : History of (Formation by the Nuffield Foundation of a Unit for the), 436
Scientific Information · Abstracting, 358
Scientific Information Notes Title of *Science Information News* to be changed to (United States National Science Foundation), 437
Scientific Institutions and Scientists in Latin-America (Unesco, Centro de Cooperacion Cientifica para America Latina), Vol. 1, Paraguay , Vol. 2, Chile, 203
Scientific Instrument Research Association, British : *Instrument Abstracts*, Vol. 15, No 1, 359, *erratum*, 685
Scientific Instrument Research Association, British (Optical Panel) : Optimization Methods used for Optical Design, 17
Scientific Journals : International Communications and, 358
Scientific Men . Movements of, 763
Scientific Methods in the Care of Works of Art (F. I G. Rawlins), 437
Scientific Periodical Publications : Cost of (K. W. Humphreys and H D. Barry), 124
Scientific Problems of Crop Protection (Hungarian Academy of Sciences International Conference on), 523
Scientific Publications Council : Discussion on the Rapid Increase in the number of New Scientific Journals, 18
Scientific Research in Antarctica, 212
Scientific Research in the Overseas Territories of the British Commonwealth, 501
Scientific Research at South African Universities, 1959 : Register of Current (edited by D. Ryle Masson), (South African Council for Scientific and Industrial Research), 854
Scientific Research and Development : A Bibliography on the Economic and Social Implications of (United States National Science Foundation), 14
  Projects in Colleges and Universities on the Economic and other Impacts of (United States National Science Foundation), 14
Scientific Research and Technical Services in the Federation of Rhodesia and Nyasaland : Government Organizations and Statutory Bodies concerned with, 202
Scientific Russian without Tears (Prof. J. W. Perry), 359
Scientific Societies, South-Eastern Union of : Sixty-fifth Annual Congress, 770
  Presidential Address, East Anglian Mammals (Lord Cranbrook), 770
  Presidential Address to the Archaeological Section, Archaeology in Suffolk (N. Smedley), 770
  Presidential Address to the Botanical Section, Changes In the Suffolk Flora during the Past 100 Years (F. W. Simpson), 771
  Presidential Address to the Geological Section, Investigating Glacial and Interglacial Geology in East Anglia (Dr. R. G. West), 771
  Presidential Address to the Zoological Section, Some East Anglian Butterflies (S. Beaufoy), 771
Scientific Techniques in Art and Archaeology (Dr. A. E. Werner), 674
Scientific Techniques in the Conservation of Paintings, 437
Scientific Unions, International Council of : Work of the Abstracting Board (Prof. E. A. Boutry), 358
Scientific Unions, International Council of (Committee on Space Research) : First International Space Science Symposium, 749
Scientific and Industrial Research The Balance of, 997
Scientific and Industrial Research, Department of : Grants to the University of Oxford—£1,170 for the purchase of apparatus for the structural investigation and synthesis of peptides, to be carried out in the Dyson Perrins Laboratory , £10,800 for the purchase of an electron-microscope for use in research in the Department of Metallurgy ; £7,450 for work being carried out in the Clarendon Laboratory ; and £940 for work on the expansion of X-ray fluorescence analysis to lower atomic numbers being carried out in the Research Laboratory for Archaeology and the History of Art, 126
  Grants to the University of Bristol—£6,500 to the Department of Physics, in connexion with an investigation of high-altitude flight and recovery techniques in the Mediterranean region ; £1,600 to the Department of Organic Chemistry, for an investigation into the structure and synthesis of natural products ; £2,200 to the Department of Physics, towards research on the study of fragmentation of heavy cosmic ray nuclei in hydrogen and carbon, 284
  Automatic Control in Soviet Industry, 287
  Appointment of Dr. J A. Saxton as deputy director of the Radio Research Station, Slough, 357
  Problems of Progress in Industry, No 5, Human Problems of Innovation (Based on a Study of some Scottish Firms by Tom Burns and G. M. Stalker), 419
  Name of the Control Mechanisms and Electronics Division of the National Physical Laboratory to be changed to Autonomics Division, 440
  Open days at the National Physical Laboratory, 523
  Grant of £2,055 to the Department of Zoology in the University of Leeds, for research projects under the direction of Dr. Broadhead, 767
  Structural Loading in Factories, 851
  Appointment of A. C. Copisarow as director of the Forest Products Research Laboratory, 934
  Industrial Research and Development Expenditure 1958, 997
Scientific and Industrial Research, Department of (Chemical Society, in co-operation with the) . To issue a translation of the *Russian Journal of Physical Chemistry*, 601
Scientific and Industrial Research, Indian Council of : The Wealth of India, a Dictionary of Indian Raw Materials and Industrial Products—Raw Materials, Vol 5, H–K, *review* by Dr. F. N Howes, 70
Scientific and Industrial Research, Indian Council of (Chemical Research Committee) · Symposium on Proteins, 767
Scientific and Industrial Research, Department of (New Zealand) : Report for 1958-59, 129
Scientific and Industrial Research, South African Council for : Register of Current Scientific Research at South African Universities, 1959 (edited by D. Ryle Masson), 854
Scientific and Industrial Research Organization (Australian Commonwealth) : Appointment of Lord Casey and E. P. S. Roberts as members of the Executive, 12
  Rural Research, 29, Mistletoe in Australia (G. C Greenham), 135
  Appointment of Dr Geoffrey Kesteven as director of fisheries research in the Division of Fisheries and Oceanography at Cronulla, 280
  Appointment of Dr Douglas F Waterhouse as chief of the Division of Entomology, 763
  Symposium on Nitrogen in Tropical Agriculture, 941
  Symposium on Visco-Elastic Systems, 942
Scientific and other Fields of Learning The Problem of Language in Publications of Works in (Prof. D. Keilin), 912
Scientific, Medical and Technical Conferences Guide to Press Arrangements for (edited by Ronald Bedford), 437
Scientific and Technical Books · Recent, Supp. vi, April 30 ; Supp. vi, May 28 , Supp vi, June 25
Scientific and Technical Research : Co-operation in the Field of (Organization for European Economic Co-operation), 998
Scientist : The (Ministry of Labour and National Service, Choice of Careers Series No. 100), 682
Scientist (British) : The Wandering, 436
Scientists : Russian for, 359
Scientists (Consulting), Association of : Election of Officers for 1960–61, 766
Scientists (Scientific Institutions and), in Latin-America (Unesco, Centro de Cooperacion Cientifica para America Latina), Vol. 1, Paraguay ; Vol. 2, Chile, 203
Scientists and Administration (T H. Hawkins), 446
Scintillation Counting of Carbon-14 (David S. Jenkinson), 613
Scintillation Techniques : Radiocarbon Dating System using (C. F. G. Delaney and I. R. McAulay), 204
Sclerotium rolfsii Sacc : Perfect Stage of (Prof. A P. Misra and S Q. Haque), 567
Scotland (South-West) : *Elminius modestus* Darwin in (H. Barnes and Margaret Barnes), 989
Scotland (West Coast of) : Occurrence of *Falkenbergia rufolanosa* on the (Dr. Elsie Conway), 566
Scott, Dr. A. E. · Appointed lecturer in chemistry at the University of Bristol, 937
Scott, Dr. A. I. . Biosynthesis of Colchicine, 556
Scott, Dr J. F. : Stevin's Mathematical Works, *review*, 60

Scott, Dr. T. G , and others . Antithromboplastin in Human Serum and Plasma, 248
Scott, V. D. : Formation of Beryllium Carbide during the Corrosion of Beryllium in Carbon Monoxide and in Carbon Dioxide Gas, 466
Scottish Geographical Society (Royal) : Seventy-fifth Anniversary Exhibition (Mapping Britain), 523
Scottish Geology, 1019
Scottish Home Department, and others : Postgraduate Training Grants in Fishery Research, 360
Sea (Central Tyrrhenian) : The Sediments of the (E. Norin), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 8, Sediment Cores from the Mediterranean Sea and the Red Sea, No. 1), 609
Sea (Mediterranean) and the Red Sea · Sediment Cores from the (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 8, No 1), 609
Sea (Red) : Sediment Cores from the Mediterranean Sea and the (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 8, No. 1,) 609
Sea-Level Air Pressure . New Record Low (C. L. Jordan), 283
Sea-lion (California), *Zalophus californianus* Chronic Aortitis in the (Dr. Arthur L. Kelly and Dr. David Jensen), 731
Sea-Water as the Primary Source of Sulphate in Tidal Swamp Soils from Sierra Leone (J C D. Watts), 308
Seal, Vera G , and Chambers, Rosalind (Barbara Wootton, assisted by) : Social Science and Social Pathology, *review* by Prof. E. Stengel, 41
Seal (Harbour), *Phoca vitulina* L. · Age Determination in the (A. W. Mansfield and H. D. Fisher), 92
Seaman, Dr G. F. V. · Elected to a Beit Memorial Junior Fellowship for Medical Research, 520
Searle, Dr A. G. · Genetic Radiation Hazards, *review*, 109
Searle, W H. · *Obituary* by Dr F. S Russell, 518
Sears, L. (Legg, S. P , and) : Zinc Sulphate Treatment of Parakeratosis in Cattle, 1061
Sears, Prof Paul B. Retirement from the Department of Botany, Yale University, 1020
Seasonal Differences in Ovulating Hormone in the Merino Ewe (Dr. D. R. Lamond), 971
Seaway The St. Lawrence (Lionel Chevrier), *review* by Prof R W. Steel, 110
  The St. Lawrence (Prof. T. L Hills), *review* by Prof R. W Steel, 110
Sechzig Jahre Medizinische Radiologie (Prof Hans R. Schinz), *review* by Dr. R E. Steiner, 921
Secker, Dr. P. E (Lewis, Dr T. J., and) Effect of Cathode Surface Roughness and Oxidation on Arc Movement, 30
Second Crystalline Modification in Polyethylene · Effect of a, on X-Ray Crystallinity Measurements (Dr C. G. Vonk), 962
Secondary Growth in Plants · Detoxication during (C M. Stewart), 374
Secondary Schools. Science in (Ministry of Education, Pamphlet No. 38), 663
Secondary Wall (Outer), on Unbleached Spruce Sulphite Fibres : Structure of the (O. Kallmes and J. A. S. Newman), 566
Secretion (Gastric), of Hydrogen Ions : Mechanism of the (Prof. Spyridon G. A. Alivisatos), 368
Sectioned Tissues : A Method of Staining, with Lead for Electron Microscopy (Dr. J D. Lever), 810
Sections (Ultra-Thin) : Water-Soluble Methacrylates as Embedding Media for Preparation of (Dr. O. Wichterle, Dr. P. Bartl and Dr. M. Rosenberg), 494
Secular and Periodic Motions of the Node of an Artificial Earth Satellite (Prof. Leon Blitzer), 874 ; (D. G. King-Hele), 875
Sediment (Bed) : Haemoglobin Content of the Larvae of *Tendipes f.l. plumosus* L. from Various Levels of (B Czeczuga), 484
Sediment Core from the Central Equatorial Pacific : X-Ray Determination of Phillipsite in a (F. Lippman), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 10, Special Investigations, No. 3), 609
Sediment Core from the Mindanao Trough (K. Frediksson), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No. 4), 609
  Mineralogical Composition of some <2 Micron Fractions in a (J. Ch. L. Favejee), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Sediment Cores from the West Pacific, No. 5), 609
  A Note on the Foraminifera in a (R. A. Reyment), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No. 6), 609
  Fragments of Calcareous Algae in a (H. Horn af Rantzien), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 6, Sediment Cores from the West Pacific, No. 7), 609
Sediment Cores from the Mediterranean Sea and the Red Sea (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 8, No. 1), 609
Sediment Cores from the North Atlantic Ocean (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Nos. 4-5), 609
Sediment Cores from the West Pacific (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Nos. 4-7), 609
Sedimentation : Theory and Practice of, *review* by Dr. K. V Shooter, 56
Sedimentation (Concentration-Dependent), of Aggregating Proteins in the Ultracentrifuge (Dr. G A. Gilbert), 882
Sedimentpetrografische Untersuchung der Lotkerne 255 und 257 (F. W. Locher), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Sediment Cores from the North Atlantic Ocean, No. 4), 609
Sediments of the Central Tyrrhenian Sea (E Norin), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 8, Sediment Cores from the Mediterranean Sea and the Red Sea, No 1), 609
Sedlák, Jozef : Level of Sulphydryl Compounds in Rat Liver following Feeding with Goitrogenous and Non-goitrogenous Cabbage, 892
Seed, Dr. John C , and others : Improvement of the Intravenous Glucose Tolerance Test, 808
Seed (Lettuce) Presence of Gibberellin-like Substances in (Dr. S. Blumenthal-Goldschmidt and Prof. A Lang), 815
Seedlings (Wheat) · Chlorophyll Content of Gibberellin-treated (Prof Frederick T. Wolf and Dr Alan H. Haber), 217
Segregation (Spontaneous and Induced Somatic), in *Aspergillus nidulans* : High Frequency of (Dr. Etta Kafer), 619
Seismic Net (A Telemetered), in Tasmania (Prof Gordon Newstead and P A. Watt), 704
Seismic *P* and *S* Waves Structure of the Upper Mantle as derived from the Travel Times of (Dr I. Lehmann), 956
Select Committee on Estimates : Fifth Report from the, Session 1958-59, United Kingdom Atomic Energy Authority (Production Group and Development and Engineering Group), 1
Selection for High-Order Resistance to 'Dieldrin' in *Lucilia cuprina* Wied. (G J Shanahan), 100
Selection of Iodinated Protein in the Young Mouse (W A. Hemmings), 399
Selective Elimination of Single Sense Cells with Methylene Blue (Dr. Ulrich Clever), 812
Selective Visits of Butterflies to Flowers—a Possible Factor in Sympatric Speciation (K. R. Dronamraju), 178
Selenium in the Rat : Whole-Body Turn-over of (Clifton Blincoe), 398
Self-Quenching Geiger Counters containing Mixtures of Permanent Gases (Dr. Oswald Riedel), 876 ; (A. J L. Collinson, I. C Demetsopoullos, J. A. Dennis and J. M. Zarzycki), 876
Self-Regulation for Children, *review* by Prof. M. D. Vernon, 38, 912 , (Paul Ritter), 911
Self-supporting Metal Fresnel Zone-plate to Focus Extreme Ultra-violet and Soft X-Rays (Dr. Albert V. Baez), 958
Self-sustaining Corbino Disk : The Possibility of a (Dr. D. Midgley), 377
Self-trapped Electrons ('Polarons') : Primary Processes in the Action of Ionizing Radiations on Water—Formation and Reactivity of (Prof. Joseph Weiss), 751
Selye, Prof. Hans · The Chemical Prevention of Cardiac Neuroses, *review* by Dr D. C. Deuchar, 423
Semiconductor Components, 602
Semiconductors, Ltd (Royal Aircraft Establishment, and) : The *Corsair*, a Digital Differential Analyser, 201
Sen, N. N , and others : Foetal Haemoglobin in the Monkey, 977
Senior Research Fellowships (United States Public Health Service), 439
Sense Cells : Selective Elimination of Single, with Methylene Blue (Dr. Ulrich Clever), 812
Sensitivity of Thermal Conductivity Detectors : Effect of Carrier Gas on the (C Bokhoven and A. Dijkstra), 793
Sensitivity (Phage), in *Erwinia amylovora* : An Association between Capsulation and (Eve Billing), 819
Sensitized Mast Cells : Antigen-induced Damage to Isolated (Dr I Mota and W Dias da Silva), 245
Sensory Specialization in Response to Environmental Demands (Zoological Society of London Symposium on), 688
Separation of the α- and β-Chains of Globins by means of Starch-gel Electrophoresis (C J. Muller), 643
Septicaemia (Haemorrhagic) Mechanism of Immunity in (R V. S. Bain), 734
Sera (Normal Human) : Agar-gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_1-Globulin Region of (Dr Jan Hirschfeld), 321
Serengeti National Park (Dr. A. S. Thomas), 605
Serial Irradiation : Changes in the Deoxyribonucleic Acid Content of Mouse Sarcoma 37 Cells following (Dr. A. E. G. Pearson and N. B. Atkin), 647
Serjeant, E. P. . Preparation of Pure Standard Metallic Perchlorate Solutions, 963
Seromucoid Contents of Human Bile (Dr. C. Mihaescu and Edith Mihaescu), 394
Serotonin Content of the Pineal Glands of Man and Monkey (Prof. Nicholas J. Giarman, Daniel X. Freedman and Luis Picard-Ami), 480
Serratia · Induction and Reversion of *c*-Mutations by Irradiation of the Extracellular χ-Phage of (Prof. R. W Kaplan, U. Winkler and H. Wolf-Ellmauer), 330
Serum : Measurement of Transaminases in (Dr. H. Yatzidis), 79
Serum (Blood) : Determination of Calcium in, by Atomic Absorption Spectroscopy (J. B. Willis), 249
Serum (Human) : A Haemoglobin-binding β-Globulin in (Dr. M. P. Tombs), 1055
Serum (Rabbit Antiglobin) : Observations on Globin, Haemoglobin and Haptoglobin using a (D. S. Rowe and J. F. Soothill), 975
Serum (Saliva–) Ratios of Tritium after the Administration of Tritiated Water (Dr. A. J. Coppen and Dr. J. L. Gibbons), 724
Serum Albumin (Bovine) · Iodination of Specific Sites on (Dr. David Pressman and Dr. Gerald Radzimski), 1049
Serum Groups (Haptoglobin) Frequencies of the, among Blood Donors from Austria and Germany (Dr. H. Baitsch, G. Meier, L. Scoeller and D. M. Kahlich-Koenner), 976
Serum Proteins of Pigs : Thread Protein and β-Globulin Polymorphism in the (G. C. Ashton), 991
Serum, Connective Tissue and Osseous Chemistry in Lathyritic Rats : Aortic, (Dr. R. A. Grant, M. Hathorn and Prof Theodore Gillman), 164
Serum and Milk from Cattle : Inheritance of β-Globulins in (Bo Gahne, Jan Rendel and Dr. Ole Venge), 907
Serum and Plasma (Human) : Antithromboplastin in (Dr. T. G. Scott, Dr. C. Symons and R. L. Markham), 248
Serum and Pleural Fluid . Mucopolysaccharides of (Prof C W. Fishel), 804
Serum Filtrates Presence of Protein in some (Dr. F J Scandrett), 558
Serum Gonadotropin (Pregnant Mare) : Effect of *p*H on Biological Activity of (Bengt H. Persson and Stig E. J. Melander), 163
Serum Haptoglobin in Rabbits : Elevation of, in Response to Experimental Inflammation (R. K. Murray and G. E. Connell), 86
Service to Management : Organization and Methods, a (edited by G. E. Milward), *review* by E. S Hiscocks, 62
Services (Psychiatric), and Architecture (A Baker, R. Llewelyn Davies and P. Sivadon), (United Nations, World Health Organization, Public Health Papers No 1), 936
Services (Technical), in the Federation of Rhodesia and Nyasaland · Government Organizations and Statutory Bodies concerned with Scientific Research and, 202
Services (Training), in Industry (Industrial Training Council), 123
Seshachar, Prof B. R. Effect of Centrifugation on the Macronucleus of *Spirostomum* and *Blepharisma*, 333
Seshadri, Prof T. R. : Elected a Fellow of the Royal Society, 11
Settlement Size and Population : Increase of, since the Inception of Agriculture (Dr. Max Pettersson), 870
Severing the Olfactory Bulbs · Effect of, on the Intake and Excretion of Water in the Rat (V. Nováková and H. Dlouhá), 638
Sewage Effluent Discharge · Effect of a, on the Deposition of Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith), (R. W. Edwards and J Heywood), 492
Sewage Purification, Institute of : Annual Conference, 127, 938

Sex in a Parthenogenetic Parasite : Environmental Determination of (F. Wilson and L. T. Woolcock), 99
Sex Difference in Accidental Mortality of Guppies exposed to Elevated Temperature (Prof. John A. Freeman), 491
Sex Organ (Male), in certain Fern Species : Purification of a Specific Inducer of the (Ross B. Pringle, Ulrich Naf and Armin C. Braun), 1066
Sex-Ratio : Evolutionary Origin of Sexual Differentiation and the (Dr. H. Kalmus and Dr C. A. B Smith), 1004
Sex Ratio of Ammocoetes (M. W. Hardisty), 988
Sex Ratio at Birth · Dependence of the, on the Age of the Father (Dr. Leo Szilard), 649 , (Dr. A. Comfort), 1065
Sex Ratio in *Drosophila* Homeostasis of the (Dr. P. A. Parsons), 411
Sexual Differentiation : Evolutionary Origin of, and the Sex-Ratio (Dr. H. Kalmus and Dr C. A. B. Smith), 1004
Sexual Reproduction in *Opalina ranarum* Parasitic in *Rana temporaria* : Endocrine Control of (Dr M. El Mofty and Prof. J. D. Smyth), 559
Shain, C. A. : *Obituary* by Dr. J. L. Pawsey, 594
Shakespeare and Medicine (R. R. Simpson), *review* by Sir Russell Brock, 35
Shakespeare's Writings : Medicine in, *review* by Sir Russell Brock, 35
Shanahan, G. J. : Selection for High-Order Resistance to 'Dieldrin' in *Lucilia cuprina* Wied , 100
  Genetics of Resistance to Dieldrin in *Lucilia cuprina* Wied , 181
Shand, J. A., and others · Influence of Geological Features on Very Low Frequency Geomagnetic Fluctuations, 141
Shanta, Dr. P : Recent Advances in Coconut Research in India, 861
Shape Discrimination in *Octopus* : Theories of (The Visual System of *Octopus*), (Dr N. S Sutherland), 840
Shape and Function of a Salivary Mucoprotein : Correlation between Composition, Structure, (Dr. Alfred Gottschalk), 949
Shapley, Prof. Harlow : The Inner Metagalaxy, *review* by Dr. D. W Dewhirst, 109
Sharma, J. C., and others Influence of Dietary Intake of certain Insecticides on the Haemoglobin and Erythrocyte Contents of Chick Blood, 172
Sharman, Dr. B. C *Volvox* Colonies and the Snail 'Cystase', 90
Sharman, D. F. (Ashcroft, G W., and) : 5-Hydroxyindoles in Human Cerebrospinal Fluids, 1050
Sharman, G. A M : Minor Elements in Nutrition (Selenium in Animal Health), 940
Sharp, Dr. R. A., and others : Abundances of the Rare-Earth Elements, Lanthanum to Lutetium, in Chondritic Meteorites, 863
Shearman, D. J. *Obituary* of Dr. Francis Jones, 596
Sheath (Peripheral Nerve Fibre Myelin) Neurokeratin Network of the, as a Centre of Metabolic Activity (Dr. H. B. Tewari and Prof Geoffrey H. Bourne), 645
Sheep . Anthelmintic Efficiency of Tetrachlorodifluoroethane again *Fasciola hepatica* in (J. C. Boray and I. G Pearson), 252
  Methane Exhalation in (E. Cresswell), 560
  Retarded Development of *Ostertagia* Species in (J D Dunsmore), 986
Sheep Husbandry and Wool Technology at Pretoria, 280
Shells of the Snail *Potamopyrgus jenkinsi* (Smith) . Effect of a Sewage Effluent Discharge on the Deposition of Calcium Carbonate on (R. W. Edwards and J. Heywood), 492
Shell Mex and B.P. Ltd : Contribution of £20,000 to the 1962 Centenary Appeal Fund of the University of Southampton, 284
Shepherd, Robert J , and others : Purification and Properties of Cauliflower Mosaic Virus, 656
Shettles, Dr. Landrum B. : Nuclear Morphology of Human Spermatozoa, 648
Shibuya, Dr T. (Takagi, Dr. S. F., and) : Potential Oscillations in the Lower Olfactory Pathway of the Toad, 724
Shielding (Reactor) : Fundamental Aspects of (Dr. Herbert Goldstein), *review* by Dr T. E. Allibone, 917
Shikimic Acid : Production of, by *Penicillium griseofulvum Dierckx* (Prof. Paul Simonart and Anselme Wiaux), 78
Shimizu, Dr. Nobuo, and others : Histochemical Demonstration of Ascorbic Acid in the Locus Coeruleus of the Mammalian Brain, 479
Shimwell, J. L (Carr, J. G., and) . Pigment-producing Strains of *Acetobacter aceti*, 331
Shirasaka, M , and others : Microbiological 11β-Hydroxy Dehydrogenation of Corticosterone, 390
Shirkov, D. V., and others : A New Method in the Theory of Superconductivity (translated from the Russian), *review* by Dr. C. G. Kuper, 833
Shock (Heat) : Blocking of Mitosis by (Per Bergan), 905
Shooter, Dr K. V. : Theory and Practice of Sedimentation, *review*, 56
Shores (Jamaican) : Occurrence of *Halimeda opuntia* var. *minor* on (P. F. James), 493
Short Genetic Interval in *Drosophila melanogaster* : Apparent Double Crossing-Over in a (Prof. M. M. Green), 990
Shrimps · Cave-dwelling (A. Snell), 521
Shunted Flow of Blood (Intrahepatic) in Cirrhosis of the Liver : Measurement of the (T. Nakamura, S. Nakamura and K. Tokita), 243
Sialic Acid (Nonulosaminic Acid) in Protists (Dr. S. Aaronson and T. Lessie), 719
Sialic Acids : Thiobarbituric Acid Spray Reagent for Deoxy Sugars and (Dr. Leonard Warren), 237
Sibatani, Prof A , and others . Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in Animal Cells and its Bearings on Cancer, 215
Sibatani, Prof. A. (Okagaki, H , and) Effects of Chloramphenicol on the Recovery of Ultra-violet-irradiated *Escherichia coli B*, 818
Sickle-Cell Anaemia in Nigerian Children (R. G. Hendrickse), 1027
Siegel, Dr Benjamin V. . Filamentous Structures in Ectromelia Virus-infected Cells, 820
Siegel, Dr B Z , and Siegel, Dr. S M. : Enhancement of Peroxidase Action by Polysaccharides, 391
Siegel, Dr. S M (Siegel, Dr. B. Z , and) : Enhancement of Peroxidase Action by Polysaccharides, 391
Sierra Leone · Sea-Water as the Primary Source of Sulphate in Tidal Swamp Soils from (J. C. D Watts), 308
Sigel, Dr. M. M., and Grant, Dr. L S. : Medical Research in the British Caribbean (Intra-dermal Inoculation against Asian Influenza), 863
Sigmoid Survival Curve in Radiobiology (Dr. Tikvah Alper, Dr. N. E. Gillies and Dr. M. M. Elkind), 1062
Signals (Direct Current) : Transistor Modulators for Low-Level (J. F. Evans), 626
Signals (Radio), from Artificial Satellites : Electron Density Measurements in the Upper Ionosphere using the Faraday Rotation of (Dr. D. McL. A. Wilson), 623
Significance : Earthquakes and Uranus—Misuse of a Statistical Test of (E. J. Burr), 336 ; (Prof. R. Tomaschek), 337
Significance of Adrenals for Increased Oxygen Consumption in Rats during Irradiation (Dr. A Vacek), 90
Significance of the 'Equivalent Redox Potential' in Aqueous Solutions under Ionizing Radiation (Dr. G. H. Cartledge), 370
Significance (Biological), of Peptide containing Hydroxyproline during the Development of Carrageenin Granuloma (Dr. M. Chvapil and B. Cmuchalová), 806
Significant Trends in Medical Research : Ciba Foundation Symposium on (edited by G. E. W. Wolstenholme, Cecilia O'Connor and Maeve O'Connor), *review* by Prof. L J. Witts, 42
Silcox, A. A , and others : Life-like Preservation of Cytoplasmic Detail in Plant Cells, 1068
Silene and *Saponaria* : Basic Chromosome Numbers in (Dr. T. N. Khoshoo), 412
Silica–Alumina Catalysts : Infra-Red Spectra of Ammonia adsorbed on (D. E. Nicholson), 630
Silicon Absorption Spectra of Diatomic Radicals containing Boron or (Dr. B. A. Thrush), 1044
Silicon in the Metal Phase of Enstatite Chondrites (A. E. Ringwood), 465
Silkworm, *Bombyx mori* L. : Xanthine Dehydrogenase in the (Yoshiyuki Hayashi), 1053
Sillans, Roger : Les Savanes de l'Afrique Centrale, *review* by J. P. M. Brenan, 505
Sills, S. A. (Dainton, Prof. F. S , and) : Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide irradiated with Ultra-violet Light, 879
Silobrčič, V , and others : Graft versus Host Reaction in Parabiotic Disease, 322
Siloxane Polymers (Dimethyl) . Proton Magnetic Resonance in a Series of—a Specific Long-Chain Effect? (Dr. J. G. Powles and A. Hartland), 26
Silva, M. A., and others : A Technique for Sampling Oxide Layers and Brittle Materials for Microdiffraction, 147
Silver, Ann : Ataxia in Hens poisoned by Tri*para*ethylphenyl Phosphate, 766
Silver, Dr. Richard T., and others : Evidence for a New Allele in the Kidd Blood Group System in Indians of Northern Mato Grosso, Brazil, 481
Silver Single Crystals : Orientation of Stearic Acid Monolayers on (Robert T. Mathieson), 301
Silver-activated Nitrocellulose as Recording Material for X-Ray Microscopy (Saara K. Asunmaa), 1036
Silver–Cadmium Alloy : Thin Films of (K. Bahadur and P. V. Sastry), 467
Silverblatt, Dr. F. (Green, Dr. H., and) : Effect of Antibody and Complement on Volume Control in an Ascites Tumour Cell, 646
Simmonds, N. W. Bananas, *review* by Prof. C. W. Wardlaw, 48
Simmons, L. M. : Periodic Classification of Elements, 154
Simon, Albert : An Introduction to Thermonuclear Research, *review* by Dr. T. E. Allibone, 917
Simonart, Prof Paul, and Wiaux, Anselme Production of Shikimic Acid by *Penicillium griseofulvum* Dierckx, 78
Simons, Dr. Elwyn L. : *Apidium* and *Oreopithecus*, 824
Simons, Dr. J. P A Model to account for the Production of Vibrationally Hot Molecules in Free-Radical Reactions, 551
Simons, W R. : Use of Miniature Gyroscopes in Aircraft and Guided Missiles, 522
Simonsen, Dr. M. . Awarded a grant from the Tata Memorial Trust, for research on leukaemia and allied diseases, 1020
Simple Method for Obtaining Perforated Supporting Membranes for Electron Microscopy (V. Drahoš and A Delong), 104
Simplified Bulk Growth of *Vibrio foetus* (Dusan Jakovljevic and H. E. R. Beattie), 736
Simplified Method for the Study of Chromosomes in Man (C. Bottura and I. Ferrari), 904
Simpson, F. W. : Changes in the Suffolk Flora during the Past 100 Years (Presidential Address to the Botanical Section of the South-Eastern Union of Scientific Societies), 771
Simpson, Dr. G G. : Man among the Primates, *review*, 665
Simpson, J D., and Greening, Dr. J. R. : Preparation of Tritiated Water Samples by Distillation, 467
Simpson, R. R. : Shakespeare and Medicine, *review* by Sir Russell Brock, 35
Singer, Prof Charles : The Royal College of Surgeons of England, *review*, 35
Singer, Dr. K. (Longstaff, J. V L., and) . Gaussian Wave Functions for the Hydrogen Molecule, 799
Singer, Dr. Leon, and Armstrong, Dr. W. D. : Removal of Strontium from Milk, 484
Single Cells of Mouse Parotid Tumours : Virus Release from (Dr. Mathilde Krim and Dr Leo Sachs), 262
Single Crystals of Copper · Growth of (Rev. D. S. Kemsley), 33 ; (Prof, E N da C. Andrade), 540
Single Crystals of Potassium Chloride containing Barium Chloride · Micromosaic Patterns in (J Ewles and J. B. Dawson), 381
Single Crystals (Aluminium) : First Stage of Work Hardening in (N. A. McKinnon), 148
Single Crystals (Silver) : Orientation of Stearic Acid Monolayers on (Robert T. Mathieson), 301
Single Isolated Mammalian Cells · Are Macromolecules required for Growth of? (Ralph B. Gwatkin), 984
Sirlin, Dr. J L. The Nucleolus Problem, 275
Sites (Specific) : Iodination of, on Bovine Serum Albumin (Dr. David Pressman and Dr Gerald Radzimski), 1049
Sivadon, P , and others : Psychiatric Services and Architecture, 936
Sixth-Form Science as a Preparation for University Work (Dr. W. L. Sumner), 686
60 Years of Learning Theory, *review* by Prof. K. R. L. Hall, 40
Size (Settlement), and Population : Increase of, since the Inception of Agriculture (Dr. Max Pettersson), 870
Size Distribution of Tobacco Smoke Droplets by a Replica Method (W. J. Harris), 537
Skellon, Dr J. A. : Gas Chromatography, 943
Skempton, Prof. A. W. : Fellowship of the City and Guilds of London Institute conferred on, 13

Skin of Rats : Effect of Vitamin A on the Cystine Content in (Prof. Tatsuo Koyanagi and Satoru Odagiri), 809
Skin (Guinea Pig) : Effect of *S*-β-aminoethyl*iso*thiouronium Bromide Hydrobromide on X-Ray Damage to (Dr. J. B. Walter and Prof. D. Slome), 177
Skin (Mouse) · Conjugation of 3:4-Benzpyrenols in (Dr. K. H. Harper and Dr. G. Calcutt), 80
Skin ('Painted' Mouse) : Effect of Molecular Structure upon Concentration of Hydrocarbons in (Mary Burnham and Fred G. Bock), 323
Skin Lesions of Cattle . Isolation of a Cytopathogenic Agent from (Dr. C. Huygelen, D. Thienpont and M. Vandervelden), 979
Skinner, H. H., and others Influence of Route of Inoculation and Strain of Mouse on Infectivity Titrations of the Virus of Foot-and-Mouth Disease, 909
Skinner, Prof. H. W. B : *Obituary* by Dr T. G. Pickavance, 354
Skoglund, Dr. Sten : Activity of Muscle Receptors in the Kitten, 478
Skowrońska-Serafin, B , and others : Antimalarial Properties of some Guanidine Derivatives, 170
Sky : The Night, in May, 284 , in June, 604 ; in July, 938
Skyring, G. W., and Carey, Barbara J. : Nitrogen in Tropical Agriculture (Microbial Species involved in Nitrification and Denitrification), 941
Skyring, G. W. (Martin, A. E., and) : Nitrogen in Tropical Agriculture (Losses of Nitrogen from the Soil/Plant System), 941
Slates (Welsh) . Anisotropy of Susceptibility and the Natural Remanent Magnetization of some (M. D. Fuller), 791
Slevin, Joseph Richard . The Galápagos Islands, a History of their Exploration, 365
Slack, R., and others . Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methyl*iso*thiazole), a New Bacterial Sulphonamide, 221
Slight Structural Resemblance to Natural Bradykinin : Bradykinin Activity of some Synthetic Peptides with only (Dr. G. L. Tritsch and Prof. D W. Woolley), 76
Slipper Limpet, *Crepidula fornicata* L., in Ireland : Occurrence of the (D. C. Arnold), 95
Slome, Prof. D. (Walter, Dr. J. B , and) : Effect of *S*-β-aminoethyl*iso*thiouronium Bromide Hydrobromide on X-Ray Damage to Guinea Pig Skin, 177
Slugs : Chromosome Numbers of (Gillian E. Beeson), 257
Small Intestine : Fate of Bacteria in the (J. M. S. Dixon), 521
Small Rapid Volume Changes in a Muscle during Activity Determination of (Prof. B. C. Abbott and R. J. Baskin), 1055
Smart, Prof. W. M. : Early Science in China, *review*, 36
Smartt, J . Genetic Instability and Out-crossing in the Groundnut Variety Mani Pintar, 1070
Smeaton, Dr. W. A. . Robert Boyle, Father of Chemistry, *review*, 63
Smedley, N. . Archaeology in Suffolk (Presidential Address to the Archaeological Section of the South-Eastern Union of Scientific Societies), 770
Smeed, Dr. R. J : Proneness of Drivers to Road Accidents, 273
Smilagenin (*Epi*-) from *Dioscorea* Saponin . Smilagenone and (D Chakravarti, Prof R. N Chakravarti and M. N. Mitra), 236
Smilagenone and *Epi*-Smilagenin from *Dioscorea* Saponin (D. Chakravarti, Prof. R. N. Chakravarti and M. N. Mitra), 236
Smith, A. G. (Harrison, R. A., and) : Effect of Relative Humidity on Hatching and on Toxicity of Ovicides to Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina Tetranychidae), 409
Smith, A. N. : Boron Deficiency in *Grevillea robusta*, 987
Smith, A. N. (Child, Dr R., and) : Manganese Toxicity in *Grevillea robusta*, 1067
Smith B. S. : Appointed head of the Isotope Research Division of the Atomic Energy Research Establishment, 933 , work of, 933
Smith, Dr C. A. B. (Kalmus, Dr. H., and) : Evolutionary Origin of Sexual Differentiation and the Sex-Ratio, 1004
Smith, Donald W., and others · Mycosides, a New Class of Type-Specific Glycolipids of *Mycobacteria*, 887
Smith, E. B , and Lea, K R. : A Monte Carlo Equation of State for Mixtures of Hard-Sphere Molecules, 714
Smith, Prof. Hobart M. (Boys, Prof Floyd, and) : Poisonous Amphibians and Reptiles, *review* by A. G. C. Grandison, 269
Smith, Honor V. (Hunter, Dr. G , and) : Calcium and Magnesium in Human Cerebrospinal Fluid, 161
Smith, Dr. Isabel W. : Furunculosis in Salmon Kelts, 733
Smith (J. Lawrence) Medal of the United States National Academy of Sciences awarded to Dr. E. J. Öpik, 280, 686 ; *erratum*, 361
Smith, Dr. P. (Robinson, R., and) : Urinary Phenols in Stress, 240
Smith, Robert C., and Wyard, S. J. Electron Spin Resonance in Hydrogen Peroxide–Water Solutions at 90° K. Irradiated with Ultra-Violet Light, 226
Smith, Prof Walter L : Probability and Statistics, 338
Smith, Mrs. Watson (Dr Lucy M. Cranwell), and others · Lower Tertiary Microfossils from McMurdo Sound, Antarctica, 700
Smith-Rose, Dr R. L. : Results of the Royal Society's International Geophysical Year Expedition (Ionospheric Measurements), 191
Smithsonian Institution . Annual Report for 1957-58, 124
  Bureau of American Ethnology, Bulletin No. 170, Excavations at La Venta, Tabasco, 1955 (Philip Drucker, Robert F. Heizer and Robert J. Squier), 134
  Annual Report (1958-59), 443
Smoke Droplets (Tobacco) · Size Distribution of, by a Replica Method (W. J. Harris), 537
Smoking · Cardiovascular Effects of Nicotine and of (New York Academy of Sciences Symposium on), 525
Smooth Muscle . Membrane Potential Changes associated with Stimulation of, by Adrenalin (G Burnstock), 727
Smooth Muscle (Depolarized) : Calcium and Contractility in (Dr. P A. Robertson), 316
Smorodinsky, Ya. (Landau, L. D., and) : Lectures on Nuclear Theory (translated from the Russian), revised edition, *review* by Dr. T E. Allibone, 917
Smyth, Prof. J D. (El Mofty, Dr. M., and) : Endocrine Control of Sexual Reproduction in *Opalina ranarum* Parasitic in *Rana temporaria*, 559
Snail : Multiple Infections of Trematodes in a (Wm. H. Ewers), 990
Snail 'Cystase' : *Volvox* Colonies and (Dr. B C. Sharman), 90
Snail *Potamopyrgus jenkinsi* (Smith) : Effect of a Sewage Effluent Discharge on the Deposition of Calcium Carbonate on Shells of the (R. W. Edwards and J Heywood), 492
Snail (Freshwater) : Chromosomes of *Gyraulus circumstratus*, a (John B. Burch), 497
Snell, A. : Cave-dwelling Shrimps, 521
Snodgrass, Dr. Robert E. : Elected a Foreign Member of the Linnean Society of London, 766
Snow Loads and Roof Designs, 603
Snowman' ('Abominable) : A Reconstruction of the Foot of the (W. Tschernezky), 496
Sobolewski, Georges (Nadeau, Dr. Guy, and) . Tolerance to Drugs, especially to Morphine, 169
Social Aspects : Intraspecific Differentiation—Biological and (Dr. Max Pettersson), 431
Social Implications (Economic and), of Scientific Research and Development : A Bibliography on the (United States National Science Foundation), 14
Social Pathology : Social Science and (Barbara Wootton, assisted by Vera G. Seal and Rosalind Chambers), *review* by Prof. E. Stengel, 41
Social Purposes of Education (K. G. Collier), *review* by Prof. H. L. Elvin, 420
Social Research (Economic and), National Institute of : Economic and Social Studies, Vol. 18, British Industrialists—Steel and Hosiery, 1850-1950 (Charlotte Erickson), *review* by R. Brightman, 347
Social Science, Criminology and Psychiatry, *review* by Prof. E. Stengel, 41
Social Science and Social Pathology (Barbara Wootton, assisted by Vera G. Seal and Rosalind Chambers), *review* by Prof. E. Stengel, 41
Social Sciences Research Council (Colonial) · Report for 1958-59, 501
Società Italiana di Fisica : International School of Physics, 17
Société de Chimie Biologique (Biochemical Society and the) : Joint Meeting to be held in Paris, 440
Société de Chimie Physique Conference on the Structure of Graphite and the Kinetics of its Reactions, 284
Société Française de Métallurgie (Non-destructive Testing Group of the Institute of Physics and the) . Conference on Physical and Structural Aspects of Non-destructive Testing of Metals, 284
Société Française de Minéralogie et de Cristallographie . Index of Crystallographic Supplies (edited by Dr A. J. Rose), second edition, 1019
Société Française de Physique and the Physical Society : Holweck Medal and Prize awarded to J. Brossel, 440
Sociological Imagination (Prof C. Wright Mills), *review* by E Gellner, 504
Sociology : Education in, *review* by Prof. H. L Elvin, 420
Sociology—the New Hope, *review* by E. Gellner, 504
Sodium-24, Potassium-42 and Iodine-131 . Clearance Rates of, in Normal Dog Hip Joints (Prof. Patrick G. Laing and Dr. Ik Dong Kim), 898
Sodium Hydroxide (Concentrated), or Potassium Hydroxide : Photo-stimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with (J Wawrzyniak and Dr. B. Sujak), 467
Sodium Iodide in Benzene : Reaction of *p*-*n*-Decyloxybenzenediazonium Fluoborate with (Prof. W. Bradley and J. D. Thompson), 631
Sodium/Potassium Ratio in Rain-Water (Dr. A. T. Wilson), 705
Soft X-Rays (Ultra-violet and) : A Self-supporting Metal Fresnel Zone-plate to Focus Extreme (Dr. Albert V. Baez), 958
Soil Conditions in New Zealand : An Association between Dental Caries and certain (T. G. Ludwig, W. B. Healy and Capt F. L. Losee), 695
Soil Surfaces (Tropical) : Capillary Movement of Nitrate towards (R. Wesselaar), 572
Soils Discussion Group (Welsh) : Field Meeting, 127
Soils (Paddy), and Rice Production (Dr. H. Greene), 511
Soils (Tidal Swamp), from Sierra Leone Sea-Water as the Primary Source of Sulphate in (J. C. D. Watts), 308
Solar Extreme Ultra-violet Radiation as a Source of Interplanetary Ionization (Dr Hans E. Hinteregger), 523
Solar Flare of July 10, 1959 : Ionospheric Effects associated with the (V. A. H. Harrison), 228
Solar Furnace Glass (Origin of Tektites), (Dr. Gerald S. Hawkins and Dr. Sumner H. Wolfson), 1027
Solar Limb Surges accompanied by X-Ray Emission (Dr. J. Kleczek and Dr. L. Křivsky), 1035
Solar Radio Emission and Polar Cap Absorption of Cosmic Noise : A Relation between (Dr M. R. Kindu and Prof. F. T Haddock), 610
Solar System : Dirac's Cosmology and the Origin of the (Prof. L. Egyed), 621
Solar Terrestrial Relationships (K. D. Cole), 874
Solar Ultra-violet Spectrum : Rocket and Satellite Observations of the (R Grant Athay), 1036
Solberg, Bjorn (Dougherty, Dr. Ellsworth C., and) : Monoxenic Cultivation of an Enchytraeid Annelid, 1067
Solid Imperfections : Superficial Chemistry and (Prof. F. C. Tompkins), 3
Solid Metals Determination of Adsorption in Double Layers involving (Dr. Erik A. Blomgren and Dr. John O'M. Bockris), 305
Solid Oxygen (Copper and), condensed at Very Low Temperatures from a Gas Discharge : Reaction between (Jerome Kruger and William J. Ambs), 794
Solid State Electronics, No 1, 851
Solid State Physics Russian–English Glossary of (edited by I. Emin), *review* by Prof S. I. Tomkeieff, 347
Solids · Conduction of Heat in (Prof H. S Carslaw and Prof J. C. Jaeger), second edition, *review* by Prof L. S. Goddard, 421
  Lattice Defects and the Mechanical Properties of (International Union of Crystallography Symposium on), 1020
  Mathematics and the Conduction of Heat in, *review* by Prof L. S. Goddard, 421
  The Tesla-coil Method for producing Free Radicals from (Dr C. H. Bamford, A D. Jenkins and J. C. Ward), 712
  Time-Dependent Tensile Strength of (Dr. C. C. Hsiao), 535
Soluble (Water-) Methacrylates as Embedding Media for Preparation of Ultra-Thin Sections (Dr. O. Wichterle, Dr. P Bartl and Dr. M. Rosenberg), 494
Solution : Disproportionation and Dimerization of the Benzyloxyl Free Radical in (Dr. J B de Souza and S. K. Ho), 776
Solution (Dilute Aqueous) Chemical Effects of Ionizing Radiation on Deoxyribonucleic Acid in (G. Hems), 710
Solutions (Aqueous) . Use of Nitrous Oxide to discriminate between the Forms of Hydrogen Atoms (H· and H_2^+?) produced by γ-Irradiation of (Prof F. S Dainton and Dr D. R. Peterson), 878
Solutions (Aqueous), under Ionizing Radiation . Significance of the 'Equivalent Redox Potential' in (Dr. G. H. Cartledge), 370

Solutions (Aqueous), of Potassium Iodide irradiated with Ultra-violet Light . Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in (Prof. F S Dainton and S. A. Sills), 879
Solutions (Concentrated) : The Physico-chemical Constants of Binary Systems in (Prof Jean Timmermans), Vol. 1, Two Organic Compounds (without Hydroxyl Derivatives) ; Vol. 2, Two Organic Compounds (at least one a Hydroxyl Derivative), *review* by Dr. E. F. G Herington, 918
Solutions (Cupric Alkanoate) : Nature of (Dr. D. P. Graddon), 715
Solutions (Perchlorate) Preparation of Pure Standard Metallic (E. P Serjeant), 963
Solutions (Water) Ultra-Violet Spectra of (R M Golding), 308
Solvent Polarizability : Effect of, on the Ultra-violet Spectral Shifts of Aromatic Compounds (Dr F. A. Bovey and S. S. Yanari), 1042
Solvents containing Ethyl Iodide : Use of, in the Investigation of Phosphorescence Spectra of Organic Compounds (Dr. I. J. Graham-Bryce and J M. Corkhill), 965
Solvents and Dry Cleaning, 764
Somatic Antigen 15 as a Precursor of Antigen 34 in *Salmonella* (Hisao Uetake and Shin Hagiwara), 261
Somatic Segregation (Spontaneous and Induced) in *Aspergillus nidulans* · High Frequency of (Dr. Etta Kafer), 619
Sommer, Prof. Karlheinz Elected a member of the Medicine Section of the Leopoldina Academy of Natural Sciences, 766
Sondheimer, Dr. E. H. Appointed to the University of London chair of mathematics in Westfield College, 440
Soothill, J. F. (Rowe, D. S , and) : Observations on Globin, Haemoglobin and Haptoglobin using a Rabbit Antiglobin Serum, 975
Sor-Rondane Mountains (Queen Maud Land) . Geological Reconnaissance of the (Prof E. E Picciotto), 740
Sorsby, Arnold, and others (edited by) : Documenta Ophthalmologica (Advances in Ophthalmology, Vol. 13), *review* by R C Davenport, 42
Sounding Rockets (Homer E Newell, jun.), *review* by W. H Stephens, 269
Sounds : Korotkov's—Action of the Heart (Wing-Comdr. J E. Malcolm), 723
Source of Interplanetary Ionization . Solar Extreme Ultra-violet Radiation as a (Dr. Hans E. Hinteregger), 523
Source (Major), of Electrical Energy Fuel Cells—Will they soon Become a (F. T. Bacon), 589
Source (Primary), of Sulphate in Tidal Swamp Soils from Sierra Leone : Sea-Water as the (J. C. D. Watts), 308
Source Book in Greek Science (Prof Morris R Cohen and Dr. I E. Drabkin), second printing, with corrections, *review*, 63
South Africa A Mesozoic Microflora from (A. R. H. Martin), 95
  True's Beaked Whale from the South-East Coast of (F H. Talbot), 406
South Africa, Royal Society of · Election of Officers and Council for 1960, 766
South African Council for Scientific and Industrial Research · Register of Current Scientific Research at South African Universities, 1959 (edited by D. Ryle Masson), 854
South African Universities : Register of Current Scientific Research at, 1959 (edited by D Ryle Masson), (South African Council for Scientific and Industrial Research), 854
South Australia : Late Precambrian Fauna in (M. F. Glaessner and B. Daily), 205
South-East Asia · The Development of Science in (Unesco South-East Asia Science Co-operation Office and the Indonesian Council of Sciences Discussion on), 859
South-Eastern Union of Scientific Societies : Sixty-fifth Annual Congress, 770
  Presidential Address, East Anglian Mammals (Lord Cranbrook), 770
  Presidential Address to the Archaeological Section, Archaeology in Suffolk (N. Smedley), 770
  Presidential Address to the Botanical Section, Changes in the Suffolk Flora during the Past 100 Years (F. W Simpson, 771
  Presidential Address to the Geological Section, Investigating Glacial and Interglacial Geology in East Anglia (Dr. R G West), 771
  Presidential Address to the Zoological Section, Some East Anglian Butterflies (S Beaufoy), 771
South-West Scotland . *Elminius modestus* Darwin in (H Barnes and Margaret Barnes), 989
Southern Auroral Zone : Geometry of the, and the Evidence for the Existence of an Inner Zone (Dr. T. Hatherton), 288
Southern Regional Council for Further Education . Twelfth Annual Report, 123
Southern Sweden · Fall-out Radioactivity in (Prof. Pontus Ljunggren), 655
Soviet Industry : Automatic Control in (Department of Scientific and Industrial Research), 287
Soviet Reviews of Nuclear Science on the 40th Anniversary of the October Revolution, *review* by Dr. T. E Allibone, 917
Space · Between Earth and (Dr. Clyde Orr, Jr), *review* by B. R. Leaton, 68
Space (Interplanetary) : Cosmic Ray Intensity in (Dr H Elliot), 299
Space Flight Problems of, *review* by D G. King-Hele, 59
Space Science (Dr. R. L F. Boyd), 749
Space Science (Committee on Space Research of the International Council of Scientific Unions first International Symposium on), 749
Specialization (Sensory), in Response to Environmental Demands (Zoological Society of London Symposium on), 688
Speciation (Sympatric) . Selective Visits of Butterflies to Flowers—a Possible Factor in (K R Dronamraju), 178
Specific Detection of Glucose on Paper Chromatograms (Dr M R J Salton), 966
Specific Inducer of the Male Sex Organ in certain Fern Species Purification of a (Ross B Pringle, Ulrich Naf and Armin C. Braun), 1066
Specific Inhibition of Obligate Anaerobes (Dr. Herbert N. Prince), 816
Specific Interaction of Native Protein and Inorganic Salts (Folke Rønnike), 88
Specific Long-Chain Effect ? · Proton Magnetic Resonance in a Series of Dimethyl Siloxane Polymers—a (Dr. J. G. Powles and A. Hartland), 26
Specific Nucleoprotein Reaction in Cell Nuclei : Quantitative Cytochemical Observations on a (Dr. E. A. Barnard), 447
Specific Sites : Iodination of, on Bovine Serum Albumin (Dr. David Pressman and Dr. Gerald Radzimski), 1049
Specific Stain for Mast Cell Granules (Dr. B. G. Radden), 400
Specificity Loss of, on Passage of Immunologically Competent Cells in the Chick Embryo (Sir Macfarlane Burnet and Georgiana Boyer), 175
Specificity (Pathogenic) : An Enzymic Basis for (Elizabeth M. C. Turner), 325
Specimen (A New), of *Nipa* Fruit from Mohgaonkalan Cherts (Dr S. D. Chitaley), 495
Specimens (Type), of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick Catalogue of the (J F. Gates Clarke), Vol 3, Tortricidae, Olethreutidae, Noctuidae, *review* by R. G. Fennah, 188
Spector, W. G., and Willoughby, D A : Suppression of Increased Capillary Permeability in Injury by Monoamine Oxidase Inhibitors, 162
Spectra (Absorption), of Diatomic Radicals containing Boron or Silicon (Dr B. A Thrush), 1044
Spectra (High-Resolution Nuclear Magnetic Resonance), of Starch Gels : Broadening of the Water Proton Line in (Dr. Roger Collison and Dr M. P. McDonald), 548
Spectra (Infra-Red), of Ammonia adsorbed on Silica–Alumina Catalysts (D. E. Nicholson), 630
Spectra (Infra-Red), of Deoxyribonucleic Acids from Human Leucocytes (G. Zerbi, P. A. Bianchi and E E. Polli), 964
Spectra (Infra-red), of Deuterium-labelled Carbohydrates (Dr S. A. Barker, R. H Moore, Prof. M. Stacey and Dr. D. H. Whiffen), 307
Spectra (Phosphorescence), of Organic Compounds Use of Solvents containing Ethyl Iodide in the Investigation of (Dr. I. J. Graham-Bryce and J M. Corkill), 965
Spectra (Ultra-Violet), of Water Solutions (R M. Golding), 308
Spectral Shifts (Ultra-violet), of Aromatic Compounds . Effect of Solvent Polarizability on the (Dr F A. Bovey and S. S Yanari), 1042
Spectrofluorimetry (Photoelectric Spectrometry Group Meeting on), 938
Spectroscopic Applications of Photographic Emulsion Mosaics (Prof. R W. Nicholls), 715
Spectroscopy : Russian–English Glossary of Optics and, *review* by Prof. S. I. Tomkeieff, 347
Spectroscopy (Atomic Absorption) : Determination of Calcium in Blood Serum by (J B. Willis), 249
Spectrum (Infra-Red), of Garnets (P. Tarte), 234
Spectrum (Solar Ultra-violet) Rocket and Satellite Observations of the (R. Grant Athay), 1036
Speden, I. G., and others : Lower Tertiary Microfossils from McMurdo Sound, Antarctica, 700
Speeds (Wind), near a Tornado . Measurement of, 360
Spencerism : Herbert, *review* by Dr John Tucker, 37
Spermatozoa (Flagellate) · Position of the Proximal Centriole in (Prof. Vishwa Nath, Brij L. Gupta and L C Mittal), 899 ; (Dr. J. Bronte Gatenby and R. S. Mathur), 900
Spermatozoa (Human) . Nuclear Morphology of (Dr. Landrum B. Shettles), 648
Sperry, Prof R. W. : Elected a member of the United States National Academy of Sciences, 773
Sphere (Hard-) Molecules : A Monte Carlo Equation of State for Mixtures of (E. B. Smith and K. R. Lea), 714
Spider *Uloborus walckenaerius* Latreille Unusual Web Pattern made by an Unfertilized Female of the (Dr. Rasza Szlep), 94
Spider Mite (Red), *Tetranychus telarius* (L.) (Acarina : Tetranychidae) : Effect of Relative Humidity on Hatching and on Toxicity of Ovicides to Eggs of the (R. A. Harrison and A. G Smith), 409
Spiers, Veronica M., and others A Technique for Sampling Oxide Layers and Brittle Materials for Microdiffraction, 147
Spin Resonance (Electron) : Study of the Oxidation of Hindered Phenols by (Dr J. E. Bennett), 385
Spin Resonance (Electron), in Hydrogen Peroxide–Water Solutions at 90° K. Irradiated with Ultra-Violet Light (Robert C. Smith and S. J Wyatt), 226
Spinach Chloroplasts (Isolated) : Induction Phenomena in Photosynthesis of (Dr. Knud Vejlby), 652
Spinning Satellites (Fast) . Faraday Effect in the Transmissions from (R. S. Roger and J. H. Thomson), 622
Spirochaeta Phage · A (Dr. Ralph A. Lewin), 901
Spirostomum and *Blepharisma* Effect of Centrifugation on the Macronucleus of (Prof. B. R. Seshachar), 333
Spleen (Ox) : Absence of Catecholamines in Cardioactive Acetone Extracts of (Dr. L. B. Cobbin and Prof. R. H. Thorp), 473
Splitting Component (Indoxyl-acetate), in the α_2-Globulin Region of Normal Human Sera : Agar-gel Electrophoretic Demonstration of Individual Variations in Electrophoretic Position of an (Dr Jan Hirschfeld), 321
Sponges · Influence of Environment on the Distribution and Form of (Prof. M. A Ali), 177
Spontaneous Generation · Thermodynamics and Kinetics of (Dr. D. E Hull), 693 ; (Prof. J. D Bernal), 694
Spontaneous Potential Changes at Crayfish Neuromuscular Junctions (Dr Josef Dudel and Richard K. Orkand), 476
Spontaneous Potentials from Explants of Brain Tissue in Culture (Prof A. W B. Cunningham, Marshall Dougherty and B. J. Rylander), 477
Spontaneous and Induced Somatic Segregation in *Aspergillus nidulans* . High Frequency of (Dr. Etta Kafer), 619
Spooner, Dr. E. T. C. Medical Research in the British Caribbean, 862
Spores of the Fungus *Allomyces* : Cell Wall Formation in (J M. Aronson and Prof. R. D. Preston), 95
Sporidesmin (Facial Eczema Toxin) Detection and Estimation of a (G R. Russell), 788
Spot Formation (Multiple), by Pure Substances : Paper Chromatography—(Dr. A. H Beckett, M. A. Beaven and Dr. Ann E Robinson), 775
Spot Tests for Nitrogenous Compounds : Use of Ionizing Radiation in (H. J M. Bowen, E. Arter and P. A. Cawse), 383
Spray Reagent (Thiobarbituric Acid), for Deoxy Sugars and Sialic Acids (Dr. Leonard Warren), 237
Spray-dried Danish Milk : Caesium-137 in (Per Gert Jensen), 562
Spray-Drop Data . Distribution-Free Interpretation of (John B. Opfell), 822
Sprayed Mud Surfaces : Determination of Dieldrin Deposits on (Dr. R. E. Ford), 994
Spreadborough, J. (Bollmann, W., and) : Action of Graphite as a Lubricant, 29
Spring Oat Variety resistant to the Stem Eelworm (T. Glyn Davies), 813
Sproson, J. C. (Earnshaw, A W., and) : Rheological Properties of Barytes Suspensions, 378

Spruce Sulphite Fibres : Structure of the Outer Secondary Wall on Unbleached (O. Kallmes and J. A. S Newman), 566
Sputnik III Profile of Upper-Atmosphere Air Density at the Height of 180-212 km. derived from the Orbit of (Z. V. Bochníček), 460
Sputnik (*Korabl'*-), 598
Squier, Robert J., and others : Excavations at La Venta, Tabasco, 1955, 134
Srivastava, Prof B. K., and others : Influence of Dietary Intake of certain Insecticides on the Haemoglobin and Erythrocyte Contents of Chick Blood, 172
St. Lawrence Seaway (Lionel Chevrier), *review* by Prof R. W. Steel, 110
St. Lawrence Seaway (Prof. T. L. Hills), *review* by Prof. R W. Steel, 110
St. Mary's Hospital Medical School, London : Grant of £2,500 per annum for up to 5 years from the Wellcome Trust, to provide technical assistance and research expenses for work on the physiology of pre-natal growth, 439
  Appointment of Dr R. E. O. Williams to the University of London chair of bacteriology, 938, 1016
St. Salvator's College, St Andrews : Appointment of Dr. D. V. Osborne as senior lecturer in the Department of Natural Philosophy, 767
Stability in Celestial Mechanics (Prof Yusoke Hagihara), *review* by Dr. R. H. Garstang, 60
Stability (Glutathione), and Pyrophosphatase Activity in Reticulocytes—Direct Evidence for the Importance of Glutathione for the Enzyme Status in Intact Cells (Prof. S Rapoport and D. Scheuch), 967
Stacey, Prof M., and others Pentafluoropyridine, 231
  Infra-red Spectra of Deuterium-labelled Carbohydrates, 307
  Behaviour of some Aldehydes on a Sulphonated Polystyrene Resin, 469
Stachera, H. S. . Appointed lecturer in electronics at the University of Southampton, 284
Staff College for Technical Teachers, 185
Stage (Perfect), of *Fusarium oxysporum* Schl. forma *pisi* (Lindf.) S. and H. ? : Is *Nectria haematococca* Berk. and Br. the (W. L Gordon), 903
Stage (Perfect), of *Microsporum gypseum* (Dr. D. M. Griffin), 94
Stage (Perfect), of *Sclerotium rolfsii* Sacc. (Prof. A P. Misra and S. Q. Haque), 567
Stain (A Specific), for Mast Cell Granules (Dr. B. G. Radden), 400
Staining Schedules : Biology (R. R. Fowell), sixth edition, 125
Staining Sectioned Tissues with Lead for Electron Microscopy : A Method of (Dr. J. D. Lever), 810
Stalker, G. M. (Burns, Tom, and) : Human Problems of Innovation—Based on a Study of some Scottish Firms (Department of Scientific and Industrial Research, Problems of Progress in Industry No. 5), 419
Stamburgo, M., and others Synergetic Action of 2(*o*-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia, 893
Stamp, Prof. L. Dudley : Physical Geography, *review*, 190
  The Le Play Society, 606
Standard Metallic Perchlorate Solutions : Preparation of Pure (E. P. Serjeant), 963
Standardization of Drugs : The Use of Laboratory Animals in the (Research Defence Society, Pamphlet No 1;), 438
Standards, United States National Bureau of : Monograph No. 5, Preservation of Documents (W. K. Wilson and B W. Forshee), 124
Standards (New Weight), for Men and Women (Metropolitan Life Insurance Co Ltd , New York, Bulletin, Vol 40), 445
Standing Advisory Committee for Medical Research in the British Caribbean Fifth Annual Scientific Conference, 862
Stanley, H M. : Polymeric Progress (The Impact of Petrochemical Development on the Plastic Industry), 442
Stansfield, Prof. H. *Obituary* by C. E. Chester, 517
Staphylococcal Virulence for Mice : Enhancement of, by Intraperitoneal Cortisone Acetate, Cholesterol and Lecithin (Dr Daniel Amsterdam and Dr. S Stanley Schneierson), 101
Staphylococci (Penicillin-treated) : Streptomycin-induced Lysis of (Dr R. Hancock), 658
Staphylococcus aureus Isolation of a Phagocytosis-inhibiting Substance from Culture Filtrates of an Encapsulated (Dr. Stephen I. Morse), 102
Starch-gel Electrophoresis Separation of the α- and β-Chains of Globins by means of (C. J Muller), 643
Starch Gels : Broadening of the Water Proton Line in High-Resolution Nuclear Magnetic Resonance Spectra of (Dr. Roger Collison and Dr. M P McDonald), 548
Starch—Agar-Gel Electrophoresis of Tuberculoproteins from Heated Culture Filtrates (T. P. Dekker), 392
Starlings : Radar 'Ring Angels' and the Roosting Movements of (E. Eastwood, G. A. Isted and G. C. Rider), 112
Starr, Dr. Kenneth W. : Biological Equilibria in Human Cancer, 1006
Starr, Mortimer P., and others (edited by) : Annual Review of Microbiology, Vol. 13, *review* by Dr. B A. Newton, 49
Stars : Existence of Net Electric Charges on (Prof. V. A Bailey), 508
  Man's Conquest of the (Pierre Rousseau), *review* by D. H. P Jones, 69
State A Monte Carlo Equation of, for Mixtures of Hard-Sphere Molecules (E. B. Smith and K. R. Lea), 714
State Scholarships and Commonwealth Co-operation, 935
States (New) : Science in the Advancement of (Weizmann Institute of Science International Conference on), 604
States (Steady) : Autocatalytic Particles and (Dr. Allan Campbell), 256
Statically Indeterminate Structures : A Treatise on, *review* by Prof. A. J.S. Pippard, 582
Statistical Methods in Biological and Medical Sciences, *review* by R. M. Cormack, 746
Statistical Methods in Biology (Dr. Norman T. J. Bailey), *review* by R. M. Cormack, 746
Statistical Review (Registrar General), Part 2, Tables, Population, 765
Statistical Society (Royal) : Election of Officers, 1020
Statistical Test of Significance : Earthquakes and Uranus—Misuse of a (E J. Burr), 336 ; (Prof. R. Tomaschek), 337
Statistics at University College, London, 599
Statistics : Information Theory and (Prof. Solomon Kullback), *review* by Prof Colin Cherry, 506
  Probability and (Prof. Walter L. Smith), 338
Statistics (Elementary), with Applications in Medicine and the Biological Sciences (Prof Frederick E. Croxton), *review* by R. M. Cormack, 746
Statistics (United Kingdom Petroleum Industry), relating to Consumption and Refinery Production, 1958 and 1959 (Petroleum Information Bureau), 851
Status (Professional) : Higher National Certificates and, 123
Status and Development of the Teaching of Chemistry (Organization for European Economic Co-operation Seminar on the), 208
Statutory Bodies concerned with Scientific Research and Technical Services in the Federation of Rhodesia and Nyasaland : Government Organizations and, 202
Steady States : Autocatalytic Particles and (Dr. Allan Campbell), 256
Stearic Acid Molecules in Monolayers : Overturning of (George L. Gaines, jun.), 384
Stearic Acid Monolayers : Orientation of, on Silver Single Crystals (Robert T. Mathieson), 301
Stebbing, Prof. E P *Obituary* by Sir Harry Champion, 515
Steel, Prof. R. W. : The St. Lawrence Seaway, *review*, 110
Steel : Effect of Moisture on Carboxylic Acid Adsorption to (M. E. Schrader and J. L. Kalinsky), 710
Steer Hide : Liberation of Hexuronic Acid, Hexosamine and Hydroxyproline from, by Stem Bromelain (E. A. Botan and T B. Brother), 314
Stein, Dr G., and others . Mechanism of the Oxidation and Reduction of Metal Ions by Hydrogen Ions, 629
Stein, Prof. W. H. : Elected a member of the United States National Academy of Sciences, 773
Stein-Werblowsky, R. : Induction of a Chorion-epitheliomatous Tumour in the Rat, 980
Steinbuch, Dr. M., and Niewiarowski, Dr S. : Rivanol in the Preparation of Plasminogen (Profibrinolysin), 87
Steiner, Dr R. E. : Sechzig Jahre Medizinische Radiologie, *review*, 921
Steinmann Medal of the Deutsche Geologische Vereinigung awarded to Prof H H Read, 206, 690
Stem Bromelain : Liberation of Hexuronic Acid, Hexosamine and Hydroxyproline from Steer Hide by (E. A. Botan and T. B Brother), 314
Stem Eelworm : A Spring Oat Variety resistant to the (T Glyn Davies), 813
Stengel, Prof. E. : Social Science, Criminology and Psychiatry, *review*, 41
Stenhouse, David The Redpoll in New Zealand—Interbreeding Subspecies, 488
Stephens, W. H : Sounding Rockets, *review*, 269
Stephenson, Prof. T. A., and Wareing, Prof. P. F : New Biology Building of the University College of Wales, Aberystwyth, 1021
Stereobalanus, a Genus New to the Old World (C Burdon-Jones and A. D. McIntyre), 491
Stereospecificity in Hydrolysis by Chymotrypsin : Requirements for—Diethyl β-Acetamidoglutarate (Prof. Saul G Cohen and Ezra Khedouri), 75
Steric Course of Microbiological Reactions (edited by G. E. W. Wolstenholme and Cecilia M. O'Connor), *review* by Prof. D. C. Harrison, 835
Sterilizing Doses of X-Rays : Divergence between Lethal Doses and, with Progressive Development in *Habrobracon* Females (Dr. Howard E. Erdman), 254
Stern, Prof. Curt A Mosaic of *Drosophila* consisting of 1X, 2X and 3X Tissue and its Probable Origin by Mitotic Non-disjunction, 179
Steroid Chemistry, *review* by Dr. W Klyne, 668
Steroids (Prof. Louis F. Fieser and Mary Fieser), *review* by Dr. W. Klyne, 668
Steroids (Hormonally Active) : A New Class of (Dr. E. H Reerick, H F. L. Scholer, P. Westerhof, A. Querido, A A H Kassenaar, E Diczfalusy and K C Tillinger), 168
Sterol Analysis by Gas Chromatography (R. K. Beerthuis and J. H. Recourt), 372
Sterols Ciba Foundation Symposium on the Biosynthesis of Terpenes and (edited by G. E. W Wolstenholme and Maeve O'Connor), *review* by Dr D T. Elmore, 745
Sterols and Terpenes, *review* by Dr. D. T. Elmore, 745
Stevens, Dr. B., and Hutton, E. : Radiative Life-time of the Pyrene Dimer and the Possible Role of Excited Dimers in Energy Transfer Processes, 1045
Stevens, Dr. I D. R. : Appointed lecturer in chemistry at the University of Southampton, 284
Stevenson, Dr. A. C Human Growth, 19
Stevin, Simon : The Principal Works of (edited by Prof. D. J. Struik), Vol. 2A, Mathematics , Vol 2B, Mathematics, *review* by Dr. J F. Scott, 60
Stevin's Mathematical Works, *review* by Dr J. F. Scott, 60
Steward, E G., and Cook, B P. Mosaic Texture of Graphites, 797
Stewart, C. M. : Detoxication during Secondary Growth in Plants, 374
Stewart, F. S., and Pearson, Dr. A. E G : Estimation of Mouse Tumour Blood Volumes employing a Radioactive Isotope Technique, 250
Stewart, J. E., and others Microquantitative Infra-Red Analysis—Application to Gas Chromatographic Fractions, 628
Stewart, N. G. : Appointed head of the Health Physics Division of the Atomic Energy Research Establishment, 933 ; work of, 933
Stewart, N. G. (Burton, W. M., and) : Use of Long-lived Natural Radioactivity as an Atmospheric Tracer, 584
Stewart, Sarah E., and others : Development of Resistance in Mice to Tumour Induction by S E Polyoma Virus, 615
Stilboestrol labelled with Carbon-14 . Enzymic Oxidation of (P H Jellinck), 157
Stiles, Prof W : Advances in Plant Physiology, *review*, 747
Still, Dr. C. J. : *Obituary* by Dr D Hamer, 848
Stimulating Effects of Nuclear Radiations on Development and Productivity of Rice Plants (Dr. Maung Mya Thaung), 982
Stimulation of Phagocytic Activity of the Reticulo-Endothelial System : Duration of, after Cessation of Treatment with Diethylstilboestrol (C. C. Ware and Prof. T Nicol), 974
Stimulation of Smooth Muscle by Adrenalin : Membrane Potential Changes associated with (G. Burnstock), 727
Stimulation (Dichotic), and Memory Disorder (Prof James Inglis), 181
Stimulation (Electrical) : Effect of, on a Muscle Fibre Model in the Presence of Adenosine Triphosphate (Prof. Masahiro Fujino, Tatsuaki Matsushima, Tomizo Muroya, Hideyo Yabu, Saburo Yamaguchi and Masaki Takahashi), 318
Stimulation (Vagal) or Acetylcholine Administration : Intracellular Potentials in Rat Atria during and after (P. A. Biersteker, J. Th. F. Boeles and L. N. Bouman), 637
Stjarne, L. (Bygdeman, M., and) : Effects of 1,4-Dihydrazinophthalazine on the Catechol Amines, 82
Stolk, Prof. A. : Cytoplasmic Inclusions of the Ageing Neurons of some Teleosts, 332

Stone, Prof. W. S.: Elected a member of the United States National Academy of Sciences, 773
Stoneley, Dr. R.: *Obituary* of Prof. B. Gutenberg, 433
Storage: The Theory of (Prof. P. A. P. Moran), *review* by D. G. Kendall, 344
Store: Food Losses in Field and (Nutrition Society Symposium on), 685
Stork, Prof G J.: Elected a member of the United States National Academy of Sciences, 773
Stormont, Prof. Clyde, and others: Bacterially Mediated False-Positive Reactions in Lytic Blood-Typing Tests, 247
Stour Estuary Mud Fauna of the (Frances Bull, Helen Honeyman and Susan Knott), 1018
Strachey, John: The End of Empire, 501
Strahlenbiologie—Grundlagen und Ergebnisse (Prof. Dr Hedi Fritz-Niggli), *review*, 66
Strain of Mouse: Influence of Route of Inoculation and, on Infectivity Titrations of the Virus of Foot-and-Mouth Disease (Wendy Heatley, H. H. Skinner and H. Subak-Sharpe), 909
Strain (Original), and Sub-line of the Ascites Tumour resistant to Alkylating Reagents Non-Protein Sulphydryl Group in the (Iwao Hirono), 1059
Strains (Pigment-producing), of *Acetobacter aceti* (J. G. Carr and J. L. Shimwell), 331
Strathy Bog Nature Reserve, 358
Stratified Flow (Thermally): Wind Profile in (W. C. Swinbank), 463
Stratigraphic Correlation: West-Pacific (Dr M. F. Glaessner), 1039
Stratigraphy of some Bottom Sections from the Central Pacific: On the (F. Brotzen and A Dinesen), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 10, Special Investigations, No. 4), 609
Stratton, Dr. F.: World Distribution of ABO Blood Groups, *review*, 581
Stratton, Prof. F. J. M.: *Obituary* of Prof. S A. Mitchell, 200
Stratton, G. Burder (edited by). The Zoological Record, Vol. 93, Being the Records of Zoological Literature, relating chiefly to the Year 1956, *review* by Dr. Edward Hindle, 831
Streisinger, Dr. George Appointed associate professor of biology in the Institute of Molecular Biology at the University of Oregon, 681; work of, 681
Strength (Time-Dependent Tensile), of Solids (Dr C. C Hsiao), 535
Streptococci (Lactic): Heritable Changes in, induced by Physical Treatments (B. S. Gossling), 868
Streptomycin-induced Lysis of Penicillin-treated *Staphylococci* (Dr. R. Hancock), 658
Stress: Urinary Phenols in (R. Robinson and Dr. P Smith), 240
Stretch, K L.: Appointed vice-principal of the College of Advanced Technology, Birmingham, 12; work of, 12
Stretch, Roger G. A. Exploratory Behaviour in the Rat, 454
Stretching Frequencies (Metal-ligand), of some Metal Hydrazine Complexes: The 'Irving–Williams' Order in the (Prof L. Sacconi and A. Sabatini), 549
Strontium: Removal of, from Milk (Dr. Leon Singer and Dr. W. D. Armstrong), 484
Strontium-90 in Milk and Agricultural Materials in the United Kingdom, 1958-59 (Agricultural Research Council), 852
Strontium-90 in the 'Mixed Layer' of the Atlantic Ocean (Dr. Vaughan T. Bowen and Prof Thomas T Sugihara), 71
Strontium-90 Content of British Diet, 852
Structural Aspects (Physical and), of Non-destructive Testing of Metals (Non-destructive Testing Group of the Institute of Physics and the Société Française de Métallurgie Conference on), 284
Structural Lipoprotein of Rat Liver: Binding of a Hepatocarcinogen to the—its Bearing on the Immunological Theory of Cancer (J. W. Westrop and Prof H. N Green), 350
Structural Loading in Factories (Department of Scientific and Industrial Research), 851
Structural Resemblance (Slight), to Natural Bradykinin: Bradykinin Activity of some Synthetic Peptides with only (Dr. G. L. Tritsch and Prof. D. W. Woolley), 76
Structural Tool for the Chemist, *review* by Prof E. R. Andrew, 55
Structure of Bhilawanol (Dr. Bernard Loev), 389
Structure of Graphite and the Kinetics of its Reactions (Société de Chimie Physique Conference on), 284
Structure of High-Rank Coals deduced from Helium Densities (T. S. Polansky, H J. Donald and Prof. C. R. Kinney), 792
Structure of the Outer Secondary Wall on Unbleached Spruce Sulphite Fibres (O. Kallmes and J A S Newman), 566
Structure of a Periclinical Chromosomal Chimera of Apple: Changes in, following X-Irradiation (Charlotte Pratt), 255
Structure of the Upper Mantle as derived from the Travel Times of Seismic *P* and *S* Waves (Dr. I. Lehmann), 956
Structure of the Viscous Phase of Liquid Sulphur (Dr. E. McLaughlin), 76
Structure (Antigenic), of Non-Infectious Adenovirus Materials (Dr. H. G. Pereira), 571
Structure (Collagen): Reversible Transformation of Gelatin to the (Dr. Arthur Veis and Dr. Jerome Cohen), 720
Structure (Crystal), of Adenosine-5'-Phosphate (J. Kraut and L. H. Jensen), 798
Structure (Crystal), of Indanthrene: Electron Microscopy and the (Lewis T. Chadderton), 541
Structure (Crystal), of Mellitic Acid (S F. Darlow), 542
Structure (Crystal), of Potassium Trivanadate (Dr. Stanley Block), 540
Structure (Crystal), of Tetraphenyl*cyclo*butadiene Iron Carbonyl (R. P. Dodge and Dr V. Schomaker), 798
Structure (Crystal) Determination. Modern Methods of (Manchester College of Science and Technology Summer School in), 766
Structure (Electronic), of Molecules, *review* by Prof C. A Coulson, 54
Structure (Letter), of the English Language (A. D. Baddeley, R. Conrad and W. E. Thomson), 414
Structure (Microscopic), of some Wools. Anomalies in the (T. D. Brown and W J Onions), 93
Structure (Molecular) Effect of, upon Concentration of Hydrocarbons in 'Painted' Mouse Skin (Mary Burnham and Fred G. Bock), 323
Structure (Primary), of the Protein of Tobacco Mosaic Virus (F. A. Anderer, H. Uhlig, E. Weber and Prof. G. Schramm), 922
Structure (Ultra-) of the Clear Cells in Renal Carcinomas and its Importance for the Demonstration of their Renal Origin (Prof Ch. Oberling, M. Rivière and Fr. Haguenau), 402
Structure (Ultra-) of Human Amnion and its Possible Relation to the Circulation of Amniotic Fluid (Dr. Gordon L. Bourne and Dr. Dennis Lacy), 952
Structure and Function: Protein (Brookhaven National Laboratory thirteenth Symposium in Biology), 361
Structure and Function of Genetic Elements—Report of Symposium held June 1959 (Brookhaven Symposia in Biology, No. 12), *review* by Prof. S C. Harland, 63
Structure and Growth of Plant Cell-Walls, *review* by Prof. R. D. Preston, 920
Structure, Shape and Function of a Salivary Mucoprotein: Correlation between Composition, (Dr. Alfred Gottschalk), 949
Structures: Hyperstatic (Prof J. A. L. Matheson), Vol. 1, *review* by Prof A. J. S. Pippard, 582
  A Treatise on Statically Indeterminate, *review* by Prof. A. J. S. Pippard, 582
Structures corresponding to Terminal Bars and Terminal Web in Many Types of Cells (Prof. C. P. Leblond, Holde Puchtler and Y. Clermont), 784
Structures (Cylindrical): Electromagnetic Radiation from (James R. Wait), *review* by W. Brown, 583
Structures (Filamentous), in Ectromelia Virus-Infected Cells (Dr. Benjamin V. Siegel), 820
Struik, Prof. D J (edited by): The Principal Works of Simon Stevin, Vol. 2A, Mathematics; Vol. 2B, Mathematics, *review* by Dr. J. F. Scott, 60
Stuart, Dr K. L: Medical Research in the British Caribbean (Hypertension in Jamaica and St. Kitts), 862
Student's Introduction to Physics (Franklin Miller, Jr), *review* by T. M. Yarwood, 68
Students, National Union of Memorandum to the University Grants Committee on the Expansion of University Education (1960-1970), 687
Students (Postgraduate): The Training of, 915
Students (University): The Needs of, 687
Studentships and Fellowships (Agricultural Research Council), 126
Studies (Business): The Future Development of Management Education and of—Revision of Joint Examination Schemes (Ministry of Education, Circular 1/60), 743
  Management, Education and, 743
Studies (Comparative), of Yeasts (J. A. Barnett), 449
Studies (Economic), concerning Africa South of the Sahara: Inventory of—an Annotated Reading List of Books, Articles and Official Publications (edited by Peter Ady), (Commission for Technical Co-operation in Africa South of the Sahara, CSA/CCTA Publication No 30, Joint Project No. 4), 202
Studies (Genetical and Biochemical), of the Immobilization Antigens of *Paramecium aurelia* (J. O Bishop and Dr. G H. Beale), 734
Studies (Histochemical and Biochemical), of Rat Liver in Experimental Cirrhosis after Partial Hepatectomy (I. Bartók, Gy Domján, R. Horváth and Prof. B. Korpássy), 397
Studies (Management): Report of the Working Party appointed to examine the Scheme of (Ministry of Education, Appendix to Circular 1/60), 743
Studies (Radio), of the Universe (Dr. R. D. Davies and Dr. H. P. Palmer), *review* by Dr. J. S. Hey, 59
Studies (X-Ray), of some Carbonized Coals (R. Diamond and P. B. Hirsch), 204
Study of Chemical Thermodynamics An Introduction to the (Prof. D. H. Everett), *review* by Prof A. R. Ubbelohde, 55
Study of Chromosomes in Man: A Simplified Method for the (C. Bottura and I Ferrari), 904
Study of Human Biology, Society for the: Symposium on Human Growth, 19
Study of Man (Prof. Michael Polanyi), *review* by F I G. Rawlins, 347
Study of the Oxidation of Hindered Phenols by Electron Spin Resonance (Dr. J. E. Bennett), 385
Study (Histophotometrical), of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat (S L. Liu), 475
Study (A Synoptic), of Infra-red Radiation over the United States (Dr. John L. Gergen and Dr. William F. Huch), 426, *erratum*, 604
Study (X-Ray Diffraction), of Denatured Ferritin and Apoferritin (Vladimir Kleinwachter), 313
Study Group on the Mental Health Problems of Automation (World Health Organization, Report Series No. 183), 364
Studying the Quantitative Aspects of Cytochemical Reactions: A New Technique for, and its Application to the Feulgen Reaction (P. van Duijn and J. P. Persijn), 805
Stunkard, Dr. Albert J., and others: Improvement of the Intravenous Glucose Tolerance Test, 808
Sturgeon, Dr. R J.: Appointed to the Biochemistry Section of Twyford Laboratories, Ltd, London, 523
Sub-aquatic Medicine (Club Alpin Sous-Marin International Colloquium on), 440
Sub-line (Original Strain and), of the Ascites Tumour resistant to Alkylating Reagents: Non-Protein Sulphydryl Group in the (Iwao Hirono), 1059
Sub-normal Level of Carbonic Anhydrase in Blood of Carcinoma Patients? (Dr N. W H. Addink), 253
Sub-Zero Temperatures. Effect of, on Diapause Eggs of *Acheta commodus* (Walk), (T. W. Hogan), 98
Subak-Sharpe, H, and others: Influence of Route of Inoculation and Strain of Mouse on Infectivity Titrations of the Virus of Foot-and-Mouth Disease, 909
Substances with Gibberellin-like Biological Properties: Distribution and Prevalence of *Fusarium moniliforme* Sheld (*Gibberella fujikuroi* (Saw.) Wr) producing (Prof W. L. Gordon), 698
Substances (Gibberellin-like), in Lettuce Seed: Presence of (Dr. S. Blumenthal-Goldschmidt and Prof. A. Lang), 815
Substances (Pure) Paper Chromatography—Multiple Spot Formation by (Dr A. H. Beckett, M. A. Beaven and Dr. Ann E. Robinson), 775
Substitutes (Indian), of Male Fern in Pharmacognosy (Prof. P. N. Mehra and T. C. Mittal), 722
Substrate: Accumulation of, by Isolated Rat Diaphragm—a Possible Mechanism for the Anti-Inflammatory Action of Corticosteroids (Prof. Ira G. Wool), 728

Substrates and Inhibitors (Chymotrypsin) Inhibition of the Anaphylactic Release of Histamine from Chopped Guinea Pig Lung by (Dr. K. F. Austen and Dr. W. E. Brocklehurst), 866
Succinate, Adenine Nucleotides and Thyroxine Swelling of Fresh and Aged Liver Mitochondria as affected by (Dr. P. Emmelot, C. J. Bos, P. J. Brombacher and I H. M Reyers), 556
Succinate Oxidation (α-Ketogluratate and), in E-Deficient Liver Homogenates · Maintenance of, by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine (Dr Laurence M. Corwin and Dr Klaus Schwarz), 1048
Suffolk Archaeology in (N Smedley), 770
Suffolk Flora · Changes in the, during the Past 100 Years (F. W Simpson), 771
Suffolk Naturalists' Society Transactions, Vol 11, Part 3, Mud Fauna of the Stour Estuary (Frances Bull, Helen Honeyman and Susan Knott), 1018
Suffolk Ponds and Pond Animals (J. E. Marston), 771
Suffredini, C S, and others Abundances of the Rare-Earth Elements, Lanthanum to Lutetium, in Chondritic Meteorites, 863
Sugars (3-Deoxy) . Estimation of, By means of the Malonaldehyde–Thiobarbituric Acid Reaction (Dr. Morris A. Cynkin and Dr. Gilbert Ashwell), 155
Sugars (Deoxy), and Sialic Acids Thiobarbituric Acid Spray Reagent for (Dr. Leonard Warren), 237
Sugihara, Prof Thomas T. (Bowen, Dr. Vaughan T, and) : Strontium-90 in the 'Mixed Layer' of the Atlantic Ocean, 71
Sugiura, S (Nakahira, Dr. M, and) A Regular Mixed-Layer Chlorite–Vermiculite Mineral, 877
Suitability of the General Certificate of Education Advanced Level Syllabuses in Science as a Preparation for Direct Entry into First Degree Courses in the Faculty of Science . Report of an Enquiry into the (University of Birmingham), 687
Sujak, Dr. B (Wawrzyniak, J, and) · Photostimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide, 467
Sullivan, T J . Effect of Manganese Edetate on Blood Formation in Rats, 87
Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methylisothiazole), a New Antibacterial Sulphonamide (A Adams, W. A. Freeman, A. Holland, D Hossack, J. Inglis, J. Parkinson, H. W. Reading, K Rivett, R. Slack, R Sutherland and R Wren), 221
Sulphate : A Modification for Washing the Benzidine Sulphate Precipitate in the Determination of (Dr. I. P. T. Hakkinen), 232
Sulphate in Tidal Swamp Soils from Sierra Leone Sea-Water as the Primary Source of (J C D Watts), 308
Sulphate (Benzidine) Precipitate : A Modification for Washing the, in the Determination of Sulphate (Dr I P. T. Hakkinen), 232
Sulphate (Peroxy Titanium) : Nature of the Colour-forming Species in (Dr C C Patel and M. S Mohan), 803
Sulphate (Zinc) Treatment of Parakeratosis in Cattle (S P. Legg and L. Sears), 1061
Sulphates (Isomeric Chondroitin) Identification of (J B Adams), 555
Sulphite Fibres (Spruce) : Structure of the Outer Secondary Wall on Unbleached (O Kallmes and J. A Newman), 566
Sulphonamide (Antibacterial) . Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methylisothiazole), a New (A. Adams, W. A. Freeman, A. Holland, D. Hossack, J. Inglis, J. Parkinson, H. W. Reading, K. Rivett, R. Slack, R. Sutherland and R. Wren), 221
Sulphonated Polystyrene Resin : Behaviour of some Aldehydes on a (Dr S. A. Barker, K Murray and Prof. M. Stacey), 469
Sulphoxide ((+) S-Methyl-L-Cysteine), an Inhibitor of Aspartic Acid Utilization in *Leuconostoc mesenteroides* (Wilfred N Arnold, Clayton J. Morris and John F Thompson), 1051
Sulphur Aspects of the Organic Chemistry of (Prof. Frederick Challenger), *review* by Dr. F G Mann, 53
  The Organic Chemistry of, *review* by Dr F G. Mann, 53
Sulphur-35 : Release of Methionine labelled with, from Muscle Tissue and Mitochondria (Dr. R. Zák and Dr. Z. Drahota), 973
Sulphur Compounds The Metabolism of (Leslie Young and George A. Maw), *review* by Dr. G. D. Greville, 424
Sulphur Deposits (Coloured), at Low Temperatures (Dr. B Meyer and Prof E. Schumacher), 801
Sulphur (Liquid) . Structure of the Viscous Phase of (Dr. E. McLaughlin), 76
Sulphydryl Compounds : Effect of Oxygen on the Radiosensitivity of Bacteriophage in the Presence of (Dr. P. Howard-Flanders), 485
Sulphydryl Compounds in Rat Liver : Level of, following Feeding with Goitrogenous and Non-goitrogenous Cabbage (Jozef Sedlák), 892
Sulphydryl Content of the Embryos of the Australian Cattle Tick (W. J. Roulston and C. A. Schuntner), 1069
Sulphydryl Group (Non-Protein), in the Original Strain and Sub-line of the Ascites Tumour resistant to Alkylating Reagents (Iwao Hirono), 1059
Summer Laboratory Course in Techniques and Applications of the Electron Microscope (Cornell University), 127
Sumner, Dr. W L. : Sixth-Form Science as a Preparation for University Work, 686
Sun : Density of the Upper Atmosphere and its Dependence on the, as revealed by Satellite Orbits (D. G. King-Hele and D. M. C. Walker), 928
Sun and its Influence (Prof M. A Ellison), second edition, *review* by Prof C. W. Allen, 69
Sunspot Number in 1968 . An Estimate of the Peak (C. M. Minnis), 462
Superconductivity : Methodology and, *review* by Dr. C. G Kuper, 833
  A New Method in the Theory of (N. N. Bogoliubov, V. V Tolmachev and D V Shirkov), translated from the Russian, *review* by Dr. C. G. Kuper, 833
Supercontraction of Wool Fibres and Creep in the Post-yield Region (Dr. K. J. Whiteley), 473
Supercooled Liquids Reduced Temperatures for Nucleation in (Dr. E. R. Buckle), 875
Supercooled Salol Ultrasonic Propagation Constants in (Dr. S. Parthasarathy and V. N. Bindal), 145
Superficial Chemistry and Solid Imperfections (Prof. F. C. Tompkins), 3
Superior Galactic Communities . Communications from (Prof. R. N. Bracewell), 670
Supernatant Potassium-Level : Effect of, on Cardiac Activity in Quantitative Tissue Culture (Prof A. W. B Cunningham, K Kleutch and W Herbst), 241
Supersonic Flow (Unsteady) The Potential Theory of (Prof. John W. Miles), *review* by L E Fraenkel, 505
Supply, Ministry of Technical Note No. *A.D* W.6, Making of Models of Aircraft with shells consisting of 'Araldite' Glasscloth Laminate, 360
Supply and Training of Teachers for Technical Colleges (Ministry of Education), 185
Supporting Membranes (Perforated), for Electron Microscopy A Simple Method for obtaining (V. Drahoš and A Delong), 104
Suppression of Increased Capillary Permeability in Injury by Monoamine Oxidase Inhibitors (W G. Spector and D. A. Willoughby), 162
Surface The Lunar (V. A. Firsoff), 826 ; (Dr B. E J. Pagel), 826
Surface Film : Piling-up of Dislocations beneath a (A. R. C. Westwood and L. J Demer), 146
Surface Instabilities in a Linear Pinched Discharge · Growth of (Dr. R. Latham, J. A Nation, F. L. Curzon and Dr A. Folkierski), 624
Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide : Photo-stimulated Emission of Exo-electrons from the (J Wawrzyniak and Dr. B. Sujak), 467
Surface Roughness (Cathode), and Oxidation : Effect of, on Arc Movement (Dr. T. J. Lewis and Dr. P. E. Secker), 30
Surface Temperature of Swedish Lakes and the Origin of Rainfall (Vilhelm Irgens Pettersson), 945
Surface Tissue of the Tongue : Amino-Acid Composition of Proteins from (Dr. C J. Barnes and Dr L N Ferguson), 617
Surface-Active Compounds : Methods for the Evaluation of the Antibacterial Activity of (Society for Applied Bacteriology and the Microbiology Group of the Society of Chemical Industry Symposium on), 131, *erratum*, 206
Surfaces (Sprayed Mud) · Determination of Dieldrin Deposits on (Dr R. E. Ford), 994
Surfaces (Tropical Soil) Capillary Movement of Nitrate towards (R. Wetselaar), 572
Surfactants (Non-Ionic) : Effects of, upon Animal Tissues (Helen Goldhammer and W R McManus), 317
Surgeons of England The Royal College of—a History (Sir Zachary Cope), *review* by Prof Charles Singer, 35
Surgery (Veterinary) Advances in, *review* by G. N. Gould, 667
Surges (Solar Limb), accompanied by X-Ray Emission (Dr J. Kl̓eczek and Dr L. Křivský), 1035
Surveying (Geological), by Helicopter, 521
Survival Curve (The Sigmoid), in Radiobiology (Dr. Tikvah Alper, Dr N. E. Gillies and Dr M M. Elkind), 1062
Susceptibility : Anisotropy of, and the Natural Remanent Magnetization of some Welsh Slates (M. D. Fuller), 791
Susceptibility Levels (Normal), of *Anopheles pharoensis* Theobald to DDT and Dieldrin (Dr. F Kuhlow), 410
Suspensions (Barytes) · Rheological Properties of (A. W Earnshaw and J. C. Sproson), 378
Sussex, Dr Ian M : Appointed associate professor (plant morphogenesis) in the Department of Botany in Yale University, 1020
Sutcliffe, H Appointed to a senior lectureship in electrical engineering in the University of Bristol, 284
Sutcliffe, Dr R. C. · Results of the Royal Society's International Geophysical Year Expedition (Ozone Distribution), 191
Sutherland, Dr. J. W · Appointed an I.C.I. Research Fellow in the University of Edinburgh, 767
Sutherland, Dr. Margaret : The Lack of Thinking in Examinations, 607
Sutherland, Dr. N. S. : The Visual System of *Octopus*—Theories of Shape Discrimination in *Octopus*, 840
Sutherland, R, and others Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methylisothiazole), a New Antibacterial Sulphonamide, 221
Sutton, E P. Applied Hydrodynamics, *review*, 669
Sutton, Sir Graham : The Royal Society's Expedition to Halley Bay during the International Geophysical Year, 191
Sutton, Lawrence · Appointed education officer to the Institution of Works Managers, 206
Suzuki, Yoshiko, and others . Bacterially Mediated False-Positive Reactions in Lytic Blood-Typing Tests, 247
Sved, S, and others : Crystallization of Purified Mouse Encephalomyocarditis Virus Particles, 908
Sveriges Geologiska Undersokning Ser C, No. 560, The Measurement of Rock Pressure in Mines (Nils Hast), 936
Svoboda, Dr. Jan : Presence of Chicken Tumour Virus in the Sarcoma of the Adult Rat inoculated after Birth with Rous Sarcoma Tissue, 980
Svorad, Dr D : Postural Changes in Chlorpromazine Hypothermia, 240
Swamp Soils (Tidal), from Sierra Leone Sea-Water as the Primary Source of Sulphate in (J. C. D. Watts), 308
Sweden (Southern) : Fall-out Radioactivity in (Prof. Pontus Ljunggren), 665
Swedish Deep-Sea Expedition, 1947-48 : Reports of the, Vol. 6, Sediment Cores from the West Pacific, Nos. 4-7 , Vol. 7, Sediment Cores from the North Atlantic Ocean, Nos. 4-5 ; Vol. 8, Sediment Cores from the Mediterranean Sea and the Red Sea, No 1 , Vol. 10, Special Investigations, Nos. 2-4, 609
Swedish Interplanetary Society · Eleventh International Astronautical Congress, 523
Swedish Lakes . Surface Temperature of, and the Origin of Rainfall (Vilhelm Irgens Pettersson), 945
Swelling of Calcium Montmorillonite (Dr A. V. Blackmore and Prof B P. Warkentin), 823
Swelling of Fresh and Aged Liver Mitochondria as affected by Succinate, Adenine Nucleotides and Thyroxine (Dr. P. Emmelot, C. J. Bos, P. J. Brombacher and I. H. M. Reyers), 556
Swinbank, W. C : Wind Profile in Thermally Stratified Flow, 463
Swinburne Award (Plastics Institute), 126
Swinton, Dr. W. E. : *Obituary* of Dr. Roy Chapman Andrews, 594
Sydney Hospital Appointment of Dr. H. M. Whyte as director of the Department of Medical Research in the Kanematsu Memorial Institute of Pathology, 849
  Appointment of Dr. A. A. Palmer as director of the Department of Clinical Pathology in the Kanematsu Memorial Institute of Pathology, 850
Sydney Museum of Applied Arts and Sciences : Annual Report for 1958, 683
Sykes, Dr. J. B. : Atomic Terminology, *review*, 67
Symbol (Arrow), in Biology (Dr A E. Needham), 103
Symbolic Logic and Intelligent Machines (Edmund C. Berkeley), *review* by Dr. A D. Booth, 422

Symmetry of Insulin Dimers and Hexamers (Prof. Barbara W. Low and J. Ralph Einstein), 470
Symons, Dr. C, and others : Antithromboplastin in Human Serum and Plasma, 248
Sympathectomy (Cervical), and Pituitary Stalk Section : Influence of, upon Milk Secretion in Goats (G B. Tverskoy), 782
Sympatric Speciation : Selective Visits of Butterflies to Flowers—a Possible Factor in (K. R. Dronamraju), 178
Synchronization Experiments (Long-range Clock) : Preliminary Flight Tests of an Atomic Clock in Preparation of (Friedrich H. Reder and Gernot M. R. Winkler), 592
Synergetic Action of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia (Dr. E. Fischer, J. L J. Szabó and M. Stamburgo), 893
Synoptic Study of Infra-red Radiation over the United States (Dr John L. Gergen and Dr. William F Huch), 426, *erratum*, 604
Synovial Proliferation induced by Polysaccharides (D. P. Page Thomas, J. T. Dingle and E. R Cook), 251
Syntheses : Organic, Vol. 49 (edited by Max Tishler), *review* by Prof. John Read, 669
Synthesis of 6-O-Acetyl-α-Glucose (Y. Z. Frohwein and Prof. J. Leibowitz), 153
Synthesis of Carotene : Effect of Diphenylamine on the (Gy. Schneider, Dr. B. Matkovics, J. Zsolt and Ö. Kovács), 235
Synthesis of Cellular Proteins : Ribonucleic Acids and the (Prof. J. Brachet), 194
Synthesis of Contractile Proteins in the X-Irradiated Embryo (Dr. Yoshito Ogawa), 77
Synthesis of Deoxyribonucleic Acid : Mechanism of the Radiation Effect on the (Dr. R. J. Berry, E. Hell, Dr L. G Lajtha and Dr M Ebert), 563
Synthesis in Micro-organisms : Organization, Control and, *review* by Dr. B. A. Newton, 49
Synthesis of Polypeptides : A Novel (Dr J. Oró and C. L. Guidry), 156
Synthesis (Hydrocarbon), and Hydrocarbon Conversion (Indian Institute of Science Symposium on), 691
Synthesis (Nicotinamide Mononucleotide), by Human Erythrocytes : Age Difference in (Dr. Vlastimil Habermann and Sona Habermannová), 389
Synthesis (Organic) Light-initiated, *review* by Prof. R. N. Haszeldine, 53
Synthesis (Organic Acid), in Tomato Roots (J van Die), 603
Synthesis (Radiation), of Urea (S. Dilli and J. H Green), 383
Synthetic Peptides with only Slight Structural Resemblance to Natural Bradykinin : Bradykinin Activity of some (Dr. G. L. Tritsch and Prof D. W. Woolley), 76
Synthetic Polyelectrolytes as Tumour Inhibitors (Dr. William Regelson, Stephan Kuhar, Marvin Tunis, Joseph Fields, John Johnson and Earl Gluesenkamp), 778
System (Aluminium–Zinc–Magnesium) : A Trace Element Effect in Alloys based on the (I. J. Polmear), 303
System (General), of Insect Migration and Dispersal by Flight : A Basis for a (C. G. Johnson), 348
System (An Indicator Plaque-forming), for Demonstration of Interference by Non-cytocidal Strains of Rabies Virus (Dr. Martin M. Kaplan, Dr. Eberhard Wecker, Dr. Zlatko Forsek and Dr Hilary Koprowski), 821
System (Kidd Blood Group) : Evidence for a New Allele in the, in Indians of Northern Mato Grosso, Brazil (Dr. Richard T Silver, Jane M Haber and Dr. Aaron Kellner), 481
System (Radiocarbon Dating), using Scintillation Techniques (C. F. G. Delaney and I. R. McAulay), 204
System (Solar) : Dirac's Cosmology and the Origin of the (Prof. L. Egyed), 621
System (The Visual), of *Octopus*—Regularities in the Retina and Optic Lobes of *Octopus* in relation to Form Discrimination (Prof. J. Z. Young), 836 ; Discrimination of Polarized Light by *Octopus* (M. F. Moody and J. R. Parriss), 839 ; Theories of Shape Discrimination in *Octopus* (Dr. N. S. Sutherland), 840
Systems : Visco-Elastic (Australian Commonwealth Scientific and Industrial Research Organization Symposium on), 942
Systems (Binary), in Concentrated Solutions : The Physico-chemical Constants of (Prof. Jean Timmermans), Vol. 1, Two Organic Compounds (without Hydroxyl Derivatives) ; Vol. 2, Two Organic Compounds (at least one a Hydroxyl Derivative), *review* by Dr. E. F. G. Herington, 918
Systematic Method for the Construction of Error-correcting Group Codes (Prof. R. B. Banerji), 627
Systems (Hoagland's 'Carbowax') : Freezing-Point Depressions of (Howard G. Applegate), 232
Systems (Two-Component Two-Phase) : Thermodynamical Relations in (Prof. H. Kaufman), 299
Szabó, J. L. J., and others : Synergetic Action of 2(o-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia, 893
Szarski, Prof. K. W. : *Obituary* by Prof. A. D Peacock, 679
Szilard, Prof Leo : Dependence of the Sex Ratio at Birth on the Age of the Father, 649
Szilard, Prof. Leo, and Wigner, Prof. Eugene P. : Awarded jointly the Atoms for Peace Award for 1959, 357
Szlep, Dr. Rasza : Unusual Web Pattern made by an Unfertilized Female of the Spider *Uloborus walckenaerius* Latreille, 94
Szweykowska, Alicja (Allsopp, Dr. A., and) : Foliar Abnormalities, including Repeated Branching and Root Formation, induced by Kinetin in Attached Leaves of *Marsilea*, 813

TABLES of Physical and Chemical Constants and some Mathematical Functions (Dr. G. W. C. Kaye and Dr. T. H. Laby), twelfth edition, *review* by T. M. Yarwood, 67
Tagiuri, Renato, and Petrullo, Luigi (edited by) : Person Perception and Interpersonal Behavior, *review* by Prof M D. Vernon, 919
Tail Length : The Growth in Weight and, of Inbred and Hybrid Mice reared at Two Different Temperatures (Prof. G. A. Harrison, R. J. Morton and Dr. J S. Weiner), 446
Takagi, Dr S. F., and Shibuya, Dr. T : Potential Oscillations in the Lower Olfactory Pathway of the Toad, 724
Takahashi, Masaki, and others : Effect of Electrical Stimulation on a Muscle Fibre Model in the Presence of Adenosine Triphosphate, 318
Takahashi, T., and others : Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in Animal Cells and its Bearings on Cancer, 215
Takasaki, R, and others : Microbiological 11β-Hydroxy Dehydrogenation of Corticosterone, 390
Talarico, Massimo, and others : Enzymatic Deamination of 5-Deoxycytidylic Acid and of 5-Methyl-5'-deoxycytidylic Acid in Growing and in Non-growing Tissues, 237
Talbot, F. H. True's Beaked Whale from the South-East Coast of South Africa, 406
Tannenbaum, Sheila, and others : Development of 5-Hydroxytryptophan Decarboxylase Activity in Rat Kidney, 717
Tanner, Dr. J M. : Human Growth, 19
Tapered Distensible Vessels, Reflexions, and the Hosie Phenomenon Pulsatile Flow through (Robert L. Evans), 290
Tarte, P. : Infra-Red Spectrum of Garnets, 234
Tasmania : A Telemetered Seismic Net in (Prof. Gordon Newstead and P. A Watt), 704
Tata, Dr. J. R. : Elected to a Beit Memorial Senior Fellowship for Medical Research, 520
Tata Memorial Trust : Awards for Research on Leukaemia and Allied Diseases, 1020
Tatlow, Prof J. C., and others : Pentafluoropyridine, 231
Tawab, Salah A., and others : Antipyretic Action of *l*-Phenyl-3,5-pyrazolidinedicne, 165
Taylor, Dr C. A. : 'Eidophor' Television Technique, 773
Taylor, Prof J H. : Elected a Fellow of the Royal Society, 11
Taylor, J. R. : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Taylor, L. R. : Mortality and Viability of Insect Migrants High in the Air, 410
Taylor, Monica : Recovery of Adult *Amoeba lescherae* from Dried Cultures, 329
Taylor, the late Dr. Wilfrid . Modern Explosives, 204
Teachers in Britain : Recruitment of, 600
Teachers for the Commonwealth Conference, 281
Teachers for Technical Colleges : The Supply and Training of (Ministry of Education), 185
Teachers, National Union of . University Entrance—the Basic Facts, 14
Teachers (Science) : Competition for (*Teaching Science*), 126
Teachers (Technical) : A Staff College for, 185
  Training of (Northern Advisory Council on Further Education), 281
Teaching : Films and Film Strips in, 360
  Science and Mathematics, 850
Teaching within the British Commonwealth, 281
Teaching of Chemistry : Status and Development of the (Organization for European Economic Co-operation Seminar on the), 208
Teaching of Pathology : Preventive Aspects in the (World Health Organization, Technical Report Series No 175), 602
Teaching of Veterinary Anatomy as a Branch of Biology—its Relationships to Human Anatomy (Dr. R. A. Green), 192
Teaching Science : Competition for Science Teachers, 126
Teaching and Research in British Universities, 1959 : The Use of Film in (British Universities Film Council), 444
Teale, Dr. F W. J. : Appointed lecturer in biochemistry at the University of Birmingham, 937
Technical Books . Recent Scientific and, Supp. vi, April 30 , Supp. vi, May 28 , Supp. vi, June 25
Technical Colleges . Governing, 769
  The Supply and Training of Teachers for (Ministry of Education), 185
Technical Colleges and their Government (Joint Federation of British Industries Technical Colleges Committee), 769
Technical Conferences (Scientific, Medical and) . Guide to Press Arrangements for (edited by Ronald Bedford), 437
Technical Co-operation in Africa South of the Sahara, Commission for : CSA/CCTA Publication No. 30 (Joint Project No. 4), Inventory of Economic Studies concerning Africa South of the Sahara—an Annotated Reading List of Books, Articles and Official Publications, (edited by Peter Ady), 202
Technical Course (Theoretical and), on Aerial Photogrammetry (École Nationale des Sciences Géographiques), 127
Technical Papers (Medical and), prepared by Research Workers (Cyanamid International, London, new list of), 523
Technical Research (Scientific and) : Co-operation in the Field of (Organization for European Economic Co-operation), 998
Technical Services in the Federation of Rhodesia and Nyasaland : Government Organizations and Statutory Bodies concerned with Scientific Research and, 202
Technical Teachers : A Staff College for, 185
  Training of (Northern Advisory Council on Further Education), 281
Technicians and Assistants : Laboratory (Ministry of Labour and National Service, Choice of Careers Series No. 94), 682
Technique : 'Eidophor' Television (Dr. C. A Taylor), 773
Technique for Sampling Oxide Layers and Brittle Materials for Microdiffraction (A M Adams, M. A Silva and Veronica M. Spiers), 147
Technique (A New), for Studying the Quantitative Aspects of Cytochemical Reactions and its Application to the Feulgen Reaction (P. van Duijn and J. -P. Persijn), 805
Technique (Radioactive Isotope) . Estimation of Mouse Tumour Blood Volumes employing a (F. S. Stewart and Dr. A. E. G. Pearson), 250
Techniques and Applications of the Electron Microscope (Cornell University Summer Laboratory Course in), 127
Techniques (Practical Field), in Physical and Cultural Geography (Geographical Association Course in), 1020
Techniques (Scientific), in Art and Archaeology (Dr. A. E Werner), 674
Techniques (Scientific), in the Conservation of Paintings, 437
Techniques (Scintillation) : Radiocarbon Dating System using (C. F. G. Delaney and I R. McAulay), 204
Technological Awards, National Council for . Honorary diploma in technology (engineering) awarded to Lord Hives, 767
Technological Use of Radiation (Australian Atomic Energy Commission Conference on) 126
Technology, Bradford Institute of (Department of Chemical Technology) : Symposium on Co-ordination Compounds, their Chemistry and Applications, 440

Technology, Finland's Institute of: Scientific Researches No. 13, Traffic Accidents and Driver Characteristics (Sauli Hakkinen), 273

Technology, Loughborough College of: Appointment of Dr. W. F. Floyd as first head of the Department of Ergonomics and Cybernetics, 523

Technology · Reactor Fuel Element (Imperial College of Science and Technology Course of Lectures in), 1025

Technology (Advanced), Birmingham College of Appointment of K. L. Stretch as vice-principal, 12

Technology (Glass), Society of *Glass Technology*, Vol 1, No. 1, 601
  Physics and Chemistry of Glass, Vol 1, No 1, 601

Technolgoy (Wool) : Sheep Husbandry and, at Pretoria, 280

Tektites : High-Temperature Fusing of Possible Parent Materials for (Origin of Tektites), (L. F. Lovering), 1028
  Origin of—Solar Furnace Glass (Dr Gerald S Hawkins and Dr Sumner H Wolfson), 1027 ; High-Temperature Fusion of Possible Parent Materials for Tektites (J. F. Lovering), 1028

Telemetered Seismic Net in Tasmania (Prof Gordon Newstead and P. A. Watt), 704

Teleosts · Cytoplasmic Inclusions of the Ageing Neurons of some (Prof. A. Stolk), 332

Telescope · Astronomical Photography at the (Thomas Rackham), *review by* D. H. P. Jones, 190

Telescope (Radio), at Jodrell Bank : Cost of the, 13

Television Technique : 'Eidophor' (Dr. C. A. Taylor), 773

Temperature : The Delta Plutonium Transition (Dr. R. G Cope), 539
  Effect of, on Growth in Weight and Tail-length of Inbred and Hybrid Mice (Prof. S. C. Harland), 446
  Effect of, on the Hibernation of the European Corn Borer (Stanley D. Beck), 774
  Influence of, upon Blood Coagulation in a Cold- and a Warm-blooded Animal (Dr. H. B. Anstall and Dr. R. G. Huntsman), 726

Temperature Changes in the Antarctic Atmosphere (Dr. H. Wexler), 445

Temperature Variation (Diurnal), in the Rhesus Monkey under Normal and Experimental Conditions (Dr. Lloyd B. Erikson), 83

Temperature (Elevated) : Sex Difference in Accidental Mortality of Guppies exposed to (Prof. John A. Freeman), 491

Temperature (Environmental) : Oxygen Consumption in Cattle in relation to Rate of Increase in (Prof. H. H. Kibler), 972

Temperature (High-) Creep of Graphite (Dr. D. B. Fischbach), 795

Temperature (High-) Fusion of Possible Parent Materials for Tektites (Origin of Tektites), (J. F. Lovering), 1028

Temperature (Low-) Photoproducts : Regeneration of Visual Pigments from their Dr. C. D. B Bridges), 292

Temperature (Low-) Research Fritz London Award for, 205

Temperature (Surface), of Swedish Lakes and the Origin of Rainfall (Vilhelm Irgens Pettersson), 945

Temperatures : The Growth in Weight and Tail Length of Inbred and Hybrid Mice reared at Two Different (Prof. G. A. Harrison, R. J. Morton and Dr J. S. Weiner), 446

Temperatures (Low) : Coloured Sulphur Deposits at (Dr. B. Meyer and Prof. E. Schumacher), 801

Temperatures (Reduced), for Nucleation in Supercooled Liquids (Dr. E R. Buckle), 975

Temperatures (Sub-Zero) · Effect of, on Diapause Eggs of *Acheta commodus* (Walk.), (T. W. Hogan), 98

Temperatures (Very Low) . Reaction between Copper and Solid Oxygen condensed at, from a Gas Discharge (Jerome Kruger and William J. Ambs), 794

ten Bruggencate, Prof. Paul . Elected a member of the Astronomy Section of the Leopoldina Academy of Natural Sciences, 766

ten Doesschate, J., and others (edited by) : Documenta Ophthalmologica (Advances in Ophthalmology, Vol 13), *review* by R. C. Davenport, 42

Tendipes f. l. plumosus L. : Haemoglobin Content of the Larvae of, from Various Levels of Bed Sediment (B Czeczuga), 484

Tensile Behaviour of Pyrolytic Graphite at 2,750°C. (H. E. Martens and W. V Kotlensky), 960

Tensile Strength (Time-Dependent), of Solids (Dr C. C. Hsiao), 535

Tensions (Different), of Oxygen : Some Effects of, on the Respiration and Growth of *L*-Strain Fibroblasts (A. R. Fisher), 315

Tentori, L. (Cavallini, Dr. D., and) · Inability of Thiotaurine to protect Mice against Ionizing Radiation, 254

Teoretisk Atomfysik, Nordisk Institut for (Copenhagen) : Årsberetning (1957-58), 850

Teratology Society : Formation of the, 937
  Election of Officers, 937

Tercentenary Exhibition (Royal Society), 1016

Terminal Bars and Terminal Web : Structures corresponding to, in Many Types of Cells (Prof C. P. Leblond, Holde Puchtler and Y. Clermont), 784

Terminal Web (Terminal Bars and) : Structures corresponding to, in Many Types of Cells (Prof. C. P Leblond, Holde Puchtler and Y. Clermont), 784

Terminology : Atomic—a Dictionary of Nuclear Science, Engineering and Technology in Four Languages (English–German–French–Italian), (compiled by Dr Lore Lettenmeyer), *review* by Dr. J. B. Sykes, 67

Terms (Geological) : Glossary of, *review* by Dr. V A. Eyles, 57

Terpenes . Sterols and, *review* by Dr. D. T. Elmore, 745

Terpenes and Sterols Ciba Foundation Symposium on the Biosynthesis of (edited by G E. Wolstenholme and Maeve O'Connor), *review* by Dr. D T. Elmore, 745

Terrestrial Relationships · Solar (K. D. Cole), 874

Territories (Overseas), of the British Commonwealth : Scientific Research in the, 501

Tertiary Microfossils (Lower), from McMurdo Sound, Antarctica (Dr. Lucy M. Cranwell (Mrs. Watson Smith), Dr. H. J. Harrington and I. G. Speden), 700

Tesla-coil Method for Producing Free Radicals from Solids (Dr. C. H. Bamford, A. D. Jenkins and J. C Ward), 712

Test : A Phenylthiocarbamide (André Leguebe), 970

Test (A Differential), of Arts/Science Aptitude (L. Hudson), 413

Test (Glucose Tolerance) : Improvement of the Intravenous (Dr. John C. Seed, Dr. Forman S. Acton and Dr. Albert J Stunkard), 808

Test (Statistical), of Significance Earthquakes and Uranus—Misuse of a (E. J. Burr), 336 ; (Prof R. Tomaschek), 337

Testicular Interstitial Cell Nucleus in the Adult Rat : Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the (S. L. Liu), 475

Testing : Milk (Dr. J. G. Davies), second edition, *review* by A. L. Provan, 835

Testing for Niacin : A Micromethod for (E. Medveczky), 332

Testing (Non-destructive), of Metals : Physical and Structural Aspects of (Non-destructive Testing Group of the Institute of Physics and the Société Française de Métallurgie Conference on), 284

Tests : European Barley, 16

Tests (Lytic Blood-Typing) : Bacterially Mediated False-Positive Reactions in (Prof Clyde Stormont, Yoshiko Suzuki and W. J. Miller), 247

Tests (Preliminary Flight), of an Atomic Clock in Preparation of Long-range Clock Synchronization Experiments (Friedrich H. Reder and Gernot M. R Winkler), 592

Tests (Spot), for Nitrogenous Compounds : Use of Ionizing Radiation in (H. J. M. Bowen, E. Arter and P A. Cawse), 383

Tetrachlorodifluoroethane . Anthelmintic Efficiency of, against *Fasciola hepatica* in Sheep (J. C. Boray and I. G. Pearson), 252

Tetrahydroaminacrin : Blocking Effect of, on a New Psychotomimetic Agent (Dr. Samuel Gershon), 1072

Tetranychus telarius (L.) (Acarina : Tetranychidae) (Red Spider Mite) : Effect of Relative Humidity on Hatching and on Toxicity of Ovicides to Eggs of the (R. A. Harrison and A. G. Smith), 409

Tetraphenyl*cyclo*butadiene Iron Tricarbonyl : Crystal Structure of (R. P. Dodge and Dr. V. Schomaker), 798

Tetrazolium Salt in Ascites Tumours Viability and (Dr. Gustav Dallner), 176

Tewari, Dr. H. B , and Bourne, Prof. Geoffrey H. : Neurokeratin Network of the Peripheral Nerve Fibre Myelin Sheath as a Centre of Metabolic Activity, 645

Texas Instruments, Inc., Dallas : Annual Report for 1959, 602

Textile Conference (Wool) : Second Quinquennial (Textile Institute), 206

Textile Engineering, *review* by Prof. C. S Whewell, 189

Textile Engineering Processes (edited by Prof A. H. Nissan), *review* by Prof C. S. Whewell, 189

Textile Institute : Second Quinquennial Wool Textile Conference, 206
  Golden Jubilee, 360
  Annual Conference (Fibre Science), 360
  Presidential Address (Earl of Derby), 436

Texture (Mosaic), of Graphites (E. G. Steward and B. P. Cook), 797

Thankam, C. K. : Recent Advances in Coconut Research in India, 861

Thaung, Dr. Maung Mya : Stimulating Effects of Nuclear Radiations on Development and Productivity of Rice Plants, 982

Theobroma cacao L. in West Africa : Variation in *Phytophthora palmivora* (Butl.) Butl. on (P. D. Turner), 495

Theorem Godel's, *review* by F. I. G. Rawlins, 61

Theoretical and Technical Course on Aerial Photogrammetry (École Nationale des Sciences Géographiques), 127

Theories of Learning (Prof. Ernest R Hilgard), second edition, *review* by Prof. K. R L Hall, 40

Theories of Shape Discrimination in *Octopus* (The Visual System of *Octopus*), (Dr. N. S. Sutherland), 840

Theory of Compressible Flow : Introduction to the (Prof Shih-I Pai), *review* by Dr. G K. Batchelor, 1000

Theory of Dams, *review* by D. G. Kendall, 344

Theory of Relativity : Analysis of Accelerated Motion in the (Robert T. Jones), 790

Theory of Storage (Prof. P. A. P. Moran), *review* by D. G. Kendall, 344

Theory of Superconductivity : A New Method in the (N. N. Bogoliubov, V. V. Tolmachev and D. V. Shirkov), translated from the Russian, *review* by Dr C. G. Kuper, 833

Theory (Immunological), of Cancer . Binding of a Hepatocarcinogen to the Structural Lipoprotein of Rat Liver—its Bearing on the (J. W. Westrop and Prof. H. N. Green), 350

Theory (Information), and Statistics (Prof. Solomon Kullback), *review* by Prof. Colin Cherry, 506

Theory (Learning) · 60 Years of, *review* by Prof. K. R. L. Hall, 40

Theory (Non-Equilibrium), of Gas–Liquid Chromatography (Dr. M. A. Khan), 800

Theory (Nuclear) · Introductory (Dr. L. R. B. Elton), *review* by Dr. T. E. Allibone, 917
  Lectures on (L. D. Landau and Ya Smorodinsky), translated from the Russian, revised edition, *review* by Dr. T E. Allibone, 917

Theory (Nuclear), and its Utilization, *review* by Dr. T. E. Allibone, 917

Theory (The Potential), of Unsteady Supersonic Flow (Prof. John W. Miles), *review* by L. E. Fraenkel, 505

Theory (Quantum), for the Scholar, *review* by Prof N. Kemmer, 999

Theory and Practice of Sedimentation, *review* by Dr K. V. Shooter, 56

Thermal Conductivity Detectors · Effect of Carrier Gas on the Sensitivity of (C. Bokhoven and A. Dijkstra), 793

Thermal Motion in Crystals and Molecules (International Union of Crystallography Symposium on), 1020

Thermal Syndicate, Ltd · Grant of £1,200 a year to the Houldsworth School of Applied Science in the University of Leeds, to establish a research fellowship in ceramics, 767

Thermally Stratified Flow : Wind Profile in (W. C. Swinbank), 463

Thermodynamical Relations in Two-Component Two-Phase Systems (Prof. H. Kaufman), 299

Thermodynamics : Chemical, *review* by Prof A. R Ubbelohde, 55

Thermodynamics (Chemical) : An Introduction to the Study of (Prof. D. H. Everett), *review* by Prof A. R. Ubbelohde, 55

Thermodynamics and Kinetics of Spontaneous Generation (Dr D. E. Hull), 693 , (Prof J D. Bernal), 694

Thermodynamique Chimique · Bases Fondamentales et Applications de la (Prof Maurice Dodé), Tome I, Les Principes, les Systèmes Ideaux Gazeux, et avec Phases Condensées pures, *review* by Prof. A. R. Ubbelohde, 55

Thermoelectric Cold Box : A Commercial (General Electric Co., Ltd.) 439

Thermonuclear Reactions (Controlled) : Bibliography on Plasma Physics and Magnetohydrodynamics and their Applications to (J. D. Ramer), 522

Thermonuclear Research An Introduction to (Albert Simon), *review* by Dr T. E. Allibone, 917

'Theta' Pinch : 'Prize', a Pre-ionized (R. D. Medford, A. L. T. Powell, J. D Herbert, R C. Pottinger and J K. Wright), 706

Thienpont, D., and others Isolation of a Cytopathogenic Agent from Skin Lesions in Cattle, 979
Thin Films of Silver–Cadmium Alloy (K. Bahadur and P. V Sastry), 467
Thin (Ultra-) Sections Water-Soluble Methacrylates as Embedding Media for Preparation of (Dr O. Wichterle, Dr. P. Bartl and Dr. M Rosenberg), 494
Thines, Dr. G. : Sensory Specializations in Response to Environmenta Demands (Sensory Degeneration and Survival in Cave Animals), 689
Thinking in Examinations The Lack of (Dr. Margaret Sutherland), 607
Thiobarbituric Acid Spray Reagent for Deoxy Sugars and Sialic Acids (Dr. Leonard Warren), 237
Thiol and Disulphide Groups : A Role for, in Determining the Rheological Properties of Dough made from Wheaten Flour (R. Frater, Dr F. J. R. Hird, H. J. Moss and J. R. Yates), 451
Thiotaurine : Inability of, to protect Mice against Ionizing Radiation (Dr. D Cavallini and L. Tentori), 254
Third Component of Complement · Further Evidence for the Dual Nature of the (Dr J D. Hawkins), 483
Thirring, Walter E. Principles of Quantum Electrodynamics (translated from the German by J. Bernstein), *review* by Prof N. Kemmer, 999
Thistlethwaite, W. P. · Periodic Classification of Elements, 153
Thomas, Dr. A. S. The Serengeti National Park, 605
Thomas, D. P Page, and others : Synovial Proliferation induced by Polysaccharides, 251
Thomas, E J. R. · Model-Making with 'Araldite', 360
Thomas, Dr. G M. (Evans, Dr. S., and) : Results of the Royal Society's International Geophysical Year Expedition (Visual Work on Aurora), 192
Thomas, Dr. H. Hamshaw . Presented with a Gold Medal of the Linnean Society of London, 766
  Obituary of Dr. Agnes Arber, 847
Thomas, Prof Meirion . Retirement from the chair of botany at King's College, Newcastle-upon-Tyne, 1016 ; work of, 1016
Thomas, Phyllis Menna (Crager, Dr. William P , and) : Micro-electrophoresis of Human White Cells and Platelets, 171
Thomason, D. (Schofield, R., and) : Calcium Binding in Homogenates of Ehrlich Ascites Tumour Cells, 656
Thommen, K. J. : Recent Advances in Coconut Research in India, 861
Thompson, Prof. F. C. : Progress in Metal Physics, *review*, 666
Thompson, J D (Bradley, Prof. W., and) · Reaction of *p*-*n*-Decyloxybenzenediazonium Fluoborate with Sodium Iodide in Benzene, 631
Thompson, J. Eric S. Maya Hieroglyphic Writing, second edition, *review* by Dr. G. H. S Bushnell, 580
Thompson, John F , and others : (+) S-Methyl-L-Cysteine Sulphoxide an Inhibitor of Aspartic Acid Utilization in *Leuconostoc mesenteroides*, 1051
Thompson, Marilyn M., and Mayer, Prof. Jean . Coenzyme A Content of Adipose Tissue, 640
Thompson, Prof R. H. S , and others . Biochemistry in relation to Medicine, third edition, *review* by Prof. D C. Harrison, 422
Thompson, Prof. Warren S. . Population and Progress in the Far East, *review* by Prof. W. D Borrie, 664
Thomson, J H. (Roger, R. S., and) · Faraday Effect in the Transmissions from Fast Spinning Satellites, 622
Thomson, Sir Landsborough . Paths Across the Earth, *review*, 64
Thomson, W. E , and others . Letter Structure of the English Language, 414
Thorianite : Uraninite and (Dr. Bibhuti Mukherjee), 464
Thorp, Prof R. H. (Cobbin, Dr. L. B., and) : Absence of Catecholamines in Cardioactive Acetone Extracts of Ox Spleen, 473
Thouless, Dr. D. J. : Elected to Official Fellowship of Churchill College, Cambridge, and College lecturer in mathematics, 440
Thread Protein and β-Globulin Polymorphism in the Serum Proteins of Pigs (G. C. Ashton), 991
Threadgold, Dr. L. T. : Appointed lecturer in zoology at the Queen's University, Belfast, 767
Thrush, Dr. B. A. : Absorption Spectra of Diatomic Radicals containing Boron or Silicon, 1044
Thunnus thynnus · Oxygen Equilibrium of Haemoglobin from (Prof. A. Rossi-Fanelli and E. Antonini), 895
  Oxygen Equilibrium of Myoglobin from (Prof A. Rossi-Fanelli, E. Antonini and R. Giuffrè), 896
Thyroid Dosimetry : A Comparison of Iodine-124 and Iodine-131 (Dr. C. M. E. Matthews and Dr. J. F. Fowler), 983
Thyroid-Powder Feeding and Liver Nitrogen in Mice (Dr. A. N. Granitsas, M. Kukku and M. Konstantinidu), 890
Thyroid Radioiodine Uptake Measurement (Dr. Marshall Brucer), *review* by Dr. E. E. Pochin, 424
Thyroxine and 2,4-Dinitrophenol : Effect of, on Levels of Ubiquinone and Ubichromenol in the Rat (E. E. Edwin, J. Green, A. T. Diplock and J. Bunyan), 725
Thyroxine (Succinate, Adenine Nucleotides and) : Swelling of Fresh and Aged Liver Mitochondria as affected by (Dr. P. Emmelot, C. J. Bos, P. J. Brombacher and I. H. M. Reyers), 556
Tick (Australian Cattle) : Sulphydryl Content of the Embryos of the (W. J. Roulston and C. A. Schuntner), 1069
Tidal Swamp Soils from Sierra Leone : Sea-Water as the Primary Source of Sulphate in (J C. D. Watts), 308
Tiefseesande im westlichen Teil des aquatorialen Atlantiks : Ein Beitrag zum Problem der (F. W. Locher), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 7, Sediment Cores from the North Atlantic Ocean, No. 5), 609
Tiles (Acoustic), for Noise Control, 602
Tillinger, K. C., and others · A New Class of Hormonally Active Steroids, 168
Tillotson, Ernest : The Agadir Earthquake of February 29, 199
Time-Depdent Tensile Strength of Solids (Dr. C. C Hsiao), 535
Time-lags in the Intrinsic Electrical Breakdown of Glass (M. N. Azam and H. Dickinson), 146
Times (Travel), of Seismic *P* and *S* Waves : Structure of the Upper Mantle as derived from the (Dr. I. Lehmann), 956
Timmermans, Prof. Jean : The Physico-chemical Constants of Binary Systems in Concentrated Solutions, Vol. 1, Two Organic Compounds (without Hydroxyl Derivatives) ; Vol. 2, Two Organic Compounds (at least one a Hydroxyl Derivative), *review* by Dr E F G. Herington, 918
Tinley, G H , and Garner, R. J Developments in the Propagation of Clones of *Hevea brasiliensis* by Cuttings, 407
Tinline, Dr. R. D : Nature and Exploitation of Crop Plant Resistance to Disease (Pathogenic and Cultural Variation in *Cochliobolus sativus*), 858
Tippett, Patricia, and others : An Rh Antibody Specific for V and R'^s, 171
  M_1, a Subdivision of the Human Blood-Group Antigen M, 642
Tippo, Prof Oswald . Appointed provost of the University of Colorado, Boulder, 1020
Tishler Max (edited by) · Organic Syntheses, Vol 39, *review* by Prof John Read, 669
Tissue (1X, 2X and 3X) A Mosaic of *Drosophila* consisting of, and its Probable Origin by Mitotic Non-disjunction (Prof. Curt Stern), 179
Tissue (Active) · Action Potentials in, with Delayed Potassium Permeability (Dr. E. P. George), 889
Tissue (Adipose) : Coenzyme A Content of (Marilyn M. Thompson and Prof. Jean Mayer), 640
Tissue (Brain), in Culture · Spontaneous Potentials from Explants of (Prof A. W B. Cunningham, Marshall Dougherty and B. J. Rylander), 477
Tissue (Connective), and Osseous Chemistry in Lathyritic Rats · Aortic, Serum, (Dr. R. A. Grant, M. Hathorn and Prof. Theodore Gillman), 164
Tissue (Muscle), and Mitochondria : Release of Methionine labelled with Sulphur-35 from (Dr. R. Zák and Dr Z Drahota), 973
Tissue (Rous Sarcoma) : Presence of Chicken Tumour Virus in the Sarcoma of the Adult Rat inoculated after Birth with (Dr. Jan Svoboda), 980
Tissue (Surface), of the Tongue : Amino-Acid Composition of Proteins from (Dr. C. J. Barnes and Dr. L. N. Ferguson), 617
Tissue (Tumour) . Radioactive 7-Iodo-6-Deoxytetracycline in (Dr. Joseph J. Hlavka and Donald A. Buyske), 1064
Tissue Culture : Effect of Oxygen and Nitric Oxide on the Radiosensitivity of Human Cells in (Dr D L. Dewey), 780
  L Forms of Bacteria as Contaminants in (Dr. I. A. Macpherson and K. Allner), 992
Tissue Culture (Quantitative) : Effect of Supernatant Potassium-Level on Cardiac Activity in (Prof A. W. B. Cunningham, K. Kleutch and W. Herbst), 241
Tissues (Animal) : Effects of Non-Ionic Surfactants upon (Helen Goldhammer and W. R. McManus), 317
Tissues (Growing and in Non-growing) : Enzymatic Deamination of 5-Deoxycytidylic Acid and of 5-Methyl-5'-deoxycytidylic Acid in (Dr. Eduardo Scarano, Massimo Talarico, Luisa Bonaduce and Benita De Petrocellis), 237
Tissues (Sectioned) · A Method of Staining, with Lead for Electron Microscopy (Dr. J. D. Lever), 810
Titanium The Fusion Electrolysis of (Dr W J. Kroll), 685
Titanium Sulphate (Peroxy) Nature of the Colour-forming Species in (Dr. C. C. Patel and M. S Mohan), 803
Titrations (Infectivity), of the Virus of Foot-and-Mouth Disease : Influence of Route of Inoculation and Strain of Mouse on (Wendy Heatley, H. H Skinner and H. Subak-Sharpe), 909
Toad : Potential Oscillations in the Lower Olfactory Pathway of the (Dr. S F. Takagi and Dr T. Shibuya), 724
Tobacco Leaves inoculated with Tobacco Mosaic Virus : Decarboxylation of Glutamic Acid in (M. S. Gubanski), 657
Tobacco Mosaic Virus : Decarboxylation of Glutamic Acid in Tobacco Leaves inoculated with (M. S. Gubanski), 657
  Primary Structure of the Protein of (F. A. Anderer, H. Uhlig, E. Weber and Prof. G. Schramm), 922
Tobacco Smoke Droplets . Size Distribution of, by a Replica Method (W. J. Harris), 537
α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine . Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by (Dr. Laurence M. Corwin and Dr. Klaus Schwarz), 1048
Tocopherol Metabolite, Menadione and Diphenylphenylenediamine : Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by α-Tocopherol, a (Dr. Laurence M. Corwin and Dr Klaus Schwarz), 1048
Todd, Prof David Keith : Ground Water Hydrology, *review* by E. Miller, 423
Todd, G , and Parry, E. : Radiation-Induced Changes in α-Lead Azide, 543
Tokita, K., and others : Measurement of the Intrahepatic Shunted Flow of Blood in Cirrhosis of the Liver, 243
Tolerance Antigens, Transplantation and, *review* by Dr D. M. V. Parrott, 51
Tolerance to Drugs, especially to Morphine (Dr. Guy Nadeau and Georges Sobolewski), 169
Tolerance (Immunological) · A Possible Basis for (Dr. D. T. Denhardt), 728
Tolerance (Non-Specific) of Graft and the Dissociation of Two Types of Immunity (Dr. Milan Hašek and Dr. Jan Hort), 985
Tolerance Test (Glucose) : Improvement of the Intravenous (Dr. John C Seed, Dr. Forman S. Acton and Dr. Albert J. Stunkard), 808
Tolmachev, V. V., and others : A New Method in the Theory of Superconductivity (translated from the Russian), *review* by Dr. C G Kuper, 833
Tomaschek, Prof. R : Earthquakes and Uranus—Misuse of a Statistical Test of Significance, 337
Tomato Roots . Organic Acid Synthesis in (J. van Die), 603
Tomato and Apple Fruits : Ethylene Production by (D. F. Meigh, K. H. Norris, C C. Craft and M. Lieberman), 902
Tombs, Dr M. P. : A Haemoglobin-binding β-Globulin in Human Serum, 1055
Tominaga, Kimimichi, and others : A Micro Gas Chromatograph, 309
Tomkeieff, Prof. S. I. : Russian–English Glossary of Optics and Spectroscopy, *review*, 347
  Russian–English Glossary of Solid State Physics, *review*, 347
  The Progress of Geology in the U.S.S.R , 438
Tompkins, Prof. F. C. : Superficial Chemistry and Solid Imperfections, 3
Tongue, Harold . *Obituary* by P. Bowles and R. H. Burns, 120
Tongue : Amino-Acid Composition of Proteins from Surface Tissue of the (Dr. C. J. Barnes and Dr L. N. Ferguson), 617
Tool (A Structural), for the Chemist, *review* by Prof. E. R. Andrew, 55
Tools : Australopithecine (Prof R. A. Dart, Dr. Kitching and Revil J. Mason), 205

Tordoff, Dr M Appointed editor of the *Journal of the Society of Dyers and Colourists*, 440
Tornado : Measurement of Wind Speeds near a, 360
Toronto Milk during 1959 Caesium-137 in (Prof. K. G. McNeill and O. A. D Trojan), 399
Torrey, John G. (edited by Leonard Machlis, in association with) : Annual Review of Plant Physiology, Vol. 10, *review* by Prof W. Stiles, 747
Total Acoustic Radiation Impedance of Rigid Pistons in an Array : Measurements of the (J. S. M Rusby), 144
Tousey, Dr. R N. : Elected a member of the United States National Academy of Sciences, 773
Toussaint, F (Fripiat, Dr. J. J , and) : Predehydroxylation State of Kaolinite, 627
Townsend, Dr A. A. Elected a Fellow of the Royal Society, 12
Toxicity of Ovicides to Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina : Tetranychidae) : Effect of Relative Humidity on Hatching and on (R A Harrison and A G. Smith), 409
Toxicity (Manganese), in *Grevillea robusta* (Dr R. Child and A N. Smith), 1067
Toxicology : Handbook of, Vol 5, Fungicides (analysis and compilation by Everett F. Davis, Barbara L. Tuma and Lucy C Lee), edited by Dorothy S Dittmer, *review*, 64
Toxin (Ackee), a Riboflavin Antimetabolite ? (H C. Fox and D S. Miller), 561
Toxin (Facial Eczema), Sporidesmin Detection and Estimation of a (G. R. Russell), 788
Trace Analysis by X-Ray Fluorescence using Ion Exchange Resins (J N. van Niekerk and J. F. de Wet), 380
Trace Element Effect in Alloys based on the Aluminium–Zinc–Magnesium System (I. J. Polmear), 303
Tracer (Atmospheric) : Use of Long-lived Natural Radioactivity as an (W. M Burton and N. G Stewart), 584
Trachoma, Inclusion Blennorrhoea and Lymphogranuloma : Transmission of the Viruses of, to Mice (Dr E. Weston Hurst and P. Reeve), 336
Trade Effluents : Water Pollution by, 210
Trade Effluents Sub-Committee of the Central Advisory Water Committee Final Report (Ministry of Housing and Local Government), 210
Traffic Accidents and Driver Characteristics (Sauli Hakkinen), 273
Trail Award and Medal of the Linnean Society of London presented to Dr. Lawrence Ernest Rowland Picken, 766
Traill, R. C : Addition Compounds between Copper Complexes and Organic Bases, 631
Training in Chemical Engineering Education and (Supplement to Chemical Engineering, a Career), (Institution of Chemical Engineers), 125
Training in Monkeys : Cross-Modal Transfer of (D. Burton and Dr. G. Ettlinger), 1071
Training of Postgraduate Students, 915
Training of Teachers for Technical Colleges : The Supply and (Ministry of Education), 185
Training of Technical Teachers (Northern Advisory Council on Further Education), 281
Training (Apprenticeship), in Britain, 436
Training (The Postgraduate), of Physicists in British Universities—the Report of a Joint Committee appointed by the Institute of Physics and the Physical Society, 915
Training Council, Industrial . First Report (1958–59), 15
  Training Services in Industry, 123
Training Grants (Postgraduate), in Fishery Research (Development Commissioners, the Ministry of Agriculture, Fisheries and Food, and the Scottish Home Department), 360
Training Services in Industry (Industrial Training Council), 123
Trametes cingulata Berk : Nuclear Phenomena in (Pritindra Mohan Naha), 903
Transaminases in Serum · Measurement of (Dr H. Yatzidis), 79
Transfer (Charge) · Detection of Negative Ions formed by (T. M. Donahue and F. Hushfar), 1038
Transfer (Cross-Modal), of Training in Monkeys (D. Burton and Dr. G. Ettlinger), 1071
Transfer Processes (Energy) . Radiative Life-time of the Pyrene Dimer and the Possible Role of Excited Dimers in (Dr B Stevens and E. Hutton), 1045
Transfer Reactions (Electron), involving *s*-Trinitrobenzene (Dr. R. E. Miller and Prof. W. F K. Wynne-Jones), 149
Transformation (Reversible), of Gelatin to the Collagen Structure (Dr. Arthur Veis and Dr. Jerome Cohen), 720
Transformations (Allotropic), in Plutonium (J. D. Hill), 304
Transformations (High-Pressure Phase), in Laboratory Mechanical Mixers and Mortars (Frank Dachille and Prof. Rustum Roy), 34
Transistor Modulators for Low-level Direct Current Signals (J. F. Evans), 626
Transistorized Computer . A New British (General Electric Co., and International Computers and Tabulators, Ltd.), 936
Transition Metal Ions : Heats and Entropies of Reaction of, with Ethylenediamine (M. Ciampolini, P Paoletti and Prof L. Sacconi), 880
Transition Temperature : The Delta Plutonium (Dr R. G. Cope), 539
Translation Dictionary . Russian Machine (H. S. H. Massey), 852
Translocation (Concurrent) : Evidence of (C. D. Nelson, H. J Perkins and P. R Gorham), 205
Transmission of the Viruses of Trachoma, Inclusion Blennorrhoea and Lymphogranuloma to Mice (Dr. E. Weston Hurst and P. Reeve), 336
Transmission (Neuro-Muscular), in the Earthworm (Dr. G A. Horridge and Dr. M. B V. Roberts), 650
Transmissions from Fast Spinning Satellites · Faraday Effect in the (R. S Roger and J H Thomson), 622
Transplantation and Tolerance : Antigens, *review* by Dr. D. M. V. Parrott, 51
Transport (Active), of γ-Aminobutyric Acid in Brain Cortex Slices, with special reference to Phosphorus-32 Turnover in Phospholipids in Cytoplasmic Particulates (Yasuzo Tsukada, Yutaka Nagata and Shusuke Hirano), 474
Transvaal Museum *Bulletin* of the, No. 4, 936
  Annals of the, Vol 14, Part 1, 936
Travel Scholarship : Bowles Memorial (Royal Horticultural Society), 206
Travel Times of Seismic *P* and *S* Waves Structure of the Upper Mantle as derived from the (Dr. I. Lehmann), 956
Travelling Research Fellowships · Carlsberg–Wellcome (Wellcome Trust), 283
Treatment of Depression by Drugs and other Means (Dr Linford Rees), 114
Treatment with Diethylstilboestrol Duration of Stimulation of Phagocytic Activity of the Reticulo-Endothelial System after Cessation of (C. C. Ware and Prof. T. Nicol), 974
Treatment of Injured and Regenerating Muscles with Plant Extracts (S. Hoja and J. Vittek), 283
Treatment of Tumours in Animals and Man · Actinomycins and their Importance in the (New York Academy of Sciences Conference on), 771
Treatment (Colchicine), and Polyspermy · Triploid Rat Embryos and other Chromosomal Deviants after (L Piko and O. Bomsel-Helmreich), 737
Treatment (Zinc Sulphate), of Parakeratosis in Cattle (S. P. Legg and L. Sears), 1061
Treatments (Physical) · Heritable Changes in Lactic Streptococci induced by (B S. Gossling), 868
Trebst, Dr A V , and others Equivalence of Light and Adenosine Triphosphate in Bacterial Photosynthesis, 753
Trehalose Metabolism of Trypanosomes (Dr. David Weinman), 166
Treiman, Prof S. B. · Elected to an Overseas Fellowship of Churchill College, Cambridge, 440
Trematodes in a Snail . Multiple Infections of (Wm H Ewers), 990
Trends in Medicine A Diversity of, *review* by Prof. L. J Witts, 42
Trends (Modern), in Enzymology, *review* by Prof J. Brachet, 267
Trends (Significant), in Medical Research · Ciba Foundation Symposium on (edited by G. E W. Wolstenholme, Cecilia O'Connor and Maeve O'Connor), *review* by Prof. L. J. Witts, 42
Trengrouse, G. H. : Appointed lecturer in mechanical engineering at the University of Birmingham, 522, 767
Trewavas, Dr. E : *Obituary* of Dr. Otto Schindler, 434
Triantaphyllopoulos, Dr. D. C. (Bigland, Dr. C H., and) : A Re-Evaluation of the Clotting Time of Chicken Blood, 644
Triatoma infestans · Non-Identity of Triosephosphate Dehydrogenase of Adult Male and Nymph Development Stages of (Prof. M. Agosin, A Neghme and N. Scaramelli), 1052
Trichomycete, *Amoebidium parasiticum* Pure Culture of the (Dr. Howard C. Whisler), 732
Triiodide (β-Carotene) · Electrical and Magnetic Properties of (Dr Charles M Huggins and Dr Oliver H. LeBlanc, jun.), 552
s-Trinitrobenzene Electron Transfer Reactions involving (Dr R. E. Miller and Prof W F K. Wynne-Jones), 149
Triosephosphate Dehydrogenase of Adult Male and Nymph Development Stages of *Triatoma infestans* : Non-Identity of (Prof. M Agosin, A. Neghme and N Scaramelli), 1052
Tri*para*ethylphenyl Phosphate · Ataxia in Hens poisoned by (Ann Silver), 766
Triphosphate (Adenosine) Effect of Electrical Stimulation on a Muscle Fibre Model in the Presence of (Prof Masahiro Fujino, Tatsuaki Matsushima, Tomizo Muroya, Hideyo Yabu, Saburo Yamaguchi and Masaki Takahashi), 318
Triphosphate (Adenosine), in Bacterial Photosynthesis : Equivalence of Light and (Dr. M. Losada, Dr A. V. Trebst, S Ogata and Prof. Daniel I. Arnon), 753
Triphosphate (Adenosine), and Glycogen in the Liver : Changes in the Levels of, caused by Protein Administration (Dr. Catherine M Clark, Dr. G. A. J. Goodlad, Dr. J. Chisholm and Dr. H N. Munro), 719
Triphosphate (^{32}P-Adenosine) Exchange Reaction in Rat Liver Mitochondria : Effects of Fatty Acids on the (K Ahmed and Dr P G. Scholefield), 1046
Triplet State in the Photoreduction of Chlorophyll : Role of the (Prof. Robert Livingston and Dr. A. C. P. Pugh), 969
Triploid Rat Embryos and other Chromosomal Deviants after Colchicine Treatment and Polyspermy (L. Piko and O Bomsel-Helmreich), 737
Tritch, Harold R. (Karmen, Dr. Arthur, and) · Radioassay by Gas Chromatography of Compounds labelled with Carbon-14, 150
Tritiated Water : Saliva–Serum Ratios of Tritium after the Administration of (Dr. A. J. Coppen and Dr J. L. Gibbons), 724
Tritiated Water Samples . Preparation of, by Distillation (J D Simpson and Dr. J. R. Greening), 467
Tritium : Saliva–Serum Ratios of, after the Administration of Tritiated Water (Dr A. J. Coppen and Dr. J. L. Gibbons), 724
Tritium as a Deoxyribonucleic Acid Label in Man . Hazard of (R. Oliver and Dr. L G. Lajtha), 91
Tritsch, Dr. G. L., and Woolley, Prof D. W. : Bradykinin Activity of some Synthetic Peptides with only Slight Structural Resemblance to Natural Bradykinin, 76
Trivanadate (Potassium) : Crystal Structure of (Dr Stanley Block), 540
Trojan, O. A. D (McNeill, Prof K. G , and) · Caesium-137 in Toronto Milk during 1959, 399
Tropical Agriculture : Nitrogen in (Australian Commonwealth Scientific and Industrial Research Organization Symposium on), 941
Tropical Animal Husbandry, *review* by Sir John Hammond, 49
Tropical Plants : Photoperiodic Response of some, 438
Tropical Soil Surfaces : Capillary Movement of Nitrate towards (R. Wetselaar), 572
Tropics : An Introduction to Animal Husbandry in the (G Williamson and Dr W J A. Payne), *review* by Sir John Hammond, 49
Trotman-Dickenson, Dr. A. F. · Appointed to the chair of chemistry in the University College of Wales, Aberystwyth, 681 ; work of, 681
Trout and Salmon Culture—Hatchery Methods (Earl Leitritz), 204
True's Beaked Whale from the South-East Coast of South Africa (F. H Talbot), 406
Trumpy, Dr R . Orogens, 690
Trypanosomes : Trehalose Metabolism of (Dr David Weinman), 166
Trypanosomiasis of Cattle and other Animals Precipitating Antibody in (A. R. Gray), 1058
Trypsin (Inactivation of), by Ionizing Radiation . Effect of Oxygen on the (Prof. J. A V. Butler and Dr. A. B. Robins), 697
Tryptophan and Nicotinic Acid in Man : Interrelation of, during the First Month of Life (S. Auricchio, E. Quagliariello and A Rubino), 639
Tschernezky, W. . A Reconstruction of the Foot of the 'Abominable Snowman', 496
Tschoegl, Dr. N. W. : Visco-Elastic Systems (Monomolecular Cereal Protein Films), 942
Tsetse Fly and Trypanosomiasis Committee . Report for 1958–59, 501
Tsuboi, K. K , and others : Heterogeneous Labelling of Acid-soluble Nucleoside 5'-Monophosphates during Short *in vivo* Incubation with Phosphate-^{32}P, 158

Tsukada, Yasuzo, and others . Active Transport of γ-Aminobutyric Acid in Brain Cortex Slices, with special reference to Phosphorus-32 Turnover of Phospholipids in Cytoplasmic Particulates, 474
Tsuruta, M , and others : Microbiological 11β-Hydroxy Dehydrogenation of Corticosterone, 390
Tuberculoproteins from Heated Culture Filtrates Starch–Agar-Gel Electrophoresis of (T. P. Dekker), 392
Tubers in *Begonia evansiana* Andr. : Factors affecting (—. Esashi and —. Nagao), 766 ; (—. Nagao and —. Mitsui), 766
Tubes (Geiger-Muller) : Helium–Butane Gas Mixtures as Fillings for (Dr. V. Moses and Dr. J F Fowler), 538
Tubes (Narrow) Flow of Blood through (Dr. G. W Scott Blair), 708
Tubercle Bacilli (Phenol-killed) Enhanced Resistance of Mice to Infection with *Pasteurella pestis* following Vaccination with Fractions of (Prof. David W. Weiss), 1060
Tucker, Dr. John . Herbert Spencerism, *review*, 37
Tulloch, Dr. J. A Medical Research in the British Caribbean, 862
Tumour (Ascites) resistant to Alkylating Reagents Non-Protein Sulphydryl Group in the Original Strain and Sub-line of the (Iwao Hirono), 1059
Tumour (Chorion-epitheliomatous), in the Rat Induction of a (R. Stein-Werblowsky), 980
Tumour Blood Volumes (Mouse) · Estimation of, employing a Radioactive Isotope Technique (F S. Stewart and Dr. A. E G. Pearson), 250
Tumour Cell (Ascites) : Effect of Antibody and Complement on Volume Control in an (Dr. H Green and Dr F. Silverblatt), 646
Tumour Cells (Ehrlich Ascites) Calcium Binding in Homogenates of (R Schofield and D. Thomason), 656
Tumour Inhibitors : Synthetic Polyelectrolytes as (Dr. William Regelson, Stephan Kuhar, Marvin Tunis, Joseph Fields, John Johnson and Earl Gluesenkamp), 778
Tumour Induction by *S E* Polyoma Virus : Development of Resistance in Mice to (Sarah E Stewart, Bernice E Eddy, Marjean Irwin and Stephanie Lee), 615
Tumour Ribonucleic Acid : Heterogeneity of, and the Effect of 'Degranol' on it (F Antoni, E. J. Hidvégi and K. Lapis), 81
Tumour Tissue : Radioactive 7-Iodo-6-Deoxytetracycline in (Dr. Joseph J. Hlavka and Donald A Buyske), 1064
Tumour Virus (Chicken) · Presence of, in the Sarcoma of the Adult Rat inoculated after Birth with Rous Sarcoma Tissue (Dr Jan Svoboda), 980
Tumours : Pathogenesis and Immunology of (edited by G. V Vygodchikov), translated from the Russian by R. Crawford, *review* by Dr. P. A. Gorer, 420
Tumours in Animals and Man : Actinomycins and their Importance in the Treatment of (New York Academy of Sciences Conference on), 771
Tumours (Ascites) · Viability and Tetrazolium Salt in (Dr. Gustav Dallner), 176
Tumours (Mouse Parotid) : Virus Release from Single Cells of (Dr. Mathilde Krim and Dr. Leo Sachs), 262
Tunis, Marvin, and others : Synthetic Polyelectrolytes as Tumour Inhibitors, 778
Turbellaria tricladida paludicola Chromosome Numbers of Four Species of the Genus *Dendrocoelum* Œrsted (Dr. Anders G. Dahm), 334
Turing, Alan M (Sara Turing), *review*, 63
Turing, Sara . Alan M. Turing, *review*, 63
Turner, Elizabeth M. C. · An Enzymic Basis for Pathogenic Specificity, 325
Turner, P. D. · Variation in *Phytophthora palmivora* (Butl.) Butl. on *Theobroma cacao* L. in West Africa, 495
Turnip Yellow Mosaic Virus · Protein Components from (Dr. J. M. Kaper), 219
Turnover (Whole-Body), of Selenium in the Rat (Clifton Blincoe), 398
Tverskoy, G. B : Influence of Cervical Sympathectomy and Pituitary Stalk Section upon Milk Secretion in Goats, 782
Twentieth Century Physics · A Forerunner of—a Re-view of Larmor's 'Aether and Matter' (Lancelot Law Whyte), 1010
Two-Component Two-Phase Systems . Thermodynamical Relations in (Prof. H. Kaufman), 299
Two-Phase Systems (Two-Component) : Thermodynamical Relations in (Prof. H Kaufman), 299
Twyford Laboratories, Ltd., London Appointment of Dr. C. Elizabeth Work and Dr V. A. Knivett to the Microbiology Section, 523
  Appointment of Dr J. Leggett Bailey and Dr R. J Sturgeon to the Biochemistry Section, 523
Type (A New), of Autoxidation Reaction—Cause of the Instability of Cytochrome *c* Reductase (Dr. Malcolm Dixon, J. M Maynard and P. F. W. Morrow), 1032 ; Flavin Dissociation and Inactivation of Cytochrome b_5 by Oxygen (J. McD. Armstrong, Dr J. H. Coates and Prof R. K Morton), 1033
Type Specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick . Catalogue of the (J F. Gates Clarke), Vol 3, Tortricidae, Olethreutidae, Noctuidae, *review* by R. G. Fennah, 188
Type-Specific Glycolipids of *Mycobacteria* · Mycosides, a New Class of (Donald W. Smith, H M. Randall, A. P. MacLennan and E Lederer), 887
Tyrrhenian Sea (Central) : The Sediments of the (E. Norin), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 8, Sediment Cores from the Mediterranean Sea and the Red Sea, No 1), 609

UBBELOHDE, Prof A. R. Chemical Thermodynamics, *review*, 55
Ubichromenol in the Rat : Effect of Thyroxine and 2,4-Dinitrophenol on Levels of Ubiquinone and (E. E. Edwin, J. Green, A. T. Diplock and J. Bunyan), 725
Ubichromenols in the Rat Ubiquinones and (A T Diplock, E. E Edwin, J. Green, J. Bunyan and S. Marcinkiewicz), 554
Ubiquinone and Ubichromenol in the Rat : Effect of Thyroxine and 2,4-Dinitrophenol on Levels of (E. E. Edwin, J. Green, A. T. Diplock and J. Bunyan), 725
Ubiquinones and Ubichromenols in the Rat (A T Diplock, E. E Edwin, J Green, J. Bunyan and S Marcinkiewicz), 554
Uetake, Hisao, and Hagiwara, Shin . Somatic Antigen 15 as a Precursor of Antigen 34 in *Salmonella*, 261
Uhlig, H , and others : Primary Structure of the Protein of Tobacco Mosaic Virus, 922
Uloborus walckenaerius Latrielle (Spider) : Unusual Web Pattern made by an Unfertilized Female of the (Dr Rasza Szlep), [illegible]
Ulrich, W. F., and others : Microquantitative Infra-Red Analysis—Application to Gas Chromatographic Fractions, 628
Ultracentrifugation in Biochemistry (Dr. Howard K. Schachman), *review* by Dr. K. V Shooter, 56
Ultracentrifuge Concentration-Dependent Sedimentation of Aggregating Proteins in the (Dr. G. A. Gilbert), 882
Ultra-High Resolution γ-Ray Resonance in Zinc-67 (D. E. Nagle, P. P. Craig and W. E. Keller), 707
Ultrasonic Propagation Constants in Supercooled Salol (Dr. S. Parthasarathy and V. N Bindal), 145
Ultrasonic Waves Cleaning of Fossils by (J. N. M. Firth), 684
Ultrastructure of the Clear Cells in Renal Carcinomas and its Importance for the Demonstration of their Renal Origin (Prof. Ch Oberling, M. Rivière and Fr Haguenau), 402
Ultra-Structure of Human Amnion and its Possible Relation to the Circulation of Amniotic Fluid (Dr. Gordon L. Bourne and Dr. Dennis Lacy), 952
Ultra-Thin Sections Water-Soluble Methacrylates as Embedding Media for Preparation of (Dr. O. Wichterle, Dr. P. Bartl and Dr. M. Rosenberg), 494
Ultra-Violet : Reflectance of Coal Vitrains in the Visible and, compared with that of Graphite (L A. Gilbert), 143
Ultra-violet-irradiated *Escherichia coli B* Effects of Chloramphenicol on the Recovery of (H. Okagaki and Prof A Sibatani), 818
Ultra-Violet Light : Electron Spin Resonance in Hydrogen Peroxide–Water Solutions at 90° K. Irradiated with (Robert C. Smith and S. J. Wyatt), 226
  Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide irradiated with (Prof F. S Dainton and S. A. Sills), 879
Ultra-violet Radiation : Polymerization of Crystalline Methacrylic Acid initiated by (Dr. C. H. Bamford, A. D. Jenkins and J. C. Ward), 713
Ultra-violet Radiation (Solar Extreme), as a Source of Interplanetary Ionization (Dr. Hans E. Hinteregger), 523
Ultra-Violet Spectra of Water Solutions (R. M. Golding), 308
Ultra-violet Spectra Shifts of Aromatic Compounds : Effect of Solvent Polarizability on the (Dr F. A. Bovey and S S. Yanari), 1042
Ultra-violet Spectrum (Solar) : Rocket and Satellite Observations of the (R Grant Athay), 1036
Ultra-violet and Soft X-Rays : A Self-supporting Metal Fresnel Zone-plate to Focus Extreme (Dr. Albert V. Baez), 958
Umbreit, Wayne W. (Oginsky, E. L , and) : An Introduction to Bacterial Physiology, second edition, *review* by Dr. R. H. Gorrill, 111
Unbleached Spruce Sulphite Fibres : Structure of the Outer Secondary Wall on (O. Kallmes and J. A S Newman), 566
Unesco Symposium on Arid Zone Problems, 284
Unesco (Centro de Cooperación Cientifica para America Latina) : Scientific Institutions and Scientists in Latin-America, Vol 1, Paraguay; Vol. 2, Chile, 203
Unesco South-East Asia Science Co-operation Office and the Indonesian Council of Sciences : Discussion on the Development of Science in South-East Asia, 859
Unfertilized Female of the Spider *Uloborus walckenaerius* Latrielle : Unusual Web Pattern made by an (Dr. Rasza Szlep), 94
Unicellular Algae and Aplanospores : Living and Fossil (D. M. Churchill), 493
Unit Action Potentials (Extracellular), from the Central Nervous System 'Weightless' Micro-electrodes for Recording (Prof. B. Delisle Burns and Dr. J. G. Robson), 246
United Kingdom . Assistance from the, for Overseas Development (White Paper on), 501
  Marine Nuclear Propulsion for the, 122
  Strontium-90 in Milk and Agricultural Materials in the, 1958-59 (Agricultural Research Council), 852
United Kingdom Atomic Energy Authority (Production Group and Development and Engineering Group), (Fifth Report from the Select Committee on Estimates, Session 1958-59), 1
United Kingdom Dairy Industry (edited by Prof E. L Crossley), *review* by Dr. C C. Balch, 504
United Kingdom Petroleum Industry Statistics relating to Consumption and Refinery Production, 1958 and 1959 (Petroleum Information Bureau), 851
United Kingdom Power Output 1960-65 Estimated, 122
United Nations International Conference on the Peaceful Uses of Atomic Energy : Proceedings of the Second, held in Geneva, 1958, Vol 2, Survey of Raw Material Resources, *review* by Prof C. F Davidson, 921
United Nations (Food and Agriculture Organization) André Mayer Fellowships for 1960, 15
  Animal Health Yearbook 1958, 291
United Nations (World Health Organization) First Meeting of the Expert Committee on Radiation, 125
  Technical Report Series No 176, Role of Hospitals in Ambulatory and Domiciliary Medical Care—Second Report of the Expert Committee on Organization of Medical Care, 202
  Technical Report Series No. 183, Study Group on the Mental Health Problems of Automation, 364
  Technical Report Series No. 175, Preventive Aspects in the Teaching of Pathology—Seventh Report of the Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel, 602
  World Health Organization Chronicle, Vol. 14, No. 3, Resistance of Gonococcus Strains to Penicillin (Alice Reyn and M. W Bentzon), 608
  Technical Report Series No. 184, Report of a European Technical Conference on Food-borne Infections and Intoxications, 852
  Library News, Vol. 12, Supp. 2, Current Indexing and Abstracting Periodicals in the Medical and Biological Sciences, 936
  Public Health Papers, No 1, Psychiatric Services and Architecture (A. Baker, R. Llewellyn Davies and P. Sivadon), 936
  Technical Report Series, No 188, Tenth Report of the Committee on Addiction-producing Drugs, 1018

- United States : Industrial Research in the, 763
  - Science and Economics in the, 14
  - A Synoptic Study of Infra-red Radiation over the (Dr. John L. Gergen and Dr. William F. Huch), 426, *erratum*, 604
- United States Air Force, and others : Conference on Coherence Properties of Electromagnetic Radiation, 127
- United States Air Force Office of Scientific Research, and Institute of Aeronautical Sciences : Second Annual Astronautics Symposium—Vistas in Astronautics, Vol. 2 (edited by Morton Alperin and Hollingsworth F Gregory), *review* by D. G. King-Hele, 59
- United States Army (Office of Ordnance Research), and Brown University : Conference on the Mechanisms of Peroxide Reactions, 127
- United States Department of Health : Research Programmes in Ageing, 852
- United States Expenditure on Academic Research and Development, 1016
- United States Geological Survey Publication by the *American Journal of Science* of a 'Festschrift' in appreciation of the work of Dr W. H. Bradley, chief geologist (1944-59), 934
- United States Geophysical Research Directorate . Guenter Loeser Memorial Lecture (Dr. Hans E Hinteregger), 523
- United States National Academy of Sciences · Biographical Memoirs of the, Vol. 33, *review*, 70
  - J Lawrence Smith Medal awarded to Dr. E J. Öpik, 280, 686 ; *erratum*, 361
  - James Craig Watson Medal awarded to Prof Yusuke Hagihara, 686
  - Agassiz Medal awarded to Dr Anton Frederick Bruun, 686
  - Kimber Genetics Award awarded to Prof George Wells Beadle, 686
  - Public Welfare Medal awarded to Dr. Alan T. Waterman, 686
  - Election of Dr Lloyd V. Berkner as treasurer, 773
  - Election of Prof G Evelyn Hutchinson and Dr. Robley C. Williams as members of the Council, 773
  - Election of new Members, 773
- United States National Academy of Sciences (National Research Council) : The Radiochemistry of Cadmium (James R. DeVoe), 602
  - The Radiochemistry of Arsenic (Harold C. Beard), 602
  - The Radiochemistry of Francium (Earl K Hyde), 602
- United States National Academy of Sciences, and others : Tenth Pacific Science Congress of the Pacific Science Association, 604
- United States National Aeronautics and Space Administration : Grant of 216,000 dollars to the University of Maryland, to accelerate its programme of basic research dealing with the growth and metabolism of unicellular algae, 604
- United States National Bureau of Standards Monograph No. 5; Preservation of Documents (W. K Wilson and B. W. Forshee), 124
- United States National Research Corporation · Appointment of Dr. Milo P. Hnilicka as scientific assistant to the vice-president and director of research, 604
- United States National Research Council (National Academy of Sciences) : The Radiochemistry of Cadmium (James R DeVoe), 602
  - The Radiochemistry of Arsenic (Harold C. Beard), 602
  - The Radiochemistry of Francium (Earl K. Hyde), 602
- United States National Science Foundation : Projects in Colleges and Universities on the Economic and other Impacts of Scientific Research and Development, 14
  - Bibliography on the Economic and Social Implications of Scientific Research and Development, 14
  - Ninth Annual Report (1958-59), 362
  - Title of *Science Information News* to be changed to *Scientific Information Notes*, 437
  - Award of Graduate Fellowships for 1960-61, 684
  - Science and Engineering in American Industry—Report of a 1956 Survey, 763
  - Report on Research and Development in Colleges and Universities in the Fiscal Year 1958, 1016
- United States National Science Foundation (Organization for European Economic Co-operation and the) : Award of Senior Visiting Fellowships in Science, 1019
- United States Public Health Authority : Grant of 152,517 dollars to the Department of Biomolecular Structure in the University of Leeds, 767
- United States Public Health Service : Senior Research Fellowships, 439
- United States–Canadian Satellite Project Joint, 13
- Universe From Nucleus to—a Course of Selected Lectures in Physics and Astronomy, University of Sydney, 1960 (edited by Prof S T Butler and Prof H. Messel), *review* by G. R Noakes, 748
  - Radio Studies of the (Dr. R. D. Davies and Dr H. P Palmer), *review* by Dr J S Hey, 59
- Universitaire de Liège (Commission Administrative du Patrimoine), and the Council for International Organizations of Medical Sciences · Symposium on Biological Problems of Grafting, *review* by Dr D. M. V. Parrott, 51
- Universities . The Function of, 107
- Universities of the British Commonwealth, Association of Report for 1958-59, 600
- Universities (British) . The Postgraduate Training of Physicists in—the Report of a Joint Committee appointed by the Institute of Physics and the Physical Society, 915
  - The Use of Film in Teaching and Research in, 1959 (British Universities Film Council), 444
- Universities (South African) Register of Current Scientific Research at, 1959 (edited by D. Ryle Masson), (South African Council for Scientific and Industrial Research), 854
- Universities (British) Film Council · The Use of Film in Teaching and Research in British Universities (1959), 444
- Universities (Colleges and) Research and Development in, in the Fiscal Year 1958 (United States National Science Foundation Report on), 1016
- University of Birmingham Thirtieth Annual Report of the University Research Committee (1958-59), 361
  - Appointment of Dr G H. Burkhardt as lecturer in mathematical physics, 522, 767
  - Appointment of Dr D. C. Champeney and D A O'Connor as lecturers in physics. 522, 767
  - Appointment of Dr. M J. Lawrence as lecturer in genetics, 522, 767
  - Appointment of G H. Trengrouse and E. Amini as lecturers in mechanical engineering, 522, 767
  - Report of an Enquiry into the Suitability of the General Certificate of Education Advanced Level Syllabuses in Science as a Preparation for Direct Entry into First Degree Courses in the Faculty of Science, 687
  - Title of reader in reactor physics conferred on Dr J. Walker, 767
  - Appointment of Gillian Vaisey as lecturer in civil engineering, 767
  - Appointment of G. Lees as lecturer in road materials, 767
  - Appointment of D. R. Milner as Lucas Fellow in metal-joining in the Department of Industrial Metallurgy, 767
  - Retirement of Prof. F H. Garner from the chair of chemical engineering, 849
  - Appointment of Dr. J T. Davies to the chair of chemical engineering, 849
  - Appointment of Dr. S. Mandelstam to the newly established chair of mathematical physics, 937
  - Appointment of Dr. R W. Whitworth and Dr. A. B. Robbins as lecturers in physics, 937
  - Appointment of Dr. J. R. Majer as lecturer in chemistry, 937
  - Appointment of Dr. E. H. Creaser as senior lecturer in microbiology, 937
  - Appointment of Dr F W. J. Teale and Dr. D. C. Walker as lecturers in biochemistry, 937
  - Appointment of A. M. Hoare to a Research Fellowship in pure mathematics, 937
  - Appointment of J. S. Lilley to a Research Fellowship in nuclear physics, 937
  - Appointment of B Cockayne as William Gibbins Research Fellow in the Department of Physical Metallurgy, 937
  - Appointment of E. N. Corlett as senior Research Fellow in the Department of Engineering Production, 937
- University of Bristol : Appointment of Dr. A S. King to a senior lectureship in veterinary anatomy, 284
  - Appointment of H. Sutcliffe to a senior lectureship in electrical engineering, 284
  - Appointment of J. S. Cooper as lecturer in prosthetics, 284
  - Grant of £25,000 from the Research Grants Advisory Panel of NATO to the Department of Physics, for the support of an international expedition to the central Mediterranean, 284
  - Grant of £6,500 from the Department of Scientific and Industrial Research to the Department of Physics, in connexion with an investigation of high-altitude flight and recovery techniques in the Mediterranean region, 284
  - Grant of £1,600 from the Department of Scientific and Industrial Research to the Department of Organic Chemistry, for an investigation into the structure and synthesis of natural products, 284
  - Grant of £2,200 from the Department of Scientific and Industrial Research to the Department of Physics, towards research on the study of fragmentation of heavy cosmic ray nuclei in hydrogen and carbon, 284
  - Grant of £2,000 from the Nuffield Foundation to the Department of Surgery, for work on vascular disease, 284
  - Grant of £1,250 per annum for two years from Roche Products Ltd., to the Department of Organic Chemistry, for the establishment of a Roche fellowship for research work, 284
  - Appointment of Dr. P. G. Drazin as lecturer in mathematics, 937
  - Appointment of Dr A. E. Scott as lecturer in chemistry, 937
  - Appointment of J. K. Whitaker as lecturer in mathematical economics, 937
  - Appointment of K. F. H Murrell as a Research Fellow in the Department of Psychology, 937
  - Election of Dr. D. H. Perkins as reader in physics, 937
- University of Cambridge : Retirement of Prof. G. E Briggs from the professorship of botany, 356
  - Appointment of Dr H Godwin as professor of botany, 356
  - Election of Dr. F. H Hahn to Official Fellowship, and College lecturer in economics to Churchill College, 440
  - Election of Dr. D. J. Thouless to Official Fellowship, and College lecturer in mathematics to Churchill College. 440
  - Election of Dr F H. C. Crick to an Extraordinary Fellowship of Churchill College, 440
  - Election of Prof. S. B Treiman to an Overseas Fellowship of Churchill College, 440
  - Modification of Matriculation requirements, 603
  - Retirement of Prof E. B. Moullin from the chair of electrical engineering, 680
  - Appointment of Prof C. W Oatley to the chair of electrical engineering, 680
  - Election of Prof A. B Pippard to the John Humphrey Plummer professorship of experimental physics, 762
- University of Chicago . Appointment of Prof M. J. S Dewar to the chair of organic chemistry, 762
- University of Colorado, Boulder : Appointment of Prof Oswald Tippo as provost, 1020
- University of Durham · Appointment of Prof D G. Christopherson as Warden of the Durham Colleges, 604
  - Appointment of Dr O. E W R. Kurth as senior lecturer in mathematics, 937
  - Appointment of D J. Bellamy as lecturer in botany, 937
  - Appointment of Dr R D. Chambers as lecturer in chemistry, 937
  - Appointment of Dr D P. Hendry as lecturer in psychology, 937
  - Appointment of Dr. D M. Hirst as lecturer in geochemistry, 937
  - Appointment of Dr M J. Morant as lecturer in applied physics, 937
  - Retirement of Prof Meirion Thomas from the chair of botany at King's College, Newcastle-upon-Tyne, 1016
- University of Edinburgh : Institution of a chair of electrical engineering, 522
  - Science and Mathematics Texts, No. 2, The Antecedents of Man (Prof. Sir Wilfrid E. Le Gros Clark), *review* by Dr. G G. Simpson, 665
  - Appointment of Dr J L. Holmes, Dr. K. R. Jennings, Dr. G R. H. Jones, Dr. A. J Charlson and Dr. J. W. Sutherland as I.C.I Research Fellows, 767
  - Appointment of M. J. O'Hara as lecturer in geology, 767
  - Appointment of E. R. S. Fifoot as University librarian, 767
- University of Hawaii, and others : Tenth Pacific Science Congress of the Pacific Science Association, 604
- University of Illinois : Appontment of Prof. Theodore Delevoryas as associate professor in the Department of Botany, 1020

University of Leeds . Appointment of Dr. D. R Woods to the chair of pharmacology, 121
  Annual Report of the Librarian for the Session 1958-59, 126
  Appointment of Prof. J. Nutting to the chair of metallurgy, 201
  Appointment of W. G. Collins and J. A. Fox as lecturers in civil engineering, 767
  Appointment of Dr. C. M. Reeves as lecturer in electronic computing, 767
  Appointment of C G Woods as lecturer in pathology, 767
  Appointment of Dr P. J. Wyllie as lecturer in experimental petrology, 767
  Portsmouth fellowship for research in multiple sclerosis awarded to Dr. D M. Robertson, 767
  Grant of £2,055 from the Department of Scientific and Industrial Research to the Department of Zoology, for research projects under the direction of Dr. Broadhead, 767
  Grant of 152,517 dollars from the United States Public Health Authority to the Department of Biomolecular Structure, 767
  Grant of £1,100 from the Medical Research Council to the Department of Biomolecular Structure, to establish a research fellowship, 767
  Grant of £3,500 from the British Coke Research Association to the Houldsworth School of Applied Science, 767
  Grant of £1,200 a year from the Thermal Syndicate, Ltd , to the Houldsworth School of Applied Science, to establish a research fellowship in ceramics, 767
University of Liverpool : Appointment of Prof. J M Cassels to the Lyon Jones chair of physics, 201
  New Laboratories at the, 844
  Mathematics, Education and Industry—a Record of a Conference of Teachers, Research Scientists and Industrialists (1959), 1017
University of London · Fifty-second Annual Report of the Governing Body of the Imperial College of Science and Technology (1958-59), 123
  Research Report of the Royal College of Science (1956-59), 123
  New Nematology Laboratory to be built and equipped at the Imperial College of Science and Technology Field Station at Silwood Park, 205
  Postgraduate Courses, 1960-61, at the Imperial College of Science and Technology, 206
  H M Queen Elizabeth the Queen Mother to open the Brunswick Square building of the School of Pharmacy, 284
  Grant of £120,000 from the Wellcome Trust to King's College, towards the purchase of the lease of premises to house a Department of Biophysics, 439
  Grant of £30,000 from the Wellcome Trust to University College, to build and furnish a research unit in cellular immunity as an annexe to the Department of Zoology, 439
  Grant of £2,500 per annum for up to 5 years from the Wellcome Trust to St Mary's Hospital Medical School, to provide technical assistance and research expenses for work on the physiology of pre-natal growth, 439
  Appointment of Dr E. H. Bellamy to the University chair of physics at Westfield College, 440
  Appointment of Dr E. H Sondheimer to the University chair of mathematics at Westfield College, 440
  Appointment of Dr. G E. Fogg to the University chair of botany at Westfield College, 440
  Appointment of Dr K. W Cross to the University chair of physiology in London Hospital Medical College, 522, 598
  Appointment of Dr. B C. L. Weedon to the University chair of organic chemistry in Queen Mary College, 522, 762
  Appointment of Dr. D V. Ager to the University readership in geology at the Imperial College of Science and Technology, 522
  Title of reader in the history and philosophy of science in the University (at University College) conferred on Dr. N. H. de V. Heathcote, 522
  Election of Sir Harold Roxbee Cox, Prof. C W. Dannatt, Prof. F. G. Gregory, G C. Lowry and Sir William Pugh to Fellowships of the Imperial College of Science and Technology, 522
  Retirement of Prof E. S Pearson from the chair of statistics in University College, 599
  Appointment of Prof M S Bartlett to the chair of statistics in University College, 599
  Dinner to be held in honour of F Howarth, on his retirement from the Botany Department of the Imperial College of Science and Technology, 604
  Appointment of Prof. M. J S Dewar (Queen Mary College) to the chair of organic chemistry in the University of Chicago, 762
  Optical Design Group to be set up at the Imperial College of Science and Technology under the direction of Dr. C G Wynne, with the support of a grant of £9,400 a year from the Department of Scientific and Industrial Research, 934
  Appointment of Dr W Klyne to the University chair of chemistry at Westfield College, 938
  Appointment of Dr. R E. O Williams to the University chair of bacteriology at St. Mary's Hospital Medical School, 938, 1016
  Appointment of Dr. J. H. Green as reader in physiology at Middlesex Hospital Medical School, 938
  Appointment of Dr H. J J Blackwood as reader in oral anatomy at the Royal Dental Hospital of London School of Dental Surgery, 938
  Appointment of J C. de C. Henderson as reader in reinforced concrete structures at the Imperial College of Science and Technology, 938
  Appointment of A. J. Buller as reader in physiology at King's College, 938
  Appointment of Dr H Harris to the University chair of biochemistry at King's College, 1020
  Appointment of A. F Huxley to the Jodrell chair of physiology at University College, 1020
  Course of Lectures in Reactor Fuel Element Technology at the Imperial College of Science and Technology, 1025
University of Manchester : Cost of the Radio Telescope at Jodrell Bank, 13
  Annual Report of the Manchester Museum for 1958-59, 521
  Appointment of Dr. John Colhoun to the chair of cryptogamic botany, 598
  Summer School in Modern Methods of Crystal Structure Determination at the Manchester College of Science and Technology, 766
  Retirement of Prof. H Wright Baker from the chair of mechanical engineering, 1015
  Appointment of W Johnson to the chair of mechanical engineering, 1015
University of Maryland : Bibliography on Plasma Physics and Magnetohydrodynamics and their Applications to Controlled Thermonuclear Reactions (J. D. Ramer), 522
  Grant of 216,000 dollars from the United States National Aeronautics and Space Administration, to accelerate its programme of basic research dealing with the growth and metabolism of unicellular algae, 604
University of Milan . Symposium on Drugs affecting Lipid Metabolism, 127
University of New South Wales . Appointment of Dr S J. Angyal to the chair of organic chemistry, 357
University of Nottingham Appointment of Dr Cyril Clifford Addison as professor of inorganic chemistry, 767
  Appointment of Dr Maurice William Partridge to the Lord Trent chair of pharmaceutical chemistry, 767
  Appointment of Dr. R Edgeworth Johnstone as the first Lady Trent professor of chemical engineering, 933
University of Oregon Appointment of Dr. George Streisinger as associate professor of biology in the Institute of Molecular Biology, 681
University of Oxford : Grants from the Department of Scientific and Industrial Research—£1,170 for the purchase of apparatus for the structural investigation and synthesis of peptides, to be carried out in the Dyson Perrins Laboratory ; £10,800 for the purchase of an electron-microscope for use in research in the Department of Metallurgy , £7,450 for work being carried out in the Clarendon Laboratory ; and £940 for work on the expansion of X-ray fluorescence analysis to lower atomic numbers, being carried out in the Research Laboratory for Archaeology and the History of Art, 126
  Grant of £1,600 from the National Coal Board, for the continuation of research on hot and humid conditions, being carried out in the Department of Human Anatomy, 126
  Grant of £10,450 from the National Institute for Research in Nuclear Science, for an investigation of the alignment of nuclei for the proton linear accelerator, to be carried out in the Clarendon Laboratory, 126
  Grant of £1,000 from the British Iron and Steel Research Association, for the continuation of research on the melting- and freezing-points of alloys, being carried out in the Department of Metallurgy, 126
  Grant of £3,330 from the Mental Health Research Fund, for research on the physiology of drive, to be carried out in the Institute of Experimental Psychology, 126
  Annual Report for 1959 of the Committee for Appointments, 682
  Appointment of Dr. E. P Abraham as reader in chemical pathology, 767
  Appointment of Dr. E Bulbring as reader in pharmacology, 767
  Appointment of Dr. W. A. Waters as reader in physical organic chemistry, 767
  Appointment of Dr. N Kurti as reader in physics, 767
University of Pennsylvania . Diagnostic Clinic of the Graduate School of Medicine, Medical Affairs, Vol 1, No. 3, Health of the Executive, 765
University of Pretoria · Appointment of Dr. J. M. Joubert to the chair of sheep husbandry and wool technology, 280
University of Reading : New Physics Laboratory of the (Prof R. W. Ditchburn), 768
University of Rochester, and others : Conference on Coherence Properties of Electromagnetic Radiation, 127
University of St Andrews . Appointment of Dr Ann R. Sanderson as senior lecturer in the Department of Zoology, Queen's College, 767
  Appointment of Dr D V Osborne as senior lecturer in the Department of Natural Philosophy, St. Salvator's College, 767
University of Sheffield Appointment of Boris Ford as director of the Institute of Education and professor of education in the Institute, 121
University of Southampton Contribution of £20,000 from Shell-Mex and B P. Ltd., to the 1962 Centenary Appeal Fund, 284
  Appointment of A. M MacIver to the newly established chair of philosophy, 284
  Title of senior lecturer in physics conferred on Dr. H G. Jerrard, 284
  Title of senior lecturer in physiology and biochemistry conferred on Dr. G. A. Kerkut, 284
  Title of senior lecturer in botany conferred on Dr. G. R Lane, 284
  Title of senior lecturer in electronics conferred on S. W. Punnett, 284
  Appointment of Dr R J Gribben and Dr. L. Marder as lecturers in mathematics, 284
  Appointment of H S Stachera as lecturer in electronics, 284
  Appointment of Dr I D. R Stevens as lecturer in chemistry, 284
  Appointment of T. C. Whitmore as lecturer in botany, 284
  Appointment of Prof G. W Hutchinson to a newly established second chair of physics, 762
University of Sydney · Astronomy in Australia—Stellar Interferometer of the School of Physics, 270
  From Nucleus to Universe—a Course of Selected Lectures in Physics and Astronomy, 1960 (edited by Prof S. T. Butler and Prof H Messel), *review* by G R Noakes, 748
University of Toronto · Grant of £70,000 from the Wellcome Trust, to build and equip basically additional research accommodation in the Charles H. Best Institute, 439
  A copy of *Illiac II* to be installed in the Computation Centre, 682
University of Wales : Retirement of Prof C. W Davies from the chair of chemistry in the University College of Wales, Aberystwyth, 680
  Appointment of Dr. A F Trotman-Dickenson to the chair of chemistry in the University College of Wales, Aberystwyth, 681
  New Biolgoy Building of the University College of Wales, Aberystwyth (Prof. T A Stephenson and Prof P F Wareing), 1021
University of Wisconsin Conference on the Chemical Organization of Cells, Normal and Abnormal, 604
University College, London · Grant of £30,000 from the Wellcome Trust, to build and furnish a research unit in cellular immunity as an annexe to the Department of Zoology, 439
  Title of reader in the history and philosophy of science in the University of London conferred on Dr N. H. de V. Heathcote, 522
  Retirement of Prof. E. S. Pearson from the chair of statistics, 599
  Appointment of Prof M. S Bartlett to the chair of statistics, 599
  Appointment of A. F Huxley to the University of London chair of physiology, 1020

University College of North Staffordshire : Appointment of Dr. Donald M. MacKay to the new Granada research chair of communication, 599
University College of Sierra Leone : Appointment of Dr Davidson Nicol as principal of Fourah Bay College, 599
University College of Wales, Aberystwyth . Retirement of Prof C. W. Davies from the chair of chemistry, 680
  Appointment of Dr. A. F Trotman-Dickenson to the chair of chemistry, 681
  New Biology Building of the (Prof. T. A. Stephenson and Prof P. F Wareing), 1021
University College of the West Indies, Jamaica : Grant of £8,000 from the Wellcome Trust, to purchase a mass spectrometer for use in the Medical Research Council's Tropical Metabolism Research Unit, 439
University Education, 1960-1970 ; Memorandum to the University Grants Committee on the Expansion of (National Union of Students), 687
University Entrance—the Basic Facts (National Union of Teachers), 14
University Grants Committee · Memorandum to the, on the Expansion of University Education, 1960-1970 (National Union of Students), 687
University Students : The Needs of, 687
University Work : Sixth-Form Science as a Preparation for (Dr. W. L. Sumner), 686
Unsteady Supersonic Flow : The Potential Theory of (Prof. John W. Miles), *review* by L. E. Fraenkel, 505
Unusual Web Pattern made by an Unfertilized Female of the Spider *Uloborus walckenaerius* Latreille (Dr. Rasza Szlep), 94
Upper Atmosphere : Density of the, and its Dependence on the Sun, as revealed by Satellite Orbits (D G. King-Hele and D. M. C. Walker), 928
Upper-Atmosphere Air Density at the Height of 180-212 km. derived from the Orbit of *Sputnik* III : Profile of (Z V Bochníček), 460
Upper Ionosphere : Electron Density Measurements in the, using the Faraday Rotation of Radio Signals from Artificial Satellites (Dr. D. McL. A. Wilson), 623
Upper Mantle : Structure of the, as derived from the Travel Times of Seismic *P* and *S* Waves (Dr. I Lehmann), 956
Uptake (Potassium-42), by the Rat Muscle *in vitro* : Effect of Denervation on (Dr. Z Drahota and O Hudlická), 396
Uptake Measurement : Thyroid Radioiodine (Dr Marshall Brucer), *review* by Dr. E. E. Pochin, 424
Uraninite and Thorianite (Dr. Bibhuti Mukherjee), 464
Uranus . Earthquakes and—Misuse of a Statistical Test of Significance (E. J. Burr), 336 ; (Prof. R Tomaschek), 337
Urbański, Prof. T., and others : Antimalarial Properties of some Guanidine Derivatives, 170
Urea . Radiation Synthesis of (S. Dilli and J H. Green), 383
Urea- or Phenol-treated T_2 Coli-Phage Preparations · Plaque-forming Ability of (Dr P H. Hofschneider), 330
Uretz, Prof. Robert B. (Freifelder, David, and) : Inactivation by Visible Light of Yeast sensitized by a Nucleic Acid Fluorochrome, 731
Urinary Excretion of a Ninhydrin-positive Compound, probably a Peptide, after Administration of β-Amino*iso*butyric Acid to the Mouse (Dr. James B. Gilbert and Dr. Yuoh Ku), 160
Urinary Phenols in Stress (R Robinson and Dr. P. Smith), 240
Urine : Desalting of, by Electrodialysis (Dr. T. Wood), 634
Urprinzip der Lebensvorgange : Die Ruckkoppelung als (Bayerische Akademie der Wissenschaften prize of 8,000 D marks for an Essay on), 938
Urquhart, Dr D. J : At the Scientific Publications Council's Discussion on the Rapid Increase in the number of New Scientific Journals, 18
U.S.A. : Water-Witching (Evon Z Vogt and Ray Hyman), *review* by Prof. H. J. Eysenck, 346
Use of an Auxiliary Grid to stabilize the Gain of a Photomultiplier (Dr. C. F. G Delaney and Dr A J. Walton), 625
Use of Film in Teaching and Research in British Universities, 1959 (British Universities Film Council), 444
Use of Ionizing Radiation in Spot Tests for Nitrogenous Compounds (H. J. M Bowen, E. Arter and P. A. Cawse), 383
Use of Laboratory Animals in the Standardization of Drugs (Research Defence Society, Pamphlet No. 10), 438
Use of Long-lived Natural Radioactivity as an Atmospheric Tracer (W M. Burton and N. G. Stewart), 584
Use of Miniature Gyroscopes in Aircraft and Guided Missiles (W. R. Simons), 522
Use of Nitrous Oxide to discriminate between the Forms of Hydrogen Atoms (H· and H_2^+ ?) produced by γ-Irradiation of Aqueous Solutions (Prof F. S Dainton and Dr D. B. Peterson), 878
Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide irradiated with Ultra-Violet Light (Prof F S Dainton and S A. Sills), 879
Use of Radioisotopes in the Physical Sciences and Industry (International Atomic Energy Agency Conference on), 284
Use of Solvents containing Ethyl Iodide in the Investigation of Phosphorescence Spectra of Organic Compounds (Dr I. J Graham-Bryce and J. M. Corkill), 965
Use (Meteorological), of Pulsed Doppler Radar (J R. Probert-Jones), 271
Use (Technological), of Radiation (Australian Atomic Energy Commission Conference on), 126
Uses (Peaceful), of Atomic Energy : Proceedings of the Second United Nations International Conference on the, held in Geneva, 1958, Vol 2, Survey of Raw Material Resources, *review* by Prof. C. F. Davidson, 921
Usinger, Prof Robert L., and Matsuda, Ryuichi · Classification of the Aradidae (*Hemiptera—Heteroptera*), *review* by R G Fennah, 46
U.S.S.R. : Cancer Research in the, *review* by Dr. P A. Gorer, 420
  Mineralogy in the (V F. Alyavdin), 853
  The Progress of Geology in the (Prof S I Tomkeieff), 438
  Reference Books on Mineralogy in the (Academy of Sciences of the U S S.R), 203
U.S S R and the International Geophysical Year, 359
Uterus of the Rat . Œstrogen–Insulin Interaction on the (Dr. R. Michel Zilberstein), 635
Utilization · Nuclear Theory and its, *review* by Dr. T E Allibone, 917
Utilization (Aspartic Acid), in *Leuconostoc mesenteroides* : (+) S-Methyl-L-Cysteine Sulphoxide, an Inhibitor of (Wilfred N Arnold, Clayton J Morris and John F. Thompson), 1051
Utne, F , and others . Vitamin A Isomers in the Liver of Rats and Chicks, 312
Uzman, L. Lahut, and others : Dipeptidase Activity of Brain, 559

VACCINATION with Fractions of Phenol-killed Tubercle Bacilli : Enhanced Resistance of Mice to Infection with *Pasteurella pestis* following (Prof. David W. Weiss), 1060
Vaccinia Virus : Eclipse Phase of (Dr. R. Postlethwaite and Prof. H. B. Maitland), 335
Vacek, Dr. A. : Significance of Adrenals for Increased Oxygen Consumption in Rats during Irradiation, 90
Vagal Stimulation or Acetylcholine Administration : Intracellular Potentials in Rat Atria during and after (P. A. Biersteker, J Th. F. Boeles and L N. Bouman), 637
Vaisey, Gillian : Appointed lecturer in civil engineering at the University of Birmingham, 767
Valantin, Dr J. G. : Quantum Effects on a Macroscopic Scale, *review*, 345
Vallance, L. G. Nitrogen in Tropical Agriculture (Nitrogen Fertilizing of Sugar), 942
Vallentine, H. R. : Applied Hydrodynamics, *review* by E. P. Sutton, 669
van Die, J. : Organic Acid Synthesis in Tomato Roots, 603
van Duijn, P., and Persijn, J.-P : A New Technique for Studying the Quantitative Aspects of Cytochemical Reactions and its Application to the Feulgen Reaction, 805
Van Gansen-Semal, Dr. P. : Occurrence of a Non-Fibrillar Elastin in the Earthworm, 654
van Gennep, Arnold : The Rites of Passage (translated by Monika B. Vizedom and Gabrielle L. Caffee), *review* by Dr. Kenneth Walker, 37
van Hecke, Francis : Polymer Formation in Irradiated *p*-Xylene, 382
van Niekerk, J. N., and de Wet, J. F : Trace Analysis by X-Ray Fluorescence using Ion Exchange Resins, 380
van Oosten, Dr. R P. : Industrial Chemistry of the Lower Olefines (The Production of Ethylene Oxide), 285
van Someren, Dr. Vernon D. : The Inland Fishery Research Station, Sagana, Kenya, 425
van Steenis, Prof. Dr. C G G. : Elected a Foreign Member of the Linnean Society of London, 766
van den Ende, J., and Koornneef, P : Gibberellic Acid and Osmotic Pressure, 327
van den Noort, Stanley, and others : Dipeptidase Activity of Brain, 559
Vanadium Catalysis of the Oxidation of Catechol Amines, Dihydroxyphenylalanine and 5-Hydroxyindoles (Dr. G M. Martin, E. P. Benditt and N. Eriksen), 884
Vandenkerckhove, Jean, and others Rocket Propulsion, *review* by J. E. P. Dunning, 186
Vandervelden, M., and others · Isolation of a Cytopathogenic Agent from Skin Lesions of Cattle, 979
Vapours : Flame and Explosion of Gases and, *review* by Dr. H F. Coward, 666
  Inhaled Particles and (British Occupational Hygiene Society International Symposium on), 524
Variance et Plans d'Expérience · Analyse de (Prof. Daniel Dugué et Prof. Maurice Girault), *review* by Dr D. J Finney, 68
Variants (Human Haemoglobin) : A New Electrophoretic Medium and its Application to the Resolution of (Dr. E. R. Huehns and Dr A O. Jakubovic), 729
Variation in *Phytophthora palmivora* (Butl.) Butl on *Theobroma cacao* L. in West Africa (P. D. Turner), 495
Variation (Diurnal Temperature), in the Rhesus Monkey under Normal and Experimental Conditions (Dr. Lloyd B. Erikson), 83
Variations in Electrophoretic Position of Haptoglobin Mixtures in Agar-gel Electrophoresis (Dr Jan Hirschfeld), 894
Variations (Individual), in Electrophoretic Position of an Indoxyl-acetate Splitting Component in the α_2-Globulin Region of Normal Human Sera · Agar-gel Electrophoretic Demonstration of (Dr. Jan Hirschfeld), 321
Various Levels of Bed Sediment : Haemoglobin Content of the Larvae of *Tendipes f. l. plumosus* L. from (B. Czeczuga), 484
Varma, Rama : Recent Advances in Coconut Research in India, 861
Vass, Dr C C. N. : At the Scientific Publications Council's Discussion on the Rapid Increase in the number of New Scientific Journals, 18
Vaughn, Joe W. (Watt, Prof. George W , and) · Mechanism of the Electroreduction of Complexes of the Type $[M(NH_3)_5X]^{n+}$, 309
Vejlby, Dr. Knud : Induction Phenomena in Photosynthesis of Isolated Spinach Chloroplasts, 652
Veis, Dr Arthur, and Cohen, Dr Jerome : Reversible Transformation of Gelatin to the Collagen Structure, 720
Velocity of Light in a Magnetic Field (Prof R. V Jones), 706
Venge, Dr Ole, and others · Inheritance of β-Globulins in Serum and Milk from Cattle, 907
Venkateswaran, Dr. S. : Appointed first controller-general of Patents, Designs and Trade Marks (India), 122 ; work of, 122
Venulet, J., and others : Antimalarial Properties of some Guanidine Derivatives, 170
Venus : Apparent Radio Radiation at 11-m Wave-Length from (Dr. J. D. Kraus), 462
Verghese, E. J Recent Advances in Coconut Research in India, 861
Verhoeven, W., and others (edited by) . Albert Jan Kluyver—His Life and Work, *review* by Prof. B. C. J G. Knight, 44
Vernon, Prof M. D. : Self-Regulation for Children, *review*, 38, 912
  The Brain in Response, *review*, 919
Vernon Prize for 1960 of the National Institute of Industrial Psychology awarded to Dr. R B. Buzzard, 938
Very Low Frequency Geomagnetic Fluctuations Influence of Geological Features on (H J. Duffus, J. A. Shand and Sir Charles Wright), 141
Very Low Temperatures · Reaction between Copper and Solid Oxygen condensed at, from a Gas Discharge (Jerome Kruger and William J. Ambs), 794
Veterinary Anatomy as a Branch of Biology · The Teaching of—its Relationships to Human Anatomy (Dr R A Green), 192
Veterinary Annual, 1959 (edited by W A. Pool), *review* by G N Gould, 667
Veterinary Association (British) · *Research in Veterinary Science*, Vol. 1, No. 1, 16
Veterinary Codex 1953 (British) 1959 Supplement to, *review* by Dr P. Jewell, 507
Veterinary Science, Research in, Vol. 1, No. 1 (British Veterinary Association), 16
Veterinary Surgery : Advances in, *review* by G. N. Gould, 667

Viability of Insect Migrants High in the Air : Mortality and (L. R. Taylor), 410
Viability and Tetrazolium Salt in Ascites Tumours (Dr. Gustav Dallner), 176
Vibrationally Hot Molecules in Free-Radical Reactions . A Model to account for the Production of (Dr. J. P Simons), 551
Vibrio foetus : Simplified Bulk Growth of (Dusan Jakovljevic and H. E. R. Beattie), 736
Vickery, B. C., and Foskett, D. J. : Classification and Indexing in Science, second edition, *review* by R Brightman, 190
Vijayalakshmi, K. . Recent Advances in Coconut Research in India, 860
Villiers, A. (textes de) : Les Plus Beaux Insectes, *review* by H Oldroyd, 187
Virulence (Staphylococcal) for Mice Enhancement of, by Intraperitoneal Cortisone Acetate, Cholesterol and Lecithin (Dr Daniel Amsterdam and Dr. S Stanley Schneierson), 101
Virus of Foot-and-Mouth Disease Influence of Route of Inoculation and Strain of Mouse on Infectivity Titrations of the (Wendy Heatley, H H Skinner and H. Subak-Sharpe), 909
Virus (Cauliflower Mosaic) Purification and Properties of (Prof. Thomas P. Pirone, Glenn S. Pound and Robert J. Shepherd), 656
Virus (Chicken Tumour) : Presence of, in the Sarcoma of the Adult Rat inoculated after Birth with Rous Sarcoma Tissue (Dr. Jan Svoboda), 980
Virus (*S E* Polyoma) : Development of Resistance in Mice to Tumour Induction by (Sarah E. Stewart, Bernice E. Eddy, Marjean Irwin and Stephanie Lee), 615
Virus (Rabies) An Indicator Plaque-forming System for Demonstration of Interference to Non-cytocidal Strains of (Dr Martin M. Kaplan, Dr Eberhard Wecker, Dr. Zlatko Forsek and Dr Hilary Koprowski), 821
Virus (Tobacco Mosaic) Decarboxylation of Glutamic Acid in Tobacco Leaves inoculated with (M S Gubanski), 657
  Primary Structure of the Protein of (F. A. Anderer, H. Uhlig, E. Weber and Prof. G. Schramm), 922
Virus (Turnip Yellow Mosaic) Protein Components from (Dr. J M. Kaper), 219
Virus (Vaccinia) . Eclipse Phase of (Dr. R. Postlethwaite and Prof H B, Maitland), 335
Virus *M* (Potato), and Paracrinkle (Dr. H. W. Howard and J. Wainwright), 993
Virus Particles (Encephalomyocarditis) : Crystallization of Purified Mouse (P. Faulkner, E M. Martin, S. Sved and Dr. T S Work), 908
Virus Release from Single Cells of Mouse Parotid Tumours (Dr Mathilde Krim and Dr. Leo Sachs), 262
Virus-infected (Ectromelia) Cells : Filamentous Structures in (Dr Benjamin V. Siegel), 820
Viruses of Trachoma, Inclusion Blennorrhoea and Lymphogranuloma : Transmission of the, to Mice (Dr E. Weston Hurst and P Reeve), 336
Viruses (Pox-) : Reactivation of, by a Non-Genetic Mechanism (Dr W. K. Joklik, Pamela Abel and I. H Holmes), 992
Visco-Elastic Systems (Australian Commonwealth Scientific and Industrial Research Organization Symposium on), 942
Viscous Phase of Liquid Sulphur : Structure of the (Dr. E. McLaughlin), 76
Visible Light : Inactivation by, of Yeast sensitized by a Nucleic Acid Fluorochrome (David Freifelder and Prof Robert B Uretz), 731
Visible and Ultra-Violet : Reflectance of Coal Vitrains in the, compared with that of Graphite (L A Gilbert), 143
Vision . The Eye and, *review* by R C. Davenport, 42
Visits (Selective), of Butterflies to Flowers—a Possible Factor in Sympatric Speciation (K R. Dronamraju), 178
Vistas in Astronautics (edited by Morton Alperin and Hollingsworth F. Gregory), Vol 2 (Second Annual Astronautics Symposium sponsored by the United States Air Force Office of Scientific Research and the Institute of Aeronautical Sciences), *review* by D G King-Hele, 59
Visual Pigment of the Horseshoe Crab, *Limulus polyphemus* (Dr Ruth Hubbard and Prof George Wald), 212
Visual Pigments : Regeneration of, from their Low-Temperature Photoproducts (Dr. C D. B. Bridges), 292
Visual System of *Octopus*—Regularities in the Retina and Optic Lobes of *Octopus* in relation to Form Discrimination (Prof J. Z Young), 836 ; Discrimination of Polarized Light by *Octopus* (M. F Moody and J R Parriss), 839 ; Theories of Shape Discrimination in *Octopus* (Dr N. S Sutherland), 840
Vitamin A : Effect of, on the Cystine Content in Skin of Rats (Prof Tatsuo Koyanagi and Satoru Odagiri), 809
Vitamin A_1 Aldehyde in Hen's Eggs (Dr. P. A Plack), 234
Vitamin A Isomers in the Liver of Rats and Chicks (O. R. Braekkan, H. Myklestad, L R. Njaa and F Utne), 312
E-Deficient Liver Homogenates . Maintenance of α-Ketoglutarate and Succinate Oxidation in, by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine (Dr Laurence M. Corwin and Dr. Klaus Schwartz), 1048
Vítek, Dr. V., and Ryšánek, K Inhibition of Monoamine Oxidase by Benactyzine *in vitro* and *in vivo*, 244
Vitrains (Coal), in the Visible and Ultra-Violet Reflectance of, compared with that of Graphite (L A Gilbert), 143
Vittek, J (Hoja, S., and) Treatment of Injured and Regenerating Muscles with Plant Extracts, 283
Vivisection (Research Defence Society Pamphlet on), 125
Vogt, Evon Z., and Hyman, Ray : Water-Witching U S.A , *review* by Prof H J Eysenck, 346
Vokes, J C., and others . Coherence and Band-width of a Gas Discharge Harmonic Generator, 626
Volatile Mercaptan Mixtures . A Rapid Method for Qualitative Analysis of (John F Carson, William J Weston and Jack W Ralls), 801
Volume Changes (Small Rapid), in a Muscle during Activity : Determination of (Prof B C Abbott and R J Baskin), 1055
Volume Control in an Ascites Tumour Cell : Effect of Antibody and Complement on (Dr H Green and Dr F. Silverblatt), 646
Volvox Colonies and Snail 'Cystase' (Dr B C Sharman), 90
von Bahr, G , and others (edited by) Documenta Ophthalmologica (Advances in Ophthalmology, Vol. 13), *review* by R. C. Davenport, 42
von Bunau, H Fischer, and others (edited by) : Documenta Ophthalmologica (Advances in Ophthalmology, Vol. 13), *review* by R. C. Davenport, 42
von Hayek, Prof Heinrich : Elected a member of the Medicine Section of the Leopoldina Academy of Natural Sciences, 766
von Humboldt, Alexander (1769-1859) : Preparation of an edition of the letters of (German Academy of Science and the Austrian Academy of Science), 685
von Kármán, Th , and others (edited by) : Advances in Aeronautical Sciences—Proceedings of the First International Congress on the Aeronautical Sciences, (Madrid 1958), *review* by Prof. A. R. Collar, 665
von Wettstein, Dr. Diter H. : Appointed associate professor in the Department of Botany in Yale University, 1020
Vonk, Dr. C. G. Effect of a Second Crystalline Modification in Polyethylene on X-Ray Crystallinity Measurements, 962
Vygodchikov, G. V. (edited by) : Pathogenesis and Immunology of Tumours, translated from the Russian by R Crawford, *review* by Dr. P. A. Gorer, 420

WACHSMUTH, Prof. Werner : Elected a member of the Medicine Section of the Leopoldina Academy of Natural Sciences, 766
Waddington, Dr. T. C. Awarded a Meldola Medal for 1959 of the Society of Maccabaeans, 519
Wain, Prof R. L. : Elected a Fellow of the Royal Society, 12
  Awarded the Research Medal of the Royal Agricultural Society of England, 685
Wainwright, J. (Howard, Dr. H. W , and) : Potato Virus *M* and Paracrinkle, 993
Wait, James R. : Electromagnetic Radiation from Cylindrical Structures, *review* by W. Brown, 583
Wake, Dr W. C. : Bonds between Rubber and Metal, *review*, 189
Waksman, Prof. Selman A. : The Actinomycins and their Importance in the Treatment of Tumours in Animals and Man, 771
Wald, Prof George (Hubbard, Dr. Ruth, and) Visual Pigment of the Horseshoe Crab, *Limulus polyphemus*, 212
Wales, National Museum of Annual Report (1958-59), 15
Walker, Dr. D. G : Appointed lecturer in biochemistry at the University of Birmingham, 937
Walker, D. M C. (King-Hele, D G., and) : Density of the Upper Atmosphere and its Dependence on the Sun, as revealed by Satellite Orbits, 928
Walker, Dr. J. : Title of reader in reactor physics in the University of Birmingham conferred on, 767
Walker, Dr Kenneth : Human Rites, *review*, 37
  Problems of Human Fertility, *review*, 188
Walker, jun , Dr P L. (Redmond, Dr. J P , and) : Gas Content of Graphites, 72
Wall, C T. C. : Elected to a Harkness Fellowship for 1960 of the Commonwealth Fund, 15
Wall, Dr. W. D. : Psychology of Gifted Children, 692
Wall of the Gastro-intestinal Tract of the Infant Mouse : Passage of Insulin through the (W A. Kelly), 971
Wallace, Prof Bruce, and Dobzhansky, Prof. Th. : Radiation, Genes and Man, *review* by Dr. A. G. Searle, 109
Waller, J G. . New Clathrate Compounds of the Inert Gases, 429
Wallis, Dr. F. S. : The Philosophy of Museums, *review*, 110
Walsh, D , and others : Coherence and Band-width of a Gas Discharge Harmonic Generator, 626
Walter, Dr J. B., and Slome, Prof. D. : Effect of *S*-β-aminoethyl*iso*thiouronium Bromide Hydrobromide on X-Ray Damage to Guinea Pig Skin, 177
Walton, Dr A. J. (Delaney, Dr. C. F G , and) Use of an Auxiliary Grid to stabilize the Gain of a Photomultiplier, 625
Walton, Dr. E. K. Orogens (The Eugenosynclinal Region of the Scottish Southern Uplands), 690
Walton, Prof J. : Miocene Floras of the Columbia Plateau, *review*, 66
  The Morphology and Anatomy of American Species of the Genus *Psaronius*, *review*, 190
Wandering British Scientist : The, 436
Wang, Dr. Dalton An Ion-Exchange Resin Method for the Fractionation of Alcoholic Plant Extracts, 326
Ward, Dr F. A. B. : Horology in Medieval China, *review*, 834
Ward, J. C , and others : The Tesla-coil Method for Producing Free Radicals from Solids, 712
  Polymerization of Crystalline Methacrylic Acid initiated by Ultra-violet Radiation, 713
Wardlaw, Prof. C. W : The Banana, *review*, 48
Ware, C. C , and Nicol, Prof. T. : Duration of Stimulation of Phagocytic Activity of the Reticulo-Endothelial System after Cessation of Treatment with Diethylstilboestrol, 974
Wareing, Prof. P F. (Stephenson, Prof T A , and) New Biology Building of the University College of Wales, Aberystwyth, 1021
Waring, S A. : Nitrogen in Tropical Agriculture (Nitrogen Fertilizing of Grain and Forage Crops), 942
Warkany, Dr. Josef : Elected president of the Teratology Society, 937
Warkentin, Prof B. P (Blackmore, Dr. A V., and) : Swelling of Calcium Montmorillonite, 823
Warm-blooded Animal (a Cold- and a) : Influence of Temperature upon Blood Coagulation in (Dr. H. B. Anstall and Dr. R. G. Huntsman), 726
Warren, Francis A . Rocket Propellants, *review* by Dr. W. B Littler, 58
Warren, Dr. Leonard : Thiobarbituric Acid Spray Reagent for Deoxy Sugars and Sialic Acids, 237
Washing the Benzidine Sulphate Precipitate in the Determination of Sulphate A Modification for (Dr I. P T Hakkinen), 232
Water . Primary Processes in the Action of Ionizing Radiations on—Formation and Reactivity of Self-trapped Electrons ('Polarons'), (Prof. Joseph Weiss), 751
Water in the Rat Effect of Severing the Olfactory Bulbs on the Intake and Excretion of (V. Nováková and H. Dlouhá), 638
Water (Drinking) Fluoridation of (Gerald H. Leatherman and J. A. Ellis), 438
Water (Ground) Hydrology (Prof. David Keith Todd), *review* by E. Miller, 423
Water (Rain-) Sodium/Potassium Ratio in (Dr. A. T Wilson), 705
Water (Sea-) as the Primary Source of Sulphate in Tidal Swamp Soils from Sierra Leone (J C. D. Watts), 308
Water (Tritiated) : Saliva-Serum Ratios of Tritium after the Administration of (Dr A. J. Coppen and Dr. J. L. Gibbons), 724

Water (Tritiated) Samples . Preparation of, by Distillation (J. D. Simpson and Dr. J. R. Greening), 467
Water Bloom (A Red), of Rotifers in Cook Strait, New Zealand (Vivienne Cassie), 328
Water-boatman (*Krizousacorixa femorata*) : Inheritance of Asymmetry in a (Dr. Walter Peters), 737
Water Committee, Central Advisory : Final Report of the Trade Effluents Sub-Committee (Ministry of Housing and Local Government), 210
Water Pollution by Trade Effluents, 210
Water Proton Line : Broadening of the, in High-Resolution Nuclear Magnetic Resonance Spectra of Starch Gels (Dr. Roger Collison and Dr. M. P. McDonald), 548
Water Research Association : Fourth Annual Report (1958-59), 683
Water Resources, *review* by E. Miller, 423
Water-Soluble Methacrylates as Embedding Media for Preparation of Ultra-Thin Sections (Dr O. Wichterle, Dr. P. Bartl, and Dr. M. Rosenberg), 494
Water Solutions · Ultra-Violet Spectra of (R. M Golding), 308
Water-Witching U.S A. (Evon Z. Vogt and Ray Hyman), *review* by Prof. H. J. Eysenck, 346
Waterhouse, Dr. Douglas F. : Appointed chief of the Division of Entomology of the Commonwealth of Australia Scientific and Industrial Research Organization, 763 ; work of, 763
Waterlow, Dr. J. C. : Medical Research in the British Caribbean, 862
Waterman, Dr. Alan T. : Awarded the Public Welfare Medal of the United States National Academy of Sciences, 686
Waters, A. C., and others : Principles of Geology, second edition, *review* by Dr. J V. Harrison, 57, 440
Waters, Lieut.-Comdr. D. W. : Appointed curator of navigation and astronomy in the National Maritime Museum, Greenwich, 12 , work of, 12
Waters, Dr. W. A. Appointed reader in physical organic chemistry at the University of Oxford, 767
Waters (Mine-) Iron Bacteria in (Dr. L. G. M. Baas Becking and Dr. D. Moore), 670
Watheroo Magnetic Observatory, Melbourne, 606
Watson (James Craig) Medal of the United States National Academy of Sciences awarded to Prof. Yusuke Hagihara, 686
Watson, Prof. Kenneth M., and others : Chemical Process Principles, Part 2, Thermodynamics, second edition, *review* by L. E. Marc de Chazal, 1003
Watson, Dr. Marion . Nature and Exploitation of Crop Plant Resistance to Disease (Interaction, or Genetic Recombination, between Potato Viruses Y and C), 858
Watt, Prof George W., and Vaughn, Joe W : Mechanism of the Electro-reduction of Complexes of the Type $[M(NH_3)_5X]^{n+}$, 309
Watt, P. A. (Newstead, Prof. Gordon, and) : A Telemetered Seismic Net in Tasmania, 704
Wattley, Dr. G. : Medical Research in the British Caribbean, 862
Watts, D. C. : Elected to a Beit Memorial Junior Fellowship for Medical Research, 520
Watts, J. C. D. : Sea-Water as the Primary Source of Sulphate in Tidal Swamp Soils from Sierra Leone, 308
Wave Functions (Gaussian), for the Hydrogen Molecule (J. V L. Longstaff and Dr. K. Singer), 799
Waverley Gold Medal Essay Competition (*Research*), 937
Waves (Gravitational), in General Relativity (Dr. H. Bondi), 535
Waves (Millimetre) from Mercury Arc Harmonic Generator (Dr. K. D. Froome), 959
Waves (Seismic P and S) : Structure of the Upper Mantle as derived from the Travel Times of (Dr. I. Lehmann), 956
Waves (Ultrasonic) . Cleaning of Fossils by (J. N. M. Firth), 684
Wawrzyczek, Dr. Wiktor : Application of Pyramidone to Detection of Nitrous Acid, 883
Wawrzyniak, J., and Sujak, Dr. B. : Photo-stimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide, 467
Ways and By-Ways : Geological, *review* by Dr J. V. Harrison, 57, 440
Wealth of India, a Dictionary of Indian Raw Materials and Industrial Products—Raw Materials, Vol. 5, H–K, *review* by Dr. F N Howes, 70
Weaver, Dr. Warren : A Quarter Century in the Natural Sciences, 20
Web (Terminal) : Structures corresponding to Terminal Bars and, in Many Types of Cells (Prof. C. P. Leblond, Holde Puchtler and Y. Clermont), 784
Web Pattern (Unusual), made by an Unfertilized Female of the Spider *Uloborus walckenaerius* Latreille (Dr Rasza Szlep), 94
Weber, E., and others : Primary Structure of the Protein of Tobacco Mosaic Virus, 922
Webster, Dr. F V. : Given the Wolfe Award for 1959, 17
Wecker, Dr. Eberhard, and others . An Indicator Plaque-forming System for Demonstration of Interference by Non-cytocidal Strains of Rabies Virus, 821
Weed Research Organization of the Agricultural Research Council, 436
  Appointment of Dr E. K. Woodford as director, 436
Weedon, Dr. B. C. L. Appointed to the University of London chair of organic chemistry in Queen Mary College, 522, 762 ; work of, 762
Weevil : The Large Pine (*Hylobius abietis*), (Forestry Commission, Leaflet No. 1), revised edition, 521
Weigel, Dr. H , and others : Action of a Bacterial Dextranase on Branched Dextrans, 553
Weight Standards for Men and Women : New (Metropolitan Life Insurance Co., Ltd , New York, Bulletin, Vol. 40), 445
Weight and Tail Length . The Growth in, of Inbred and Hybrid Mice reared at Two Different Temperatures (Prof. G. A. Harrison, R. J. Morton and Dr. J S Weiner), 446
'Weightless' Micro-electrodes for Recording Extracellular Unit Action Potentials from the Central Nervous System (Prof. B. Delisle Burns and Dr. J. G. Robson), 246
Weinberg, Dr. Alvin M. (Zinn, Dr. Walter H., and) : Awarded jointly the Atoms for Peace Award for 1960, 357
Weiner, Dr. J. S , and others : The Growth in Weight and Tail Length of Inbred and Hybrid Mice reared at Two Different Temperatures, 446
Weininger, Dr J. L. Reaction of Active Nitrogen with Polyethylene, 546
Weinman, Dr. David Trehalose Metabolism of Trypanosomes, 166
Weiss, Prof David W : Enhanced Resistance of Mice to Infection with *Pasteurella pestis* following Vaccination with Fractions of Phenol-killed Tubercle Bacilli, 1060
Weiss, Prof. Joseph : Primary Processes in the Action of Ionizing Radiations on Water—Formation and Reactivity of Self-trapped Electrons ('Polarons'), 751
Weizmann Institute of Science : The Hand of Life—the Story of the (Ritchie Calder), *review*, 64
  International Conference on Science in the Advancement of New States, 604
  Appointment of Prof. I Berenblum to the chair of experimental biology, 681
Welch, J. H. : A New Interpretation of the Mullite Problem, 545
Wellcome Trust : Carlsberg–Wellcome Travelling Research Fellowships, 283
  Grant of £120,000 to King's College, London, towards the purchase of the lease of premises to house a Department of Biophysics, 439
  Grant of £70,000 to the University of Toronto, to build and equip basically additional research accommodation in the Charles H. Best Institute, 439
  Grant of £15,000 to the Johns Hopkins Hospital, Baltimore, to adapt premises in the Department of Medicine as a research laboratory for studies of the heart and blood vessels in man, especially by the method of X-ray cinematography, 439
  Grant of £30,000 to University College, London, to build and furnish a research unit in cellular immunity, as an annexe to the Department of Zoology, 439
  Grant of £8,000 to the University College of the West Indies, Jamaica, to purchase a mass spectrometer for use in the Medical Research Council's Tropical Metabolism Research Unit, 439
  Grant of £2,500 per annum for up to five years, to St. Mary's Hospital Medical School, London, to provide technical assistance and research expenses for work on the physiology of pre-natal growth, 439
  Grant of £50,000 to the Massachusetts General Hospital, Boston, for the establishment of a Henry S. Wellcome research chair in medical science, 937
Welsh, Prof. J. H. · 5-Hydroxytryptamine in Coelenterates, 811
Welsh Coast : *Caretta kempi* Garman on (Colin Matheson), 989
Welsh Slates : Anisotropy of Susceptibility and the Natural Remanent Magnetization of some (M. D. Fuller), 791
Welsh Soils Discussion Group : Field Meeting, 127
Wenzel, Frank : The Buzzard (translated from the Danish by Reginald Spink), *review* by Frances Pitt, 65
Werkgartner, H., and others : Combined Application of Hydrogen Peroxide and Ionizing Rays in Animal Experiments, 324
Werner, Dr. A. E. · Scientific Techniques in Art and Archaeology, 674
West, Dr. R G. : Investigating Glacial and Interglacial Geology in East Anglia (Presidential Address to the Geological Section of the South-Eastern Union of Scientific Societies), 771
West Africa : Blindness in (Prof. F. C. Rodger), *review* by R. C Davenport, 64
  Variation in *Phytophthora palmivora* (Butl.) Butl. on *Theobroma cacao* L. in (P. D. Turner), 495
West African Flowers . A Handbook of (Harold N. Saunders), *review* by J. P. M. Brenan, 65
West Coast of Scotland Occurrence of *Falkenbergia rufolanosa* on the (Dr. Elsie Conway), 566
West Pacific : Sediment Cores from the (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol 6, Nos. 4-7), 609
West-Pacific Stratigraphic Correlation (Dr. M. F Glaessner), 1039
Westerhof, P., and others : A New Class of Hormonally Active Steroids, 168
Westfield College, London Appointment of Dr. E. H. Bellamy to the University of London chair of physics, 440
  Appointment of Dr. E. H. Sondheimer to the University of London chair of mathematics, 440
  Appointment of Dr. G. E. Fogg to the University of London chair of botany, 440
  Appointment of Dr. W. Klyne of the University of London chair of chemistry, 938
Weston, William J., and others : A Rapid Method for Qualitative Analysis of Volatile Mercaptan Mixtures, 801
Westrop, J. W., and Green, Prof. H. N . Binding of a Hepatocarcinogen to the Structural Lipoprotein of Rat Liver—its Bearing on the Immunological Theory of Cancer, 350
Westwood, A. R. C., and Demer, L J. : Piling-up of Dislocations beneath a Surface Film, 146
Wetselaar, R. : Capillary Movement of Nitrate towards Tropical Soil Surfaces, 572
Wetting Properties of Insect Cuticle (J. W. L. Beament), 408
Wexler, Dr H. · Temperature Changes in the Antarctic Atmosphere, 445
Whale (True's Beaked), from the South-East Coast of South Africa (F. H Talbot), 406
What is Agronomy ?, *review* by G V. Dyke, 1000
Wheat : Position of the Gene determining the Diploid-like Meiotic Behaviour of (Dr. Ralph Riley, Victor Chapman and Gordon Kimber), 259
Wheat Seedlings : Chlorophyll Content of Gibberellin-treated (Prof. Frederick T. Wolf and Dr Alan H. Haber), 217
Wheaten Flour · A Role for Thiol and Disulphide Groups in Determining the Rheological Properties of Dough made from (R. Frater, Dr. F. J. R. Hird, H. J. Moss and J. R. Yates), 451
Wheeler, Prof. T. S. : Status and Development of the Teaching of Chemistry, 208
Whewell, Prof. C. S : Textile Engineering, *review*, 189
Whiffen, Dr. D. H., and others : Infra-red Spectra of Deuterium-labelled Carbohydrates, 307
Whinfield, J. R. : Polymeric Progress, 441
Whisler, Dr. Howard C. : Pure Culture of the Trichomycete, *Amoebidium parasiticum*, 732
Whistlers with Geomagnetic Activities : Correlation of Occurrence of (Atsushi Kimpara), 230
Whitaker, J. K. : Appointed lecturer in mathematical economics at the University of Bristol, 937
White, Dr. F. W. G. : Elected a Fellow of the Australian Academy of Science, 519
  Visco-Elastic Systems, 942
White Cells and Platelets (Human) Microelectrophoresis of (Dr. William P. Creger and Phyllis Menna Thomas), 171

White Paper on Assistance from the United Kingdom for Overseas Development, 501
White Paper on Industrial Research and Development Expenditure 1958, 997
Whitehead, Dr. J. D. : The Mesopause Region of the Ionosphere, 461
Whitehead, Prof. J. H. C. : *Obituary* by Dr. I M James, 932
Whiteley, Dr. K. J. : Supercontraction of Wool Fibres and Creep in the Post-yield Region, 473
Whitmore, T. C. : Appointed lecturer in botany at the University of Southampton, 284
Whitworth, George Augustus : Honorary membership of the Institute of Mining and Metallurgy conferred on, 854
Whitworth, Dr. R. W. : Appointed lecturer in physics at the University of Birmingham, 937
Whole-Body Dose of X-Rays : Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in Rats receiving an Acute (Prof. J. Maisin, P. Dumont and A. Dunjic), 487
Whole-Body Turnover of Selenium in the Rat (Clifton Blincoe), 398
Whyte, Dr. H. M. : Appointed director of the Department of Medical Research in the Kanematsu Memorial Institute of Pathology, Sydney Hospital, 849 , work of, 849
Whyte, Lancelot Law A Forerunner of Twentieth Century Physics—a Re-view of Larmor's 'Aether and Matter', 1010
Wiaux, Anselme (Simonart, Prof Paul, and) : Production of Shikimic Acid by *Penicillium griseofulvum* Dierckx, 78
Wichterle, Dr. O , and others : Water-Soluble Methacrylates as Embedding Media for Preparation of Ultra-Thin Sections, 494
Wider Co-operation in Europe : British Dyestuffs and, 829
Wiesner, Prof. J. B. . Elected a member of the United States National Academy of Sciences, 773
Wigner, Prof. Eugene P. (Szilard, Prof Leo, and) . Awarded jointly the Atoms for Peace Award for 1959, 357
Wild Deer (A. J de Nahlik), *review* by R. S. R. Fitter, 45
Wilkinson, Prof. G , and others · Some New Complexes of Rhenium, 233
Willey, Prof. G. R : Elected a member of the United States National Academy of Sciences, 773
William Prize for 1959 of the Iron and Steel Institute awarded to I. M. D. Halliday, 13
Williams, Prof C. M. : Elected a member of the United States National Academy of Sciences, 773
Williams, J. H., and others : Adsorption of Helium on Carbons—Influence on Measurement of Density, 956
Williams, Dr. Robley C. . Elected a member of the Council of the United States National Academy of Sciences, 773
Williams, Dr. R. E. O Appointed to the University of London chair of bacteriology at St. Mary's Hospital Medical School, 938, 1016
Williams, T. F. : Modes of Radiation-induced Cross-Linking in Hydrocarbon Polymers, 544
Williamson, G., and Payne, Dr. W. J. A. : An Introduction to Animal Husbandry in the Tropics, *review* by Sir John Hammond, 49
Willis, J. B. Determination of Calcium in Blood Serum by Atomic Absorption Spectroscopy, 249
Willmer, Dr. E. N. : Elected a Fellow of the Royal Society, 12
Willoughby, D. A. (Spector, W. G., and) : Suppression of Increased Capillary Permeability in Injury by Monoamine Oxidase Inhibitors, 162
Wilson, Dr. A. T. : Sodium/Potassium Ratio in Rain-water, 705
Wilson, Dr. D. McL. A. : Electron Density Measurements in the Upper Ionosphere using the Faraday Rotation of Radio Signals from Artificial Satellites, 623
Wilson, F., and Woolcock, L. T. : Environmental Determination of Sex in a Parthenogenetic Parasite, 99
Wilson, Dr. J. Warren : Mycorrhiza, *review*, 48
Wilson, Dr. O. C. : Elected a member of the United States National Academy of Sciences, 773
Wilson, W. K., and Forshee, B. W. : Preservation of Documents (United States National Bureau of Standards, Monograph No 5), 124
Wind Profile in Thermally Stratified Flow (W. C. Swinbank), 463
Wind Speeds near a Tornado : Measurement of, 360
Winkler, Gernot M. R. (Reder, Friedrich H., and) : Preliminary Flight Tests of an Atomic Clock in Preparation of Long-range Clock Synchronization Experiments, 592
Winkler, U., and others : Induction and Reversion of *c*-Mutations by Irradiation of the Extracellular χ-Phage of *Serratia*, 330
Winkler von Hermaden, Dr. A. : Orogens (Examples of Structures from the Western Alps and Croatia), 690
Wissenschaften, Bayerische Akademie der : Prize of 8,000 D.marks for an Essay on Die Ruckkoppelung als Urprinzip der Lebensvorgänge, 938
Witts, Prof L. J . A Diversity of Trends in Medicine, *review*, 42
Wives · Working (Viola Klein), 365
Wohlfarth, Dr. E. P. (Cornwell, J. F , and) : An Energy Band Interpolation Scheme, with Application to Body-centred Cubic Lithium, 379
Wolf, Prof Frederick T., and Haber, Dr. Alan H. . Chlorophyll Content of Gibberellin-treated Wheat Seedlings, 217
Wolf-Ellmauer, H., and others : Induction and Reversion of *c*-Mutations by Irradiation of the Extracellular χ-Phage of *Serratia*, 330
Wolfe Award for 1959 given to Dr F. V. Webster, 17
Wolfson, Dr. Sumner H. (Hawkins, Dr. Gerald S., and) : Origin of Tektites—Solar Furnace Glass, 1027
Wolstenholme, Dr. G. E. W. : At the Scientific Publications Council's Discussion on the Rapid Increase in the number of New Scientific Journals, 18
Wolstenholme, Dr. G. E. W , and O'Connor, Maeve (edited by) : Ciba Foundation Symposium on the Biosynthesis of Terpenes and Sterols, *review* by Dr. D. T. Elmore, 745
Wolstenholme, Dr. G. E. W., and O'Connor, Cecilia (edited by) : Steric Course of Microbiological Reactions, *review* by Prof. D. C. Harrison, 835
Wolstenholme, Dr. G. E. W., and others (edited by) : Ciba Foundation Symposium on Significant Trends in Medical Research, *review* by Prof L. J. Witts, 42
Women in Britain : Employment of, 365
Women (Men and) : New Weight Standards for (Metropolitan Life Insurance Co., Ltd., New York, Bulletin, Vol. 40), 445
Wood, Dr. T. : Desalting of Urine by Electrodialysis, 634
Woodford, A. O., and others : Principles of Geology, second edition, *review* by Dr. J. V. Harrison, 57, 440
Woodford, Dr. E. K Appointed director of the Weed Research Organiza tion of the Agricultural Research Council, 436
Woodliff, Dr. H. J. : Awarded a grant from the Tata Memorial Trust, fo research on leukaemia and allied diseases, 1020
Woods, C. G. : Appointed lecturer in pathology at the University of Leeds, 767
Woods, Dr. D. R. : Appointed to the chair of pharmacology in the University of Leeds, 121 ; work of, 121
Wool, Prof. Ira G. : Accumulation of Substrate by Isolated Rat Diaphragm—a Possible Mechanism for the Anti-Inflammatory Action of Corticosteroids, 728
Wool Fibres : Supercontraction of, and Creep in the Post-yield Region (Dr K. J. Whiteley), 473
Wool Technology : Sheep Husbandry and, at Pretoria, 280
Wool Textile Conference : Second Quinquennial (Textile Institute), 206
Woolcock, L. T. (Wilson, F., and) : Environmental Determination of Sex in a Parthenogenetic Parasite, 99
Woolley, Prof. D. W. (Tritsch, Dr. G L., and) : Bradykinin Activity o some Synthetic Peptides with only Slight Structural Resemblance to Natural Bradykinin, 76
Woolley, Sir Leonard : *Obituary* by Prof. C. J Gadd, 516
Woolmer, Prof. R. · Elected first president of the Biological Engineering Society, 1019
Wools : Anomalies in the Microscopic Structure of some (T. D. Brown and W. J Onions), 93
Woolsey, Prof. C. N. · Elected a member of the United States National Academy of Sciences, 773
Wootton, Barbara, assisted by Vera G. Seal and Rosalind Chambers : Social Science and Social Pathology, *review* by Prof. E. Stengel, 41
Work, Dr C. Elizabeth : Appointed to the Microbiology Section of Twyford Laboratories, Ltd., London, 523
Work, Dr T. S., and others : Crystallization of Purified Mouse Encephalomyocarditis Virus Particles, 908
Work Hardening : First Stage of, in Aluminium Single Crystals (N. A. McKinnon), 148
Working Party appointed to examine the Scheme of Management Studies : Report of the (Ministry of Education, Appendix to Circular 1/60), 743
Working Wives (Viola Klein), 365
Works of Art Scientific Methods in the Care of (F. I. G. Rawlins), 437
Works in Scientific and other Fields of Learning : The Problem of Language in Publications of (Prof. D. Keilin), 912
Works Managers, Institution of : Appointment of Lawrence Sutton as education officer, 206
World of Learning, 1959-60, tenth edition, *review*, 1003
World (Old) : *Stereobalanus*, a Genus New to the (C. Burdon-Jones and A. D. McIntyre), 491
World Affairs : Present Problems in (Le Play Society Conference on), 606
World Distribution of ABO Blood Groups, *review* by Dr. F. Stratton, 581
World Health Organization (United Nations) : First Meeting of the Expert Committee on Radiation, 125
    Technical Report Series No. 176, Role of Hospitals in Ambulatory and Domiciliary Medical Care—Second Report of the Expert Committee on Organization of Medical Care, 202
    Technical Report Series No 183, Study Group on the Mental Health Problems of Automation, 364
    Technical Report Series No. 175, Preventive Aspects in the Teaching of Pathology—Seventh Report of the Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel, 602
    World Health Organization Chronicle, Vol. 14, No 3, Resistance of Gonococcus Strains to Penicillin (Alice Reyn and M. W. Bentzon), 608
    Technical Report Series No. 184, Report of a European Technical Conference on Food-borne Infections and Intoxications, 852
    Library News, Vol 12, Supp 2, Current Indexing and Abstracting Periodicals in the Medical and Biological Sciences, 936
    Public Health Papers, No 1, Psychiatric Services and Architecture (A. Baker, R. Llewellyn Davies and P. Sivadon), 936
    Technical Report Series, No. 188, Tenth Report of the Committee on Addiction-producing Drugs, 1018
World List of Institutions concerned with Atomic Energy (International Atomic Energy Agency), 361
Worm (Earth-) : Giant-Fibre Reflex of the (Dr M. B. V Roberts), 167
Wren, R , and others . Sulphasomizole (5-*p*-Aminobenzenesulphonamido-3-methyl*iso*thiazole), a New Bacterial Sulphonamide, 221
Wrenshall, Prof. G. A. (Hetenyi, jun , Dr G., and) : Abrupt and Delayed Effects of Insulin on the Distribution Space of Glucose in the Dog, 808
Wright, Sir Charles, and others · Influence of Geological Features on very Low Frequency Geomagnetic Fluctuations, 141
Wright, J. K., and others . 'Prize', a Pre-ionized 'Theta' Pinch, 706
Writing : Maya Hieroglyphic (J. Eric S. Thompson), second edition, *review* by Dr G H. S. Bushnell, 580
Writings (Shakespeare's) · Medicine in, *review* by Sir Russell Brock, 35
Wu, Y. Y., and others : Antimalarial Properties of some Guanidine Derivatives, 170
Wunderly, Dr. Ch. Diffusion of Proteins through Lipophilic Agar Cells, 885
Wurmser, R., et autres : Traité de Biochimie Générale, Vol 1, Composition Chimique des Organismes, *review* by Prof F. G. Young, 51
Wurtman, Dr. Richard J., and others : Effects of Injection of Bovine Pineal Extract on the Nuclei of Rat Pineal Parenchymal Cells, 393
Wyard, S. J. (Smith, Robert C., and) : Electron Spin Resonance in Hydrogen Peroxide–Water Solutions at 90° K. Irradiated with Ultra-Violet Light, 226
Wyatt, H. V. : Response of Larvae of *Calyptraea chinensis* (L.) to Light, 328
Wyatt, L. M. : Reactor Fuel Element Technology (Fuel Elements for the Advanced Gas-cooled Reactor and Fast Reactors), 1026
Wyllie, Dr. P. J. : Appointed lecturer in experimental petrology at the University of Leeds, 767
Wynne, Dr. C. G. : Appointed director of an Optical Design group to be set up at the Imperial College of Science and Technology, London, 934 ; work of, 934
Wynne-Jones, Prof. W. F. K. (Miller, Dr. R. E., and) : Electron Transfer Reactions involving *s*-Trinitrobenzene, 149

X-IRRADIATED Embryo: Synthesis of Contractile Proteins in the (Dr. Yoshito Ogawa), 77
X-Irradiation: Changes in Structure of a Periclinal Chromosomal Chimera of Apple following (Charlotte Pratt), 255
X-Ray Crystallinity Measurements: Effect of a Second Crystalline Modification in Polyethylene on (Dr. C. G. Vonk), 962
X-Ray Damage to Guinea Pig Skin: Effect of S-β-aminoethylisothiouronium Bromide Hydrobromide on (Dr. J. B. Walter and Prof. D. Slome), 177
X-Ray Determination of Phillipsite in a Sediment Core from the Central Equatorial Pacific (F. Lippman), (Reports of the Swedish Deep-Sea Expedition, 1947-48, Vol. 10, Special Investigations, No. 3), 609
X-Ray Diffraction Study of Denatured Ferritin and Apoferritin (Vladimir Kleinwachter), 313
X-Ray Emission: Solar Limb Surges accompanied by (Dr. J. Kleczek and Dr. L. Křivsky), 1035
X-Ray Fluorescence: Trace Analysis by, using Ion Exchange Resins (J. N. van Niekerk and J. F. de Wet), 380
X-Ray Microscopy: Silver-activated Nitrocellulose as Recording Material for (Saara K. Asunmaa), 1036
X-Ray Studies of some Carbonized Coals (R. Diamond and P. B. Hirsch), 204
X-Rays: Divergence between Lethal Doses and Sterilizing Doses of, with Progressive Development in *Habrobracon* Females (Dr. Howard E. Erdman), 254
  Effect of, on the Development of the Infective Larvae of *Oesophagostomum radiatum* (Rud. 1803) (Strongylidae: Nematoda), (R. F. Riek and R. K. Keith), 981
  Inability of Methionine to affect Lethality in Mice and Rats exposed to (Prof. Zenon M. Bacq and Dr. Marie L. Beaumariage), 1064
  Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in Rats receiving an Acute Whole-Body Dose of (Prof. J. Maisin, P. Dumont and A. Dunjic), 487
X-Rays (Ultra-violet and Soft): A Self-supporting Metal Fresnel Zone-plate to Focus Extreme (Dr. Albert V. Baez), 958
Xanthine Dehydrogenase in the Silkworm, *Bombyx mori* L. (Yoshiyuki Hayashi), 1053
p-Xylene (Irradiated): Polymer Formation in (Francis van Hecke), 382

YABU, Hideyo, and others: Effect of Electrical Stimulation on a Muscle Fibre Model in the Presence of Adenosine Triphosphate, 318
Yagi, Kunio, and others: Condensation Product of Ethylenediamine with Noradrenaline or 3,4-Dihydroxymandelic Acid, 310
Yale University (Department of Botany): Retirement of Prof. Paul B. Sears, 1020
  Prof. Oswald Tippo to assume duties as provost of the University of Colorado, Boulder, 1020
  Asst. Prof. Theodore Delevoryas to accept a post as associate professor in the Department of Botany in the University of Illinois, 1020
  Asst. Prof. Kenton L. Chambers to accept a post as associate professor and curator of the Herbarium in Oregon State College, 1020
  Appointment of Prof. Arthur W. Galston as chairman of the Department, 1020
  Appointment of Prof. Norman H. Giles as acting chairman of the Department, 1020
  Appointment of Dr. Ian M. Sussex as associate professor (plant morphogenesis), 1020
  Appointment of Dr. Diter H. von Wettstein as associate professor, 1020
  Appointment of Dr. William S. Hillman as assistant professor (plant physiology), 1020
  Appointment of Dr. John H. Miller as instructor (developmental morphology), 1020
  Appointment of Dr. Derald G. Langham as lecturer (economic botany), 1020
Yamaguchi, Saburo, and others: Effect of Electrical Stimulation on a Muscle Fibre Model in the Presence of Adenosine Triphosphate, 318
Yamana, K., and others: Fractionation of Two Metabolically Distinct Classes of Ribonucleic Acids in Animal Cells and its Bearings on Cancer, 215
Yanari, S. S. (Bovey, Dr. F. A., and): Effect of Solvent Polarizability on the Ultra-violet Spectral Shifts of Aromatic Compounds, 1042
Yarwood, T. M.: Tables of Physical and Chemical Constants and some Mathematical Functions, *review*, 67
  A Student's Introduction to Physics, *review*, 68
Yates, J. R., and others: A Role for Thiol and Disulphide Groups in Determining the Rheological Properties of Dough made from Wheaten Flour, 451
Yatzidis, Dr. H.: Measurement of Transaminases in Serum, 79
Yeast sensitized by a Nucleic Acid Fluorochrome: Inactivation by Visible Light of (David Freifelder and Prof. Robert B. Uretz), 731
Yeast (Biotin-deficient): Excretion of Nicotinic Acid and Nicotinic Acid Adenine Dinucleotide by (Dr. Anthony H. Rose), 139
Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in Rats receiving an Acute Whole-Body Dose of X-Rays (Prof. J. Maisin, P. Dumont and A. Dunjic), 487
Yeasts: Comparative Studies of (J. A. Barnett), 449
Yellow (Turnip) Mosaic Virus: Protein Components from (Dr. J. M. Kaper), 219
Yellow-legged Frog (California): A Blood Parasite from the (Donald L. Lehmann), 765
Yield (Crop): Plant Population and (R. Holliday), 22
Yolk Formation of Oocytes of *Patella coerulea* L. and *Aplysia depilans* L. as observed in the Electron Microscope (A. Bolognani), 490
Young, Prof. F. G.: General Biochemistry, *review*, 51
Young, Prof. J. Z.: Human Growth, 19
  The Visual System of *Octopus*—Regularities in the Retina and Optic Lobes of *Octopus* in relation to Form Discrimination, 836
Young, Leslie, and Maw, George A.: The Metabolism of Sulphur Compounds, *review* by Dr. G. D. Greville, 424
Young Mouse: Selection of Iodinated Protein in the (W. A. Hemmings), 399
Young Nidifugous Birds: A Possible Fundamental in the Behaviour of (Dr. Peter M. Driver), 416
Young Pig: Body-Weight and Age in relation to the Metabolic-Rate of the (Dr. L. E. Mount and J. G. Rowell), 1054
Youth of Great Britain: Education and the, 577

ŽÁK, Dr. R., and Drahota, Dr. Z.: Release of Methionine labelled with Sulphur-35 from Muscle Tissue and Mitochondria, 973
Zalophus californianus (California Sea-lion): Chronic Aortitis in the (Dr. Arthur L. Kelly and Dr. David Jensen), 731
Zarzycki, J. M., and others: Self-Quenching Geiger Counters containing Mixtures of Permanent Gases, 876
Zerbi, G., and others: Infra-Red Spectra of Deoxyribonucleic Acids from Human Leucocytes, 964
Zero (Sub-) Temperatures: Effect of, on Diapause Eggs of *Acheta commodus* (Walk.), (T. W. Hogan), 98
Zeuner, Prof. Frederick E.: The Pleistocene Period—its Climate, Chronology and Faunal Successions, *review* by D. F. W. Baden-Powell, 833
Zilberstein, Dr. R. Michel: Œstrogen–Insulin Interaction on the Uterus of the Rat, 635
Zinc-67: Ultra-High Resolution γ-Ray Resonance in (D. E. Nagle, P. P. Craig and W. E. Keller), 707
Zinc Sulphate Treatment of Parakeratosis in Cattle (S. P. Legg and L. Sears), 1061
Zinn, Dr. Walter H., and Weinberg, Dr. Alvin M.: Awarded jointly the Atoms for Peace Award for 1960, 357
Zone-plate to Focus Extreme Ultra-violet and Soft X-Rays: A Self-supporting Metal Fresnel (Dr. Albert V. Baez), 958
Zoological Literature, *review* by Dr. Edward Hindle, 831
Zoological Record: Vol. 93, Being the Records of Zoological Literature relating chiefly to the Year 1956 (edited by G. Burder Stratton), *review* by Dr. Edward Hindle, 831
Zoological Society of London: Grant of £100,000 from the Nuffield Foundation, to found an Institute of Comparative Medicine and to provide two senior research fellowships, 435
  Grant of 550,000 dollars from the Ford Foundation, to endow research fellowships in Animal Reproduction, 519
  Symposium on Sensory Specialization in Response to Environmental Demands, 688
  The Zoological Record, Vol. 93, Being the Records of Zoological Literature relating chiefly to the Year 1956 (edited by G. Burder Stratton), *review* by Dr. Edward Hindle, 831
Zoology: Contributions to (National Museum of Canada, Bulletin No. 166), 1017
  International Congress of, 604
Zsolt, J., and others: Effect of Diphenylamine on the Synthesis of Carotene, 235
Zwart, Dr. H. J.: Orogens (Complicated Structures of the Central Pyrenees), 690
Zygmund, Prof. A.: Elected a member of the United States National Academy of Sciences, 773

Printed in Great Britain by Fisher, Knight & Co., Ltd., The Gainsborough Press, St. Albans,
and published by Macmillan & Co., Limited, at St. Martin's Street, London, W.C.2,
and St Martin's Press, Inc., 175 Fifth Avenue, New York 10, N.Y., U.S.A.
Saturday, 15th October, 1960.

DEVELOPMENT OF NUCLEAR ENERGY IN BRITAIN

THE examination of the work of the Production Group and the Development and Engineering Group, into which the Industrial Group of the Atomic Energy Authority was divided in July 1959 by the Select Committee on Estimates, was described in the Committee's Fifth Report for the Session 1958–59*. The report is noteworthy as the first detailed examination of the work of the Authority by a Parliamentary Committee. The Industrial Group comes well out of this scrutiny; the Select Committee makes numerous favourable comments, and it has since been announced that the Authority has accepted substantially all the Committee's recommendations. The organization of the Authority was, of course, scrutinized two years previously by the Fleck Committee, which was particularly concerned with the organization of the Industrial Group, and the rearrangement made last July was contrary to the recommendation of that Committee, though intended to reduce the span and hence the burden of management, which the Fleck Committee had itself regarded as a weakness in the Group. In welcoming this decision, the Select Committee expresses the opinion that the advantages are now such as to offset the disadvantages which led the Fleck Committee to oppose such a change at the time.

While the report is of particular interest for the light it throws upon the position of the Industrial Group in Britain's research effort, and the magnitude of the demand made for man-power and other resources, the two main questions with which the Select Committee was concerned are the general strategy of the development of nuclear power in the United Kingdom and the relation between the Authority and the industrial companies operating in this field. The staff position, and to some extent the research effort, is directly related to the organization of the Industrial Group, nor can either be separated sharply from the general policy adopted in the development of nuclear power or the way in which this development is shared between the Authority and the industrial consortia. Both are competing, for example, for highly skilled man-power which is relatively scarce, and it is now only too clear that the market for nuclear energy is relatively limited.

One feature in the situation is the rapidity with which the Industrial Group has expanded. From a staff of 16 when the original nucleus was formed in the Production Division of the Ministry of Supply in 1946, the Industrial Group had grown to a staff of 10,000 in 1955, and by March 1959 to more than 18,000; and its annual gross expenditure is estimated to have increased by 50 per cent between 1956–57 and 1959–60; about half the present staff of 18,000 are employed in the factories. The total is expected to exceed 23,000 by 1961–62. Works staff has increased by 16 per cent between 1958 and 1959 and is expected to increase by a further 12 per cent between 1959 and 1960. The Research and Development Branch increased by 9 per cent between 1957 and 1958, and a further 22 per cent increase on the 1958 figure is expected by 1960, including an increase of 600, of whom 80 are senior staff arising from acceptance of the recommendations of the Fleck Reports.

Nevertheless, the real check on the magnitude of the development effort of the Group has been the shortage of scientists and engineers, and serious difficulty has been encountered in filling the most senior posts. As already noted, the decision to split the Industrial Group was made to reduce the burden of management at the managing director and deputy managing director level, and to the same end the Authority has decided to restrict its research, development and design organizations to an annual growth of about 8 per cent for the next three years. This decision must strictly limit the number of reactor systems which the Group can develop; but since limitation is imposed in terms of staff, not expenditure, expansion in excess of this figure could be achieved by placing more contracts with industry and the universities.

The industrial consortia are understood to be employing already some 4,000 men on reactor design and development; but on this question of the balance of the whole research and development effort of Britain, the Select Committee, which welcomes the Authority's decision to limit its annual expansion of staff, makes no comment. It recognizes, indeed, that total development effort cannot be properly controlled on the basis of *ad hoc* decisions on individual development projects, and it found no evidence of over-staffing at any of the works or establishments it visited, though it expresses concern as to the size of the Risley headquarters, where about 20 per cent of the Group's staff is employed. About half of these are employed in the Engineering Branch, and several hundred in the Finance and Personnel and Administration Branches. The Select Committee does not regard the Engineering Branch as excessive in size at present, but suggests that it should remain fairly static in size; and it is clear from the report that the Authority is fully conscious of the danger and, apart from the beneficial effect in this respect of the creation of the two new Groups, is also taking measures to see that opportunities of down-grading jobs are not missed.

Some of the Select Committee's specific recommendations bear closely on this question of efficiency. Thus it suggests that the increased status and responsibilities of works general managers should be recognized in a way that will ensure that these posts attract men of the high calibre required. Further, the Authority should consider whether more formal arrangements are required to co-ordinate the work of the Production and Development and Engineering Groups when the present arrangements have been tried over a reasonable period. It is also recommended that after a reasonable period of experience of the new organization, the system of co-ordinating the work being done at the various laboratories should be reviewed, to avoid duplication or lack of balance. Generally, the Committee was satisfied with the way the Industrial Group has tackled a succession of novel problems, and the recognition of the importance of cost is shown in developing a modern system for controlling expenditure. Military requirements, however, are now ceasing to be the predominant influence in the work of the Group, and with the growing emphasis on reactor development and commercial activities, it is the more important to bring industry into partnership with the Group so as to obtain the greatest economic value from scientific and capital resources in this field.

---

* Fifth Report from the Select Committee on Estimates, Session 1958–59: United Kingdom Atomic Energy Authority (Production Group and Development and Engineering Group). Pp. lxxxv. (London: H.M. Stationery Office, 1959.) 5s. net.

Here in the section on partnership with industry the Select Committee makes some important comments. Admittedly, only a Government-financed organization can, at this stage, afford the necessary capital, the extended research and development work, or the long-term risks that are required for the development of nuclear power for civil purposes. The primary responsibility for the development of nuclear power for these purposes in Britain must lie with the Authority, if the limited resources of the nation are not to be dissipated. Nevertheless, the relative positions of the Authority and of industry have been changing rapidly, and the Select Committee believes that the Industrial Group should respond to the changed situation by bringing industry into closer partnership at every stage of development.

This should include a deliberate policy of enabling industry to play a greater part in certain activities for which the Group has been largely responsible in the past, partly to ease the strain on the Group's own resources, partly to ensure that resources available to industry are economically employed, and partly also to enable industry more quickly to acquire the ability to originate and exploit nuclear developments itself. Specifically, the Committee recommends that the Industrial Group should invite the industrial consortia to attach a limited number of people to experimental reactor projects and take positive steps so as to make sure that they are quickly aware of the progress of work on such projects. If no experimental reactor is to precede the prototype stage of a system, the consortia might be invited to join the Group in technical discussions as soon as feasibility studies are complete. More contracts with industry are also suggested for the design and construction of complete chemical and fuel fabrication plant, and it is expected that four-fifths of the additional design capacity required by 1960 will be provided under design contracts with industry. When further expansion of plant for the fabrication of fuel elements is required, the Select Committee recommends that the Authority, the Electricity Generating Boards and the consortia should jointly consider the possible advantages of these facilities being provided and operated by others than the Authority.

The industrial consortia are already making a considerable contribution in research and development on the Magnox system, which they are exploiting commercially, but during 1958–59 only about 8 per cent of the Group's operating expenditure on research and development was accounted for by extra-mural contracts with industry and universities. Most of this extra-mural work was done with industry, and the Committee particularly welcomes the evidence that the Authority now intends to increase considerably the volume of research and development work being placed with industry. This will mainly be work not requiring irradiation or radioactive examination facilities in mechanical or electrical engineering, gas dynamics, heat transfer and metallurgy of reactor systems. It is planned to treble the value of extra-mural work in the next few years, and, it is hoped, increase tenfold between 1958–59 and 1959–60 the extra-mural research expenditure by the Dounreay establishment.

The pattern of research and development at Dounreay is somewhat different from that at other establishments, and the work of the laboratories there is not so easily separated from that of the rest of the establishment. Most of it is in support of the fast reactor, but work is included on enriched fuel elements for the Dounreay materials-testing reactor, examinations of these elements after irradiation and plutonium technology. The most noticeable feature about the research effort of the Industrial Group as a whole, however, is the rapidity of its growth. In terms of operating expenditure, the research and development effort increased by about 280 per cent between 1956–57 and 1959–60 and by about 110 per cent even if Dounreay expenditure is excluded, while the gross expenditure of the Group is estimated to have increased by about 50 per cent between 1956–57 and 1959–60.

The Select Committee expresses no opinion as to whether the total research effort of the Industrial Group is too large or too small, but, while it is impressed by the way the Authority has so far kept the reactor development programme co-ordinated and concentrated, it does not appear to be entirely satisfied that this will remain so. In terms of manpower, it is estimated that about a quarter of the Group's total research effort will still be employed in relation to Calder Hall and Central Electricity Generating Board reactors, about a fifth on the advanced gas-cooled reactor, and about a tenth on the problems of the fast reactor. This is much the same as in 1958–59, and the Select Committee does not think it desirable that the Industrial Group should be required to devote continuing and large-scale effort to achieving marginal improvements in the operating performance of systems it has developed in the past. The Group's principal task is to create and develop new systems, and it is recommended specifically that research and development work of this character on reactors at present under construction for the Central Electricity Board should, so far as possible, be confined to problems with which the Electricity Board and the industrial consortia are not equipped to deal.

The strong support which the Select Committee lends to the development of the fast reactor programme is noteworthy, and particularly in view of the importance which it attaches to a proper balance of effort. It recommends that this priority should now receive special consideration, and it particularly welcomes the assurances that essential work on this system had not suffered from lack of plutonium, that the fast reactor was not being held back by work being done on any other reactor system and that the whole plutonium technology research programm is to be extended. The Select Committee's assessment of the situation has indeed gained in value since the report was issued in view of the tendency in some current discussions to discount the nuclear power programme on account of the over-stocking of coal. On balance, the Committee regards the Authority as right in limiting its effort as it has done, even to the extent of devoting no design or development effort in the Industrial Group specifically to reactor systems for export.

Nevertheless, the Select Committee considers that the Authority as well as industry should be ready to make some contribution in this field, and the limitations imposed by man-power considerations alone on a research and development effort of the magnitude of the Atomic Energy Authority is sufficient reason why the research and development effort of the whole of Britain needs to be brought very carefully under review before entering on large commitments in new fields such as space research. That has been very eloquently pressed by Mr. Woodrow Wyatt, and also by Mr. F. V. Corfield, Mr. G. de Freitas and Mr. G. Chetwynd in an adjournment debate in the House of Commons on February 22. Fortunately, Mr. G. Rippon, Parliamentary Secretary to the Ministry of Aviation, who replied on the debate, while sympathizing with the cogent arguments advanced, did not depart from the warning of the Advisory Council on Scientific Policy that there is a financial limit to what Britain can do. Mr. Rippon pointed out that while the Advisory Council has not recommended any British participation in the attempt to launch human beings into space, it is convinced that British science and technology have contributed, and would continue to contribute, valuable results in space research. The review by the Select Committee on Estimates of the work of the Industrial Group of the Atomic Energy Authority shows once again the severe limits on the resources of Britain, the vital necessity of keeping the research and development effort in reasonable balance, and the desirability that contributions in new fields such as space research should be made in specific directions appropriate to the special skills available in Britain and that where possible they should be part of an internationally based approach.

SUPERFICIAL CHEMISTRY AND SOLID IMPERFECTIONS*

By Prof F. C. TOMPKINS, F.R.S.

MATTER at the boundaries or interfaces between two different phases, for example a solid and a gas, has unusual properties. Of the many problems involving gases in contact with a solid surface, perhaps the most compelling and least understood is that of heterogeneous catalysis, which in the present context is confined to the acceleration of the rate of reaction of gases brought about by the introduction of a solid surface. There is a marked contrast between the extremely successful efforts of the industrial technologist in producing specific and efficient catalysts and the modest progress made in the elucidation of the basic principles of catalytic action. However, particularly in the past fifteen years, considerable advance has been made in our understanding of the bonding of gas molecules to surfaces of solids (here restricted to metal surfaces) largely arising from the use of new techniques.

The surface of a metal may be compared to a large free radical with 'dangling valences' which readily form chemical bonds of strength and character similar to those in primary chemical bonds. Not until the brilliant experimental work of J. K. Roberts in Cambridge, some thirty years ago, was it recognized that this process of chemisorption of a gas, in particular of oxygen, was practically instantaneous even at − 196° C. Calculation shows that oxygen at a pressure of 10^{-10} atm. forms a complete chemisorbed monolayer within 1–2 min. so that, at least in respect of chemisorption, most of the earlier experimental work has to be rejected. The problem to-day is, in principle, solved by the use of modern vacuum pumps, which attain pressures lower than 10^{-13} atm., so that time can be made available for accurate measurements. However, since the metal surface is bound to have been in contact with air at some time, there is the difficulty of the initial removal of the chemisorbed layer since, for example, oxygen is so strongly bound to a tungsten surface that heating to 1,500° C. in the highest vacuum over a period of a year will not remove it, nor is hydrogen reduction at this temperature any more effective. Only by flashing at 2,500° K. can a clean surface be obtained, and, even so, this is brought about by breaking the W–W bond and not the W–O link. However, Beeck's method of evaporating a metal in high vacuum and condensing the vapour on the walls of the reaction vessel has virtually removed the major difficulties of obtaining clean metal surfaces.

---

* Substance of an inaugural lecture delivered at the Imperial College of Science and Technology, London, on February 2.

A chemisorbed layer has a tremendous effect on the electron emission from tungsten at 1,500° C., because of the increase or decrease of the energy required to free an electron from the metal; from this change of work function the dipole moment of the chemisorbed bond may be calculated using an elementary theorem in electrostatics. The sign of the dipole gives information as to whether the metal acts as an electron donor or acceptor, and the magnitude is a measure of the extent of charge transfer; this knowledge has value, since the catalytic effect of metals may well be dependent on their acting as sinks or sources of electrons. The results of these investigations can be combined with those of others; from the heat of chemisorption, the strength of the chemisorbed bond may be estimated; from the change of electrical resistance brought about by chemisorption of gases on metallic films, the extent of localization of electrons in the bond may be deduced; and from the change of magnetic susceptibility, the difference in the number of paired electron spins (a property of covalent bonds) can be obtained. Considerable information is therefore available, and correlation with the known efficiency of metal catalysts may be sought.

For example, copper, silver, gold are ineffective catalysts for hydrogenations or in carbon monoxide and hydrogen syntheses, whereas nickel, iron, cobalt are highly efficient. From the fundamental investigations, the bonding of these gases to copper, silver and gold is non-directional and largely electrostatic in nature; with nickel, iron, cobalt it is specific and directional. Hence it is probable that an efficient catalyst must impose an orientational effect and so induce the formation of a particular configuration of an unstable, short-lived, intermediate product which forms the initial point of a sequence of events leading to the final products of the process—and the possession of directional properties can be associated with specific features of the atomic structure of the transition elements which are absent in Group *IB* metals.

Advantage may also be taken of the fact that the sign and magnitude of the dipole moment of the chemisorbed bond are specific. Thus, the CO-bond to nickel has a dipole moment five times that of hydrogen, both being negative outwards from the metal, and four times that of the CO-bond to copper, where, however, it is positive. An example is the reaction of carbon monoxide and hydrogen at an iron surface. The bonding of carbon monoxide to the surface is similar to that between the carbonyl group and the iron atom in the free molecule, iron carbonyl (Fig. 1); hydrogen, however, is adsorbed as atoms which are located between the surface iron atoms, that is, interstitially (Fig. 1). When there are equal numbers of carbon monoxide molecules and hydrogen atoms in the saturated layer, possible structures are shown in Fig. 2, with the corresponding measured or estimated work-function changes. Structure (*b*), and particularly (*c*), the aldehyde structure, have frequently been postulated in many mechanisms for this particular reaction, but none is consistent with the measured work-function value (Fig. 3). However, a surface structure analogous to the iron hydrocarbonyl molecule (Fig. 4), often suggested as an intermediate product in liquid-phase syntheses of similar nature, in fact gives the experimental value. Here the hydrogen atom (probably ~ 1 Å. from the surface) 'donates' about half the electronic charge to the metal.

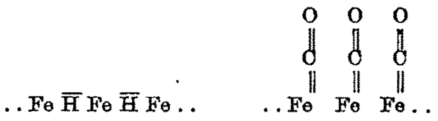


Fig. 1

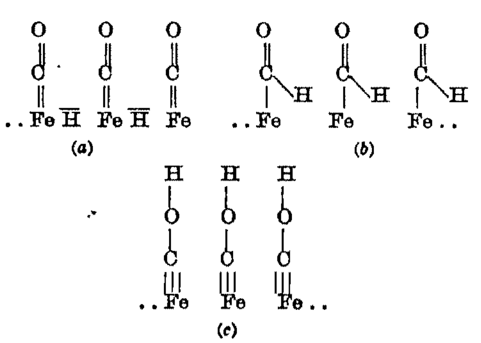


Fig. 2

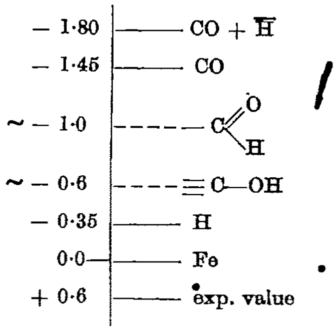


Fig. 3

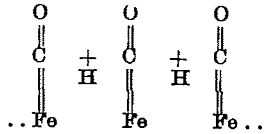


Fig. 4

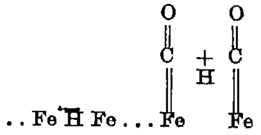


Fig. 5

The interesting new feature is the dual role of the hydrogen atom (Fig. 5)—it is bonded interstitially between two metal atoms, only when these are free of other attachments. It then carries an overall negative charge, is difficult to detach from the surface, but is reasonably free to move over the surface. When, however, the two metals have engaged in chemisorption of carbon monoxide, despite the fact that the hydrogen atom can easily get into the interstitial position, it prefers to remain 'outside' the surface, between the carbon monoxide groups, where it carries a positive charge. From this position it is easily detached, is highly reactive, and can move over the surface with comparative ease. The metal therefore appears to act simultaneously as an electron donor and electron acceptor, and the catalytic process may thus have some analogy to the Brønsted–Lewis

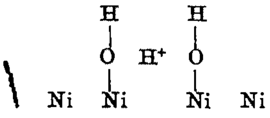


Fig. 6

acid-base catalysis familiar to students of solution kinetics. Similarly, when a nickel surface is contaminated with chemisorbed oxygen, subsequent hydrogen adsorption gives a structure shown in Fig. 6, and this may be one reason why the industrial (oxygen-contaminated) catalyst is much more effective than a clean nickel film, provided that the H⁺ species is an essential requirement for efficiency.

A second example is the oxidation of carbon monoxide by oxygen on a copper catalyst. As in the previous example, gases are added separately to the catalyst at a low temperature, and both the quantity of each gas chemisorbed and the corresponding work function changes are measured. The temperature is slowly increased, when some carbon dioxide, the product of oxidation, and carbon monoxide are evolved; the amounts of the two gases desorbed and the accompanying change of work function are recorded. Possible structures of the complexes remaining at the surface can now be postulated and the calculated estimates of the changes of work-function are compared with that actually obtained. In this system, only two or three structures for the rest of the complex on the surface remain. Finally, fresh gas, the nature of which is chosen such that chemisorption should take place with a known change of work function, is then added. If the experimental facts then accord with the forecast, the sequence of events is a reasonable and consistent one. This is illustrated in Fig. 7, where the process of separate absorption (*a*), (*b*), partial desorption (*c*) and re-adsorption of carbon monoxide (*d*) is depicted with the corresponding experimental values of the work-function.

In the past five years, another powerful technique, in which infra-red spectroscopy is employed to elucidate the structure of surface complexes, has been successfully exploited. Advantage is taken of the fact that frequency of vibration of atoms in molecules is specific to a particular bond and its immediate environs, and this may be identified as a band in the infra-red spectrum.

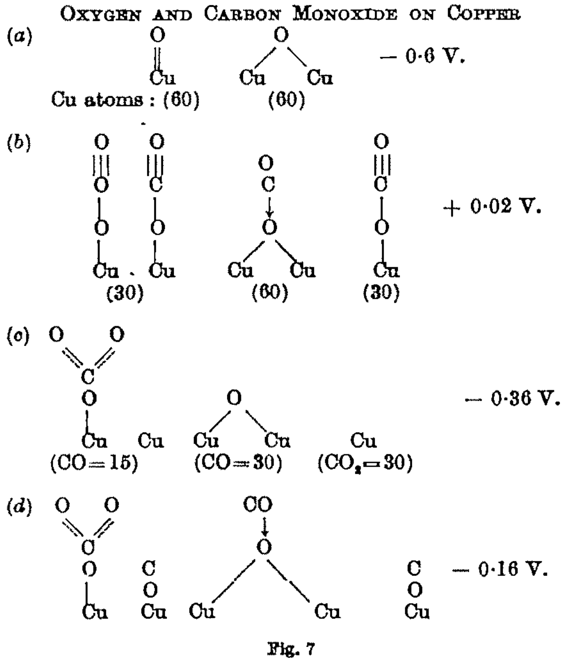


Fig. 7

The major difficulty in the application to chemisorbed substances is the requirement that there must be a comparatively large number of molecules in the light beam before the spectrometer can 'see' the bands. Eischens has recently shown this to be possible by depositing the metal on exceedingly fine particles of non-porous silica, which itself is reasonably transparent to infra-red light. Already, three different forms of binding of carbon monoxide to metal surfaces have been recognized, all of which have their analogues in the well-known free molecules, the metal carbonyls. Furthermore, the concentration of each structure can be determined from the intensity of the infra-red band; in particular, when hydrogen is adsorbed 'on top' of a chemisorbed carbon monoxide layer, there is no loss of intensity of the CO-band such as would result from combination of CO with hydrogen, nor do any new bands attributable to CH or OH or CHO bonds appear. These results confirm the conclusion drawn from the experiments on the work-function which suggested the hydrocarbonyl structure.

There are still many formidable experimental problems to be solved before the full power of the infra-red technique can be exploited for studying chemisorption. One aspect, where its usefulness has already been indicated, is the investigation of the non-uniformity of the surface. The bonding is undoubtedly different at certain 'active patches', and by noting the change in frequency of the infra-red bands, the surface may be 'scanned'.

This non-uniformity at the surface arises in part from the imperfect structure of the solid. The electron diffraction experiments of Laue *et al.* in 1912 were accepted as the first experimental proof of the theoretical concept of a crystalline solid as a perfect, orderly, three-dimensional array of atoms; but in 1914 Darwin directed attention to the intensities of the pattern, which were 10–100 times too large for diffraction from a perfect array. His suggestion of a large number of small crystallites imperfectly aligned and cemented together has finally led to the recognition of dislocations as general imperfections of all solids. However, in addition, crystals have their maximum stability when the lattice has vacancies (atoms missing from lattice sites) and interstitials (atoms squeezed into abnormal positions between lattice sites). Physical chemists interested in the chemical reactivity of solids now regard the nature and number of these imperfections as being of greater significance than the particular geometrical arrangement of atoms in a crystal.

With an ionic crystal such as sodium chloride, there are both cation and anion vacancies carrying opposite virtual charges, and having mobility. They therefore tend to attract each other to form neutral double vacancies and higher aggregates. Indeed, the solid may be regarded as the solvent and the point imperfections as the ions, and then such electrochemical terms as association constants, ion-pairs, solubility product, transport numbers, etc., may be applied and interpreted. Where there are abnormal electric field gradients, such as exist in the neighbourhood of dislocations, vacancies and interstitials can be directed to specific localities—indeed, the dislocation can give birth to point imperfections and also become their burial ground. It is therefore reasonable to associate the preferential reactivity of solids at certain unique localities with the presence of imperfections. Such abnormal regions may be made visible by certain etching and decoration techniques and may well represent, at the surface, the 'active centres' of the Taylor school of catalysis.

Within the solid, the dislocations provide paths along which atom or ion movement can occur more readily: they are localities where atom (ion) re-arrangement is easier; and they represent positions where a product of reaction finds space for precipitation and aggregation.

Many of these concepts have been applied to the mechanism of the thermal decomposition of solids, in particular metal azides, which, when heated, decompose to metal and nitrogen. In these compounds, the formation of point imperfections has been followed, their combination and aggregation recorded, and, finally, the details of growth of the metal speck analysed. From ionic conduction, the number of imperfections and their speed of movement through the lattice have been calculated; from the electronic conductivity under ultra-violet irradiation, the number of free electrons and their trapping probability have been assessed; and other information has been obtained from absorption spectra and electron spin resonance.

In all, the recognition of the role of imperfections has not only gone a long way towards the solution of the problem of how mass and charge are transferred in a solid but has also suggested the use of a large number of new techniques to further the study of this complex problem.

CHROMOSOMES IN PRIMARY NEOPLASTIC GROWTH

By DR. K. BAYREUTHER*

Institute for Cell Research and Genetics, Karolinska Institute, Stockholm

IT was the German embryologist Theodor Boveri who first aroused interest in the chromosome constitution of tumour cells. On the basis of studies on abnormal chromosome segregation and the resulting disturbances in the early larval development in dispermic fertilized sea urchin eggs, Boveri formulated the hypothesis that the malignancy of the mammalian somatic cell might be the result of a certain aberrant chromosome constitution[1]. The early efforts to test this concept yielded no conclusive information, however, mainly on account of inadequate methods.

During recent years critical facts have been collected by means of improved techniques about the chromosome cytology of various tumours. As a result discussion about the significance of aberrant chromosome constitutions in cancer cells has been revived. Several investigators consider that karyotype instability is not essential for the acquirement of neoplastic properties[2]. Others regard genetic variation at the chromosomal level as the cause of neoplastic transformation or at least indispensable for tumour progression[3]. The view of the latter group is mainly based, however, on results from material which is not truly representative of primary tumours.

With these opposing views in mind, karyotype analysis has been undertaken in some spontaneous tumours, virus-induced tumours, tumours caused by endocrine imbalance, and chemically induced primary tumours in various species including the domestic fowl, mouse, rat, Chinese hamster, domestic rabbit, cattle and man. The results obtained will be outlined.

Observations on Tumour Cells

Spontaneous primary tumours which were entirely untreated were studied in mice, cattle and man. As can be seen from Table 1, 68 out of 78 (87 per cent) neoplasms analysed revealed the species-specific and sex-specific normal chromosome complement. The majority of the experimental tumours were collected at the earliest possible stage of development and then showed mostly normal chromosome complements. Abnormal chromosome constitutions were as a rule restricted to tumours of large size. Frequently these showed several cell-types with numerically and structurally different abnormal chromosomal constitutions, often with no predominance of any one type.

A quite different picture was obtained, however, when primary spontaneous leukæmia cells with the normal chromosome set from mesenteric lymph glands of four *AK*-mice were separately transplanted to four animals of the same strain. The karyotype integrity was lost in three of the four lines in the first passage. During four subsequent transplantations the line which was normal in the first passage remained so, and the other three lines, which at the first passage contained a wide range of karyotypes, were in the fifth passage predominantly populated by a single line-specific abnormal cell type in all sites.

These findings indicate first that gross chromosome re-organization seems not to be essential for the acquirement of malignancy in spontaneous neoplasms, and that differences in the degree of malignancy as in the case of acute and chronic leukæmia in man cannot be ascribed to a diversity in chromosome complement. Secondly, they suggest that the abnormal constitutions are of secondary nature and arise spontaneously in the course of tumour development presumably as a consequence of neoplastic changes on other levels, and that the cytogenetic stem-line concept[4] has no general validity in the primary spontaneous tumour growth. Finally, they show that the chromosome mechanisms in the primary growth of spontaneous leukæmia may be quite different from those in the transplantation growth.

Virus-induced Tumours. Virus-induced neoplasia was studied in four species of experimental animals,

---

* Present address: Department of Radiology, Stanford University School of Medicine, Stanford, California.

Table 1. Chromosomes in Spontaneous Primary Tumours in Mice, Cattle and Man

Species (standard chromosome number)	Tumour type	Cases	Number of tumour sites studied				
			Total	Normal chromosome constitution	Cells counted	Abnormal chromosome constitution	Cells counted
Mouse ($2n = 40$)	Lymphocytic leukæmia (generalized and localized)	16	36	32	493	4	50
	Mammary adeno-carcinoma (*MTI*-free)	12	12	9	357	3	121
	Hepatoma	6	6	4	164	2	98
	Ovary tumour	4	4	4	176	—	—
	Uterus tumour	10	10	9	371	1	21
Cattle ($2n = 60$)	Lymphocytic leukæmia	2	2	2	68	—	—
Man ($2n = 46$)	Acute myeloic leukæmia	2	2	2	307	—	—
	Acute lymphatic leukæmia	3	3	3	424	—	—
	Chronic myeloic leukæmia	2	2	2	367	—	—
	Chronic lymphatic leukæmia	1	1	1	127	—	—

the domestic fowl, the mouse, the rat and the domestic rabbit. Chickens two weeks of age were inoculated with the erythroleukæmia virus. In the final stage of the disease erythroleukæmia cells in the femoral bone-marrow and in the spleen showed the normal 12 macrochromosomes in five male animals (total number of cells analysed $(t) = 500$, number of cells with chromosome numbers less ($<$) than the standard number $(st) = 18$, number of cells with chromosome numbers greater ($>$) than $st = 6$), and the normal 11 macrochromosomes in five female specimens ($t = 500$, $8 < st$; $4 > st$). Cells with the normal macrochromosome complements predominated also in three fibrosarcomas in male fowls ($t = 150$, $4 < st$) and in three fibrosarcomas in females ($t = 150$, $3 < st$; $2 > st$) induced by the Rous agent, and in three myxosarcomas in males ($t = 150$, $9 < st$; $2 > st$) and in two myxosarcomas in females ($t = 100$, $1 > st$) caused by the Fujinami virus. Besides the macrochromosomes about 60 additional microchromosomes were found in all tumour cells in both sexes. Because of their small size and similar form a reliable numerical and structural analysis of the latter elements is, however, not possible.

A very similar general picture was obtained from six virus tumour systems in mice and rats (Table 2): Here 75 out of 76 (98 per cent) primary and secondary tumour sites in the initial host were normal, and in addition three out of five virus-induced tumour lines, both solid and ascites, that were transplanted, also showed the normal species-specific and sex-specific chromosome complements. Thus it seems very unlikely that the tumour viruses cause neoplastic transformation via chromosome mutation. On the other hand, an abnormal genetic constitution of the host cell does not necessarily disturb the interaction of the virus and the host cell. The decreased virus titre in the transplanted reticulum cell sarcoma line (*Sq1B*)[5] may indicate that genetic variation can eventually lead to an abnormal constitution more favourable to the virus action, so that less virus is needed for a more efficient tumour growth.

Shope fibroma virus inoculated into five animals two weeks of age caused a lethal inflammatory, fibrosarcoma-like disease, while in four rabbits sixteen weeks of age the same virus sample induced benign fibromas only. The fact that both types of neoplasms, the fibrosarcoma ($t = 150$, $5 < st$; $2 > st$)

Table 2. Chromosomes in Virus-induced Tumours in Mice and Rats

Tumour type	Strain	Inducing agent	Condition	Cases	Number of tumour sites studied				
					Total	Normal chromosome constitution	Cells counted	Abnormal chromosome constitution	Cells counted
General myeloic leukæmia	Agnes Bluhm	Graffi	Primary	4	26	26	776	—	—
Solid *SOV* 16	Agnes Bluhm	Graffi	30. transfer generation	2	2	2	60	—	—
Ascites *SOV* 16	Agnes Bluhm	Graffi	37. transfer generation	2	2	—	—	2	60
Solid myeloic leukæmia	Wistar rat	Graffi	2.+4. transfer generation	2	2	2	100	—	—
General lymphatic leukæmia	C_3H (*f*)	Gross	Primary	5	22	21	686	1	47
Parotid gland tumour	*N.I.H.* White Inbred Swiss	*S.E.* Polyoma (Stewart)	Primary	6	10	10	281	—	—
Submaxillary gland tumour			Primary		1	1	32	—	—
Sublingual gland tumour			Primary		1	1	31	—	—
Mammary tumour			Primary		1	1	41	—	—
Retroperitoneal gland tumour			Primary		1	1	7	—	—
Reticulum cell sarcoma	*DBA*	Friend	Primary	2	4	4	120	—	—
Sq 1 *B*-9	*DBA*	Friend	9. transfer generation	2	6	—	—	6	240
Mammary tumour	*A*	*MTI*	Primary	5	5	5	250	—	—
Mammary tumour	C_3H	*MTI*	Primary	5	5	5	250	—	—
Mammary tumour (*S6 Ca*)	C_3H	*MTI*	33. transfer generation	3	3	3	60	—	—
Mammary tumour (*S6 Cb*)	C_3H	*MTI*	33. generation C_3H+1. generation $DBA \times C_3H$	3	3	3	60	—	—

Table 3. Chromosomes in Chemically Induced Tumours in Mice, Chinese Hamsters and Rats

Tumour No.	Tumour type	Induced by	State	Cases	Number of tumour sites studied				
					Total	Normal chromosome constitution	Cells counted	Abnormal chromosome constitution	Cells counted
1	Lymphatic leukæmia *ST*-strain (mice)	9 : 10-dimethyl-1 : 2-benzanthracene	1. transfer generation	4	20	20	441	—	—
2	Mammary tumour Lung tumour (benign) $C_3H \times WLL\,s$ (mice)	Ethyl carbamate Ethyl carbamate	Primary Primary	5 5	5 5	5 5	205 97	— —	— —
3	Mammary tumour (Wistar rats)	2-acetylamino-fluorene	Primary	6	6	4	199	2	121
4	Fibrosarcoma (Chinese hamsters)	20-methylcholanthrene	Primary	4	4	2	98	2	119
5	Fibrosarcoma (Wistar rats)	3,4-benzpyrene	Primary	4	4	2	137	2	80
6	Hepatomas (Wistar rats)	4-dimethylaminoazo-benzene	Primary	6	6	2	103	4	227

and the fibroma ($t = 120$, $3 < st$; $2 > st$), were composed almost entirely of cells with the fourty-four normal rabbit chromosomes may indicate that the degree of malignancy is not necessarily determined by the chromosome make-up of the tumour cell, but might possibly be the result of differences in the physiological state of the host. In contrast the benign papillomas in five animals caused by Shope papilloma virus had normal chromosome complements ($t = 250$, $11 < st$; $7 > st$), but after malignant transformation every resulting primary carcinoma in five animals was characterized by a different hyperdiploid chromosome complement ($t = 122$). In addition the $V \times 2$ (Rous) tumour, derived from a Shope carcinoma by transplantation for about twenty years, had fifty-eight chromosomes ($t = 92$). It may be, therefore, that the interaction between the papilloma virus and the normal genotype results in a benign tumour only, whereas an altered cell may allow the virus to cause a malignant growth. It is still undecided, however, whether the abnormal chromosome constitutions detected in the primary carcinomas represent the cytogenetic basis for the malignant growth or if they are only superimposed on changes at other levels.

Tumours induced by endocrine imbalance. The third group of neoplasms analysed are those produced by experimentally provoked endocrine imbalance. Such tumours are usually hormone-dependent during the earlier stages and will often regress if the causative imbalance is corrected. Dependent tumours tend to change to autonomous forms either in their initial hosts or after serial passages in preconditioned animals. It was interesting to see whether the intracellular changes during the acquirement of hormone-independence result in the appearance of a new genotype.

Seven male mice castrated at one month and receiving œstrone in drinking water developed hormone-dependent pituitary tumours after an average time of 16 months. All tumours had the forty normal mouse chromosomes ($t = 107$). During the course of serial transplantation in preconditioned animals, pituitary tumours can become independent. Two such tumours, the *AtT*-20-Furth, and the *TtT*-3052-Furth, have been examined. The *AtT* tumour had the normal forty chromosomes ($t = 90$). The *TtT* tumour had sixty-five chromosomes with three long metacentric markers ($t = 60$). Since both tumours had been serially transplanted after the transformation to full autonomy, the implication of the abnormal constitution in the latter tumour, however, cannot be clarified.

Mammary tumours induced by endocrine imbalance and supposedly virus-free represent a more favourable material for the elucidation of this question, since such tumours are in general hormone-independent in the original host when of macroscopic size. Eight out of nine independent tumours resulting from hormonal imbalance elicited in four different ways had the normal chromosome constitution ($t = 322$). Finally, normal chromosome sets prevailed in both phases of evolution in the endocrine tumours studied. Thus gross chromosomal re-organization does not seem to be causally related to the intracellular changes resulting in full autonomy. The abnormal chromosome constitutions detected are probably of secondary nature, since in general, hormones lack mutagenic activity[6].

Chemically induced tumours. The chromosome constitution of neoplasms induced by six different chemical carcinogens has been analysed in detail. Four of the substances used are chemical mutagens (9 : 10 dimethyl-1 : 2 benzanthracene, ethyl carbamate, 20-methylcholanthrene, 3 : 4 benzpyrene), whereas the remaining two (2 acetylaminofluorene, 4-dimethylaminoazobenzene) lack mutagenic activity[7]. As can be seen from Table 3, no correlation between the mutagenic property of the inducing carcinogens and the chromosome constitutions of the resulting tumours was found. In every case, however, when carcinogens were administered systemically or locally under similar conditions, the tumours that resulted from systemic administration (Table 3, Nos. 1, 2, 3) had fewer chromosomal abnormalities than those resulting from local and prolonged administration (Table 3, No. 4, 5, 6), regardless of the mutagenic property of the substances used. Since almost all abnormal tumours also contained some tumour cells with the normal karyotype, it seems reasonable to assume that gross chromosomal reorganization is not essential for acquiring neoplastic properties in chemical carcinogenesis. The quantitative predominance of tumour cells with the normal chromosome complement in benign (Table 3, No. 2) and smaller malignant tumours (Table 3, No. 3, 4) and of abnormal cells in larger malignant tumours (Table 3, No. 3, 4) demonstrates furthermore that the abnormal constitutions can only be of secondary nature.

Radiation-induced tumours. Karyotype studies in primary lymphoid tumours that developed in non-irradiated thymic implants residing in an irradiated environment and in thymus *in situ* as a consequence of direct whole-body irradiation have yielded contradictory results[8]. In spite of this conflict, however, there seems to be agreement that the abnormal chromosome complements are of secondary importance, since several well-documented features of leukæmia-induction rule out the possibility that the neoplastic transformation results directly from the mutagenic effect of radiation[9].

The picture evolving from the analysis of primary tumours is still incomplete. It consists of outlines which must be filled in by further work. Nevertheless, the results reported are inconsistent with the chromosome mutation theory of carcinogenesis. The marked predominance of normal chromosome complements and normal deoxyribonucleic acid values that were found in representative material from precancerous stages, benign tumours and in the majority of early malignant tumours, both spontaneous[10] and induced by viruses[11], hormone imbalance, chemicals, and radiation[12], demonstrates that genetic variation at the chromosome-level need not necessarily precede the malignant change. In consequence it is reasonable to suggest that the abnormal chromosome patterns which characteristically occur in the majority of well-advanced tumours are of secondary importance in the acquirement of malignant properties. Furthermore, since the chromosome changes may occur at any time after the malignant change, they are probably a separate event. They may not be caused directly by the tumour-inducing agents and there is also little correlation between the mutagenic and carcinogenic activity of tumour-inducing agents. Once established, such new chromosome and hence genetic constitutions may confer some advantages on the cancer cells for tumour progression.

I am indebted to Drs. O. C. Broberger, T. Caspersson, C. D. Darlington, L. Engstedt, Ch. Friend, A. Graffi, L. Gross, R. J. C. Harris, G. Klein, P. C. Koller, B. Lagerlof, E. C. Miller, J. A. Miller, O. Mühlbock, Ch. Oberling, B. M. Richards, J. Schultz, R. E. Shope, M. Simonsen, S. Sorof, S. E. Stewart and B. Thorell, who encouraged me with their advice and interest and provided me with animals and tumour material.

This work was supported by grants from the Swedish Cancer Society, the Wallenberg Foundation, and the National Cancer Institute (National Institutes of Health, U.S. Public Health Service).

[1] Boveri, Th., "Zur Frage der Entstehung maligner Tumoren" (Gustav Fischer, Jena, 1914).

[2] Nowell, P. C., Hungerford, D. A., and Brooks, C. D., *Proc. Amer. Assoc. Cancer Res.*, 2, 331 (1958). Kaplan, H. S., Ciba Found. Symp. Carcinogenesis, 233 (1959). Ohno, S., and Kinosita, R., *Fed. Proc.*, 17, 450 (1958). Sachs, L., and Gallily, R., *J. Nat. Cancer Inst.*, 16, 803 (1956). Ohno, S., Kovacs, E. T., and Kinosita, R., *Exp. Cell. Res.*, 16, 462 (1959). Koller, P. C., *Cancer*, 1 (Butterworth and Co., London, 1958).

[3] Ford, C. E., Hamerton, J. L., and Mole, R. H., *J. Cell. Comp. Phys.*, 52, Supp. 1, 235 (1958). Tjio, J. H., and Östergren, G., *Hereditas*, 44, 451 (1958). Makino, S., *Int. Rev. Cytol.*, 6, 25 (1957). Levan, A., and Biesele, J. J., *Ann. N.Y. Acad. Sci.*, 71, 1022 (1958). Hauschka, Th. S., *J. Cell. Comp. Phys.*, 52, Supp. 1, 197 (1958).

[4] Makino, S., *Int. Rev. Cytol.*, 6, 25 (1957). Levan, A., *Ann. N.Y. Acad. Sci.*, 63, 774 (1956).

[5] Friend, Ch. (personal communication).

[6] Burdette, W. J., *Cancer Res.*, 15, 201 (1955).

[7] Burdette, W. J., *Cancer Res.*, 15, 201 (1955). Barrat, R. W., and Tatum, E. L., *Ann. N.Y. Acad. Sci.*, 71, 1072 (1958).

[8] Ford, C. E., Hamerton, J. L., and Mole, R. H., *J. Cell. Comp. Phys.*, 52, Supp. 1, 235 (1958). Kaplan, H. S., Ciba Found. Symp. Carcinogenesis, 233 (1959).

[9] Upton, A. C., Ciba Found. Symp. Carcinogenesis, 249 (1959). Kaplan, H. S., *ibid.*, 233 (1959).

[10] Stich, H. F., Florian, S. F., and Emson, H. E., *The Lancet*, No. 7099 385 (1959).

[11] Palmer, C. G., *J. Nat. Cancer Inst.*, 23, 241 (1959).

[12] Kaplan, H. S., Ciba Found. Symp. Carcinogenesis, 233 (1959).

THE LIVERPOOL GEOLOGICAL SOCIETY, 1859–1959

By R. G. C. BATHURST

Department of Geology, University of Liverpool

IN 1859, on December 13, nine amateur geologists founded in Liverpool a small society, limited to eighteen 'ordinary' members, "To investigate the structure of the Earth, the character of its past inhabitants, and the changes now in progress upon its surface". Almost at once, local enthusiasm led to an abandonment of the limit on ordinary membership and by 1863 this had reached fifty-eight.

Upon the wider geological scene in 1859 had burst Darwin's "The Origin of Species", with profoundly stimulating chapters on geology. In the same year, work in the Brixham caves and in Abbeville had shown beyond a doubt the association in undisturbed sediments of flint implements with extinct Mammalia. All these matters were discussed in the young Liverpool Society. Nearer Liverpool, North Wales and Merseyside had been mapped by the Geological Survey. Sorby, inspired by the work of William Nicol, had introduced the microscopical examination of thin sections as a tool in geological research.

Before 1859, the Liverpool geologists had read papers to several local societies; but that year, led by G. H. Morton, they founded their own. Other similar associations already existed: in Edinburgh (founded 1834), Yorkshire (Wakefield) and Manchester (1838), Glasgow and London—the Geologists' Association—(1858). Others were to follow: Norwich 1864, Leeds 1873 and Hull 1888. The early Liverpool members, such as are recorded, included a solicitor, a baker, a cotton broker, a coal merchant, a cleric, three teachers, a museum assistant, two civil engineers, a customs officer, a medical practitioner, a building contractor and an analytical chemist—a range of occupations differing little from that of the present amateur membership.

From 1860 meetings were held in the new Public Library, but, after 1864, in the Royal Institution, and in recent years in the Department of Geology in the University of Liverpool. From the outset the business at meetings consisted of papers, exhibits and discussion, nearly all flowing from the work of the members themselves. The number of ordinary meetings a year has been about seven since the 1860's, and field-meetings are still actively supported.

Over the years that followed, members worked mainly on the local Trias, including the Storeton footprints of *Cheirotherium*, the local Quaternary, the Mersey estuary, changes in local topography and the water supply. Field-work was also carried out in more distant areas, and a number of studies of thin sections had been made by the turn of the century.

In the years before 1914, four men particularly influenced the progress of the Society, both as its officers and as geologists. George Highfield Morton, the founder and first honorary secretary (at the age of thirty-three), is remembered above all as the pioneer of Carboniferous Limestone stratigraphy in North Wales. His division of the Limestone into the Upper Grey, Middle White and Lower Brown is still used. Among earlier works is a detailed study of the Shelve district. He read sixty-one papers to the Society on a great variety of topics, and his clear microscopical descriptions of local sedimentary rocks were among the earliest attempted. His book, "The Geology of the Country around Liverpool", was first published in 1863. He was awarded the Lyell Medal of the Geological Society of London in 1892.

Henry Charles Beasley worked mainly on the local Trias, especially the Storeton footprints. At his suggestion, in 1886, a unique collection of photographs, now in the Society's library, was begun of "interesting sections and phenomena which are likely to be soon hidden from view". Seventy years later the photographs of, then, obscure sedimentary structures and of animal tracks in the Trias have proved of great value in recent research.

The work of Thomas Mellard Reade revealed a catholicity of interest and an insight which were to earn him the Murchison Medal of the Geological Society of London in 1896. Although his local work was considerable, he is better known for his pioneer quantitative studies on the importance of solution as a factor in erosion, based on an analysis of the suspended load of the Mississippi and other large rivers, and his book "The Origin of Mountain Ranges" (1886). In this work Reade argued that the deformation of the crust seen in mountain ranges could not be accounted for by the thermal contraction of the Earth and he developed a theory of differential heating of the crust. This local heating would cause the expansion sufficient to cause the observed difference. The subsequent discovery of radioactivity, and recent calculations on the rise of temperature which would result from the accumulation of great thicknesses of sediment, make Mellard Reade's theory much more plausible to-day than it seemed some years ago. Later, during the construction of the Mersey railway tunnel, the levels were lowered following his prediction, afterwards confirmed, of a buried channel under the Mersey.

Joseph Lomas collaborated with Herdman as petrologist in the still valuable report "The Floor Deposits of the Irish Sea". In 1886 he was appointed lecturer in the University College of Liverpool. In his study of glaciology he visited the Faröes and several times went to Switzerland. His visit to South Africa with the British Association led to a paper on the desert origin of the Trias.

In 1915 the Society published a monograph, by T. H. Cope, "On the Igneous and Pyroclastic Rocks of the Berwyn Hills".

From the beginning the Society has taken an active interest in the Liverpool City Museum, and has recently expressed its concern over the absence of a keeper of geology. The Society early pressed for a chair of geology in the University of Liverpool, which has received from the members some valuable geological collections.

During the inter-war years, after the appointment of P. G. H. Boswell as the first professor of geology in the University, the Society experienced a new surge of activity, though research was increasingly dominated by the professional geologist. Prof. Boswell and his students contributed a series of papers to the *Proceedings* on the Silurian of North Wales, and Boswell laid before the Society his reports on the geology of the Mersey road tunnel. G. H. Mitchell and Howel Williams published work on Ordovician volcanics and Alan Wood on the stratigraphy of the North Wales coalfield. Papers by E. Neaverson included a detailed study of the Carboniferous Limestone of North Wales. C. B. Travis was an active member, also editor, at this time.

T. A. Jones was the most recent of the outstanding amateurs. His detailed and extensive knowledge of local Quaternary and Triassic lithology enabled him to interpret many local borehole records. His outstanding single work, published just after the First World War, was a microscopical examination of the local Carboniferous Limestone. He demonstrated the important role of micro-organisms, especially Foraminifera, in its formation.

The Society owes its survival through the Second World War pre-eminently to the efforts of T. A. Jones and E. Montag, with D. Alan and W. Schofield as editors.

In 1918, the Society established a Medal to be awarded to any geologist for work bearing upon the interests of the Society, an award to a member for original work on the local geology, and a prize to go to a student in the University of Liverpool.

Proceedings have been published since 1861, and by their exchange a large collection of foreign periodicals has been amassed. In recent years the financial survival of the *Proceedings* became difficult, in spite of help from the Royal Society during many years. To overcome this difficulty the Society joined with the Manchester Geological Association in 1951 to found the *Liverpool and Manchester Geological Journal.*

The new *Journal* differs somewhat from the *Proceedings*. In the first half-century, nearly three-quarters of the authors were members, and this high figure was maintained between the Wars; but since 1951 fewer than half have been members. There is now therefore a tendency for papers to deal more often with material beyond the traditional Liverpool area. The papers are less frequently read at ordinary meetings, at which lectures are generally given instead by invited speakers, often from outside the district. The wider scope of the Society's work was marked in 1959 by the removal from the "Object of the Society" of a final clause, "with particular reference to Liverpool and the surrounding area", which had been added in 1917.

In the face of rising costs, the joint publication too has had a precarious existence. Following appeals to local industry, the *Journal* has been generously helped, especially by Imperial Chemical Industries, Ltd. Advertisement overseas has recently led to an encouraging increase in subscribers, a sign of the growing strength of the *Journal* during its first decade under the editorship of J. C. Harper.

The centenary of the Society was marked by a three-day meeting, during January 1–3, jointly with the eighth Inter-University Geological Congress, at which ten addresses were delivered on recent advances in geology to an audience of more than two hundred. These addresses have been published in the centenary issue of the *Journal*.

BIBLIOGRAPHY

Hewitt, W., "The Liverpool Geological Society: A Retrospect of Fifty Years' Existence and Work" (Tinling, 1910).

Jones, T. A., "Liverpool Geological Society: A Retrospect of Thirty-five Years (1910–1944)" (Woolman, 1944).

NEW FELLOWS OF THE ROYAL SOCIETY

AT a meeting of the Royal Society on March 24, the following were elected to fellowship of the Society:

MR. A. M. BINNIE, reader in engineering in the University of Cambridge, distinguished for his contributions to engineering science, particularly in the field of hydraulics.

PROF. R. HANBURY BROWN, professor of radio astronomy in the University of Manchester, Jodrell Bank Experimental Station, distinguished for his many contributions to radio astronomy particularly on galactic and extra galactic radio emissions.

PROF. D. G. CHRISTOPHERSON, professor of applied science in the University of London, Imperial College of Science and Technology (Department of Mechanical Engineering), distinguished for his researches into the deformation and cutting of metals and for his work on explosive weapons.

PROF. R. H. DALITZ, professor of physics in the University of Chicago, Enrico Fermi Institute for Nuclear Studies, distinguished for his numerous contributions to nuclear theory and the physics of elementary particles.

PROF. J. N. DAVIDSON, Gardiner professor of physiological chemistry in the University of Glasgow, distinguished for his work on the structure, distribution and biosynthesis of ribose nucleic acid and deoxyribose nucleic acid.

PROF. M. J. S. DEWAR, professor of chemistry in the University of Chicago, distinguished for his studies of chemical structure and for his contributions to the application of quantum theory to organic chemistry.

SIR STEWART DUKE-ELDER, ophthalmic surgeon and director of research at the London University Institute of Ophthalmology, distinguished for his contributions to ophthalmic medicine, pathology and physiology.

DR. L. ESSEN, deputy chief scientific officer at the National Physical Laboratory, Teddington, Middlesex, distinguished for his work on the precise measurement of frequency and of the velocity of light.

DR. D. G. EVANS, director of the Medical Research Council Biological Standards Control Laboratory, London, distinguished for his investigations on the pathogenesis and prophylaxis of anærobic wound infections and whooping cough, and for his work on biological standards.

MR. N. L. FALCON, chief geologist of the British Petroleum Company, London, distinguished for his researches in tectonics and stratigraphy in connexion with the exploration for oil.

DR. P. A. GORER, reader in experimental pathology in the University of London (Guy's Hospital Medical School), distinguished for his work on the immunological genetics of tissue transplantation.

PROF. O. V. S. HEATH, professor of horticulture in the University of Reading, distinguished for his work in plant physiology and in particular the mechanism of stomata.

DR. R. HOLROYD, a deputy chairman of Imperial Chemical Industries Ltd., London, distinguished for his work on the chemistry and engineering of synthetic fuel production.

DR. H. E. HUXLEY, member of external staff of the Medical Research Council, Department of Biophysics, University of London (University College), distinguished for his work on the fine structure of muscle and on the mechanism of muscular contraction.

DR. J. C. KENDREW, deputy director of the Medical Research Council Unit for Molecular Biology, Cavendish Laboratory, Cambridge, distinguished for his work on the three-dimensional analysis of myoglobin by direct X-ray diffraction methods.

DR. J. A. KITCHING, reader in zoology at the University of Bristol, distinguished for his contributions to the physiology of protozoa and to marine ecology.

DR. D. K. C. MACDONALD, principal research officer, Division of Pure Physics, National Research Council of Canada, Ottawa, distinguished for his investigations on the thermal and electrical properties of metals with particular reference to the study of electron interactions.

SIR GEORGE PICKERING, regius professor of medicine in the University of Oxford, distinguished for contributions to clinical science, in particular to our knowledge of the causes of high blood-pressure.

PROF. G. PORTER, professor of physical chemistry in the University of Sheffield, distinguished for his work on flash photolysis and its applications to the study of free radicals and chemical processes.

DR. K. F. ROTH, reader in mathematics in the University of London (University College), distinguished for his solutions of fundamental problems in the theory of numbers.

PROF. T. R. SESHADRI, professor of chemistry in the University of Delhi, distinguished for his studies of the chemistry of naturally occurring compounds, particularly flavonoids.

PROF. J. H. TAYLOR, professor of geology in the University of London (King's College), distinguished for his researches into the geology of ore deposits, particularly the iron ores of the Midlands.

DR. A. A. TOWNSEND, assistant director of research in the University of Cambridge, Cavendish Laboratory, distinguished for his experimental and analytical contributions to the theory of turbulent motion in fluids.

PROF. R. L. WAIN, professor of agricultural chemistry in the University of London (Wye College), distinguished for his research in plant auxins and systemic herbicides.

DR. E. N. WILLMER, reader in histology in the University of Cambridge, distinguished for his work on cells, their growth and metamorphosis, and on colour vision.

NEWS and VIEWS

Ministry of Aviation Appointment:
Mr. D. G. A. Rendel

MR. DAVID RENDEL has been promoted to deputy chief scientific officer and appointed head of the Mechanical Engineering Department of the Royal Aircraft Establishment. He was educated at Downside School and New College, Oxford, where he took an honours degree in engineering science in 1940. He joined the Royal Aircraft Establishment, Farnborough, in the summer of that year, and in 1941 was given the task of organizing a laboratory to deal with hydraulic and pneumatic power services in aircraft. This was during the period when high-pressure hydraulic and pneumatic systems were being increasingly used in aircraft and power-operated controls were being developed. Mr. Rendel was responsible for studying a number of basic problems such as the effects of oil aeration on hydraulic controls, high-pressure air flow in small pipes, behaviour of irreversible machines, etc. In 1948 he was appointed technical assistant to the Director-General of Technical Development (Air), Ministry of Supply, and served in that post during the early stages of development of V bombers, the *Hunter*, the *Javelin*, the *Brabazon*, the *Princess* and *Viscount*; also at this time the *Avon*, *Mamba*, *Dart* and *Sapphire* engines were being developed and the first operational guided weapons were being designed, together with the more advanced navigational aids which are now just coming into service. During his last year with the Director-General he was responsible for the administration of Ministry of Supply activities in the joint American, British, Canadian Air Force standardization scheme.

Issues of *Nature* are now being grouped into four volumes a year. This issue is the first number of Volume 186

On his return to Farnborough, in 1951, he served in the Mechanical Engineering Department, controlling work on aircraft pressure cabins, aircraft conditioning, aircrew equipment and escape and safety, and was responsible for Farnborough's contribution to the development of the modern oxygen breathing and pressure clothing equipment now used by Service aircrew. During this period he became interested in the subject of man-powered flight and is a member of the steering committee of the Royal Aeronautical Society group which interests itself in this subject. He was made a member of the Engineering Physics Sub-Committee of the Aeronautical Research Council and of the Instruments and Physics Sub-Committee of the Meteorological Research Committee.

National Maritime Museum:
Lieut.-Commander D. W. Waters

LIEUT.-COMMANDER D. W. WATERS, R.N., has been appointed curator of navigation and astronomy in the National Maritime Museum, Greenwich, London, in succession to Commander O. Hill. Lieut.-Commander Waters is well known for his book, "The Art of Navigation in England in Elizabethan and Early Stuart Times", which appeared in 1958, and is now the recognized authority on the subject. He served in the Fleet Air Arm and was taken prisoner by the Italians during a night torpedo attack in the Mediterranean in 1940. Since 1946 he has served at the Admiralty on the staff of the Historical Section, where he has been chiefly concerned with the history of problems connected with attack and defence of shipping. He is a Fellow of the Royal Historical Society and of the Institute of Navigation, and has written extensively on the history of navigation and maritime warfare.

College of Advanced Technology, Birmingham:
Mr. K. L. Stretch

MR. K. L. STRETCH has been appointed vice-principal of the College of Advanced Technology, Birmingham, as from June 1. At present, Mr. Stretch is director of the Central Engineering Establishment of the National Coal Board. He was educated at Merchant Taylor's School, Crosby, and at King's College, Cambridge, where he graduated in mathematics. After an engineering apprenticeship, broken by war service, with Mather and Platt and experience on the works and in design with Imperial Chemical Industries, he was works manager at the United Kingdom Atomic Energy Authority, Calder Hall, before taking up his present post in 1957. Mr. Stretch has undertaken research and development in fire and textile engineering, nuclear reactor characteristics and operation, tunnelling and non-destructive testing, and has written several articles on nuclear energy and fuel policy.

Commonwealth Scientific and Industrial Research Organization:
Executive Appointments

Two new part-time members to the Executive of the Commonwealth Scientific and Research Organization (Australia) are announced. The vacancies were created by a recent amendment to the Science and Industry Research Act, which increased the strength of the Executive from five members to nine.

The two members are Lord Casey, who recently resigned from Parliament on his elevation to the peerage, and Mr. E. P. S. Roberts, a prominent Queensland grazier. Lord Casey's association with C.S.I.R.O. dates back to 1937, when he first became minister-in-charge of the Council for Scientific and Industrial Research. Mr. Roberts, who is aged forty-six, has been associated with C.S.I.R.O. as a member of its Advisory Council since 1957. After the War, he purchased his own property at Toobeah, in Queensland, and became interested in the wider problems of the pastoral industries. His appointment will ensure that the point of view of the man on the land and the problems of northern Australia are kept constantly before the Executive.

Iron and Steel Institute: Awards

The Council of the Iron and Steel Institute has announced the award of the following medals and prizes: *Bessemer Gold Medal for* 1960: Prof. Hermann Schenck, director of the Institut für Eisenhüttenwesen, Rheinische-Westfälische Technische Hochschule, Aachen, Germany, and president of the Verein deutscher Eisenhüttenleute; *Sir Robert Hadfield Medal for* 1960: Dr. J. C. Hudson, head of the Corrosion Section, Chemistry Department, British Iron and Steel Research Association; *Andrew Carnegie Silver Medal for* 1959: Dr. P. R. V. Evans, Research Department, Metropolitan-Vickers Electrical Co., Ltd., Manchester, for a paper on "The Effect of Rolling Unstable Austenitic 0·76% Carbon Steel at 220–300° C." (*Journal*, January 1959, p. 34); his co-author, Prof. Hugh O'Neill, was not eligible for an award; *William Prize for* 1959: Mr. I. M. D. Halliday, Research and Development Department, The United Steel Companies, Ltd., Rotherham, for a paper on "Continuous Casting at Barrow" (*Journal*, February 1959, p. 121).

Mr. W. F. Cartwright, assistant managing director of the Steel Company of Wales, Ltd., since 1954, has been elected president of the Iron and Steel Institute for 1960–61.

Cost of the Radio Telescope at Jodrell Bank

In a written answer in the House of Commons on March 24, Sir David Eccles, as representing the Minister for Science, stated that there is nothing owing on the capital cost of the radio telescope at Jodrell Bank, and that the Government is not prepared to increase its contribution. The Government has already contributed substantially to the cost of upkeep of the telescope and any applications which might be made for further grants for research involving its use would continue to be dealt with on their merits by the Department of Scientific and Industrial Research. In oral replies Sir David said that the United States Government has already paid in full for work undertaken on its behalf with the radio telescope. Treasury approval for the final £130,000 of the total grant of £360,000 towards the capital cost of construction of the radio telescope was given on August 8, 1956, and payment to the University completed on March 17, 1958. Three further grants of £13,000 annually for 4 years, for running costs, £60,820 for development of new apparatus and techniques, and of £15,200 for galactic and extra-galactic neutral hydrogen emission studies and development of data-handling processes have been authorized. Sir David said he was not aware of any delay on the part of the Treasury in giving approval or by the Department of Scientific and Industrial Research in making the payments to the University. There was a sum of £60,000 left to be collected by the University of Manchester towards the capital cost and, referring to an appeal to the Government to subscribe this final sum, Sir David said that Lord Hailsham considers that the Government's contribution is sufficient and that it is well understood that the rest of the money will be raised by the University.

City and Guilds of London Institute Fellowships

The Fellowship of the City and Guilds of London Institute has been conferred upon the following past students in recognition of their contributions to industry or the professions in which they are engaged: J. J. Gracie (director and general manager of the G.E.C. Engineering Works at Witton, Birmingham); C. G. Hawes (consultant in hydrology and irrigation); T. M. Malkani (chief engineer of Calcutta Port Commissioners); H. D. Morgan (senior partner of Sir William Halcrow and Partners); D. W. Morphy (joint managing director of Morphy-Richards, Ltd.); and A. W. Skempton (professor of civil engineering, City and Guilds College, Imperial College of Science and Technology). The Council of the City and Guilds of London Institute has also conferred the fellowship of the Institute, *honoris causa*, upon: Sir Willis Jackson (president of the Institution of Electrical Engineers, director of research and education, A.E.I. (Manchester), Ltd.); Prof. D. M. Newitt (pro-rector of the Imperial College of Science and Technology), head of the Department and Courtauld Professor of Chemical Engineering).

Joint U.S.–Canadian Satellite Project

During April 1959, Dr. A. Hartley Zimmerman, chairman of the Canadian Defence Research Board, and Dr. T. Keith Glennan, administrator of the U.S. National Aeronautics and Space Administration, announced acceptance by the Administration of a proposal by the Defence Research Telecommunications Establishment for a joint satellite experiment. Initially, it was proposed that the satellite will be constructed and instrumented by the Defence Research Telecommunications Establishment and launched late in 1961 at Vandenberg Air Force Base by means of a three-stage *Thor–Delta* rocket provided by the Administration. The experiment will be designed to achieve two objectives. First, to examine and record information about the structure of upper levels of the ionosphere by using a radio sounder above the ionized layers. Secondly, to provide information about the radio signals which emanate from outer space. The satellite will be launched in a near-polar orbit, and for protection during its acceleration through the dense atmosphere, it will be enclosed in a metal nosecap or shroud. On reaching orbit altitude of 700 miles, both the nosecap and the third-stage rocket will be separated from the satellite. The Defence Research Telecommunications Establishment will operate four receiving stations in Canada. It is hoped that the satellite will continue to transmit data for about a year following the launching. The information is to be exchanged freely with other nations through the Committee on Space Research of the International Council of Scientific Unions.

Factories (Ionizing Radiations) Special Regulations

A revised draft code (Ministry of Labour. Factories Acts, 1937 and 1948. Factories–(Ionizing

Radiations)—Special Regulations—Second Preliminary Draft of Regulations. Pp. 20. (London: H.M. Stationery Office, 1960.) 1*s*. 3*d*. net) for the protection of workers engaged in operations involving the production, emission or use of ionizing radiations includes amendments based on many suggestions received since the first draft code was issued in July 1957. The preface comments on the more important changes made to the earlier draft. The "Schedule of Permitted Radiation Doses" has also been revised in the light of the views of the Medical Research Council and of the latest recommendations of the International Commission on Radiological Protection. Presumably the regulations must be phrased in language which meets legal requirements, but as they stand they will undoubtedly make difficult reading for factory officials and others who will be concerned in their implementation. It would be an enormous help to such readers if the regulations could, for example, be expressed with the clarity displayed in the "Code of Practice" (1957), which was intended primarily for the protection of persons exposed to ionizing radiations in hospitals in the National Health Service.

In view of the part played by the 'competent person' it is desirable that some definition of this term be given including the qualifications required. A particular reason for this is that the new draft does not require tests for personal exposure or medical supervision of those persons who, although employed in the operations mentioned above, remain outside adequate shielding, and it is presumably the 'competent person' who must establish whether or not the shielding is in fact adequate. The suggestion in 28 (1) that a worker, transferring his services elsewhere, should be given a copy of his own record from the health register seems fraught with some difficulty, especially because by 27 (1) it includes results of medical examinations. Comments on the new draft are invited from "industry, associations and any others concerned", to be sent to the Ministry of Labour by April 15.

British Museum (Natural History): New Exhibits

The pavilion beyond the Mammal Gallery in the Natural History Museum has been re-designed to show three groups of African game animals in their natural surroundings. The largest group is taken from the district north of Mount Kenya, with a giraffe family, a kudu and baboons coming to drink near the Guaso Nyiro river. The second group consists of an okapi and a bongo in a deep gorge in the Ituri Forest. Opposite to this is a scene in Angola, with a giant sable antelope surveying the country from the top of a termite colony. A brindled gnu and a pair of impala antelopes have been feeding in the dense grass below. A large contour map of Africa dominates the pavilion and shows the three localities depicted. The equipment of the pavilion is the gift of the Rowland Ward Trustees, in memory of the late Rowland Ward. Messrs. Rowland Ward, Ltd., have set up the three groups and provided most of the mounted animals. The okapi was specially provided for the Museum by the Governor-General of the Belgian Congo and mounted by the exhibition staff of the Museum.

A series of new cases lining the balcony on the east side of the Central Hall is devoted to exhibits illustrating the chief points in the functional morphology of mammals. Included are the skin and its derivatives, hair, spines, hoofs and glands; muscles, and adaptation of the external form and skeleton to various kinds of locomotion such as running, jumping, flying, burrowing and swimming; brains and sense-organs; the digestive, circulatory and respiratory systems; and an extensive series illustrating the structure, growth, adaptation of teeth to various types of food.

University Entrance in Great Britain

Under the title "University Entrance—The Basic Facts", the National Union of Teachers has published a concise guide for those who contemplate entering a university (London: National Union of Teachers, 1960. 3*s*. 6*d*.). Information regarding the universities themselves, the courses they offer, the educational requirements for admission, accommodation, cost of study and residence, etc., is first presented. Next follows a clear outline of the grants and scholarships available in Great Britain and Northern Ireland, and some notes are given on the various university, matriculation and faculty requirements. A novel and valuable feature of the guide is the list of universities showing in tables the subjects that may be studied either as part of a course leading to a first degree, or as the main part of such a course in which a degree can be taken either in that subject alone or in combination with one or two other principal subjects. The guide is thus admirably designed both to assist the school-leavers to determine where to train and to realize where their qualifications may lead. The Union is to be congratulated on an excellent job of work. Copies are being sent free initially to every maintained secondary school which prepares pupils for courses leading to university entrance, and additional copies are on sale to schools and members of the public.

Science and Economics in the United States

A survey "Current Projects on the Economic and other Impacts of Scientific Research and Development" was undertaken early in 1959 by the National Science Foundation of the United States, and an inventory of projects in colleges and universities has now been issued by the Foundation (Pp. v+59. National Science Foundation, Washington, D.C.: Government Printing Office, 1959. 25 cents). The 107 projects listed are classified in ten sections, comprising, for example, agriculture; expenditure for research and development; impact in selected industries; invention, innovations and patents; new sources of power and other case studies in scientific and technological developments; and sociological and man-power studies of research and development and technology. There are an author index and an index of institutions. Simultaneously the Foundation has issued "A Bibliography on the Economic and Social Implications of Scientific Research and Development" (Pp. v+53. (National Science Foundation. Washington, D.C.: Government Printing Office, 1959. 25 cents). The entries are arranged under the following headings: general background; nature, philosophy and history of science and technology; expenditure and man-power activities in research and development; associated institutional branches of science and technology, and public policy; patents and innovation, administration and management of industrial research; economic and social implications and analysis of research and development; and other bibliographies. There are an author and periodical index.

Harkness Fellowships of the Commonwealth Fund

The British Committee of Award of the Commonwealth Fund announces the following elections, among others, to Harkness fellowships for 1960, tenable for one or two years in the United States: G. S. G. Beveridge (Edinburgh to Minnesota), chemical engineering; R. Y. Calne (Royal Free Hospital to Harvard), surgery; B. Coleby (Low Temperature Research Station, Cambridge to University of California), food research; B. J. Deverall (Imperial College of Science and Technology, London to Wisconsin), plant pathology; J. E. Dove (Atomic Energy Research Establishment, Harwell to Harvard), physical chemistry; R. Hall (Royal Victoria Infirmary, Newcastle upon Tyne, to Harvard), medicine; A. M. Howard (*The Guardian* to Columbia), journalism; M. Kogan (Ministry of Education to Harvard), teacher training; D. Lynden-Bell (Cambridge to California Institute of Technology), astronomy; D. H. Mellor (Cambridge to Minnesota), chemical engineering; K. J. Reid (Cambridge to University of California), chemical engineering; I. C. Roddie (Belfast to Seattle), physiology; A. C. Rose-Innes (Admiralty to Rutgers), electronics; J. R. Taylor (Cambridge to University of California), nuclear physics; C. T. C. Wall (Cambridge to Institute for Advanced Study, Princeton), mathematics.

André Mayer Food and Agriculture Fellowships

The Food and Agriculture Organization of the United Nations has announced that it will offer 10 or 12 André Mayer fellowships during 1960. These awards, valued at 150–360 dollars a month depending on the country where they are used, will be made under the following two groups: *research*, for unusually promising persons with research experience behind them who would offer a guarantee for the carrying out of independent research work; *research training*, for younger and promising individuals who have demonstrated an inclination towards and an aptitude for research work. Due consideration will be given to geographical distribution, to ensure that a proportion of the awards is given to candidates from countries where research facilities are not highly developed and the need for trained research workers is great. The subjects presented must be in relation to the Organization's activities which comprise: land and water development, plant production and protection, animal production and health, rural institutions and services, fisheries, forestry and forest products, nutrition (non-medical), atomic energy in food and agriculture, agricultural economics (commodities, statistics, economic analysis). Further information can be obtained from the Secretariat of the Food and Agriculture Organization, National Committee for the United Kingdom, Ministry of Agriculture, Fisheries and Food, Whitehall Place (East Block), London, S.W.1.

The Canada Council

The second annual report of the Canada Council, which covers the year ended March 31, 1959, again stresses both the Council's difficulty in selecting recipients of grants and that a grant once made is not automatically renewable (pp. vi+112. Ottawa: The Canada Council, 1959). The report includes lists of scholarship awards made during the year and also special projects and grants-in-aid to individuals. During its two years the Council has made capital grants totalling 12,816,564 dollars to 31 different universities and colleges, including 1,632,600 dollars to the University of British Columbia, 1,377,141 dollars to Queen's University, Kingston, and 1,050,000 dollars to the University of Western Ontario. Under the Scholarship and Fellowship Scheme, 571 awards were made totalling, including travel grants, 1,216,000 dollars, and of these, 111 were in the arts, 236 in the humanities and 224 in the social sciences; and of the 79 senior fellowships, 23 were renewals from the previous year. Grants to organizations totalled 1,148,379 dollars in the arts, 120,772 dollars in the humanities and 167,440 dollars in the social sciences, and 75,000 dollars was earmarked to assist Canadian universities in bringing eminent scholars to Canada for short periods and for interchange of scholars between universities in Canada.

The Industrial Training Council

The first report of the Industrial Training Council covers the period from July 1958 to December 1959 (pp. 32. London: Industrial Training Council, 1960. 1*s*.). The Council's immediate task is to try to ensure that training arrangements in industry will be adequate to enable the best use to be made of the abilities of all the young people available for employment in industry during the next few years. The proper training of its workpeople is the responsibility of each industry, and the Council sees its main function as the encouragement of the employers' organizations and the trade unions in co-operation to take the necessary action. The Council is convinced that great scope exists for introducing systematic training in a wide range of industries to supplement traditional apprenticeship training of craftsmen. The bulk of the report comprises a summary of the action taken by some sixty industries, which together employ nearly two-thirds of all workpeople, to deal with the 'bulge', and nineteen industries known to be still considering the Carr Report are listed. The Council has also asked all industries to make some quantitative assessment of their future training needs for all the young workpeople they expect to recruit for whom a planned scheme of training is desirable; but although some industries have made such assessments, insufficient information is available to form any overall picture. The Council has accepted the Government's offer of a grant-in-aid to promote the expansion of training for young people in the circumstances created by the 'bulge' and particularly to assist the appointment of training development officers, and the Council has approved assistance under this arrangement to the Cotton Board and the Booksellers' Association and has agreed to a third grant to the Hotel and Catering Institute. The Council has also appointed its first two training advisers, and is now studying the information it has collected to decide what problems need more detailed consideration and what further information can usefully be distributed. Five working committees have been set up for this task.

National Museum of Wales

The year 1958–59 at the National Museum of Wales marked the retirement of Dr. F. J. North from the post of keeper of geology after a total service of more than forty-five years. The annual report quite properly pays high tribute to his services to the many tasks he undertook and the honours he received. Dr. North accepted the invitation of the Council to act for a while as a part-time special adviser to the newly formed Department of Industry. In the Geology Department the emphasis of the year's work was on the study and reserve collections; in the Botany Department an exhibit illustrating the mosses, liverworts and lichens has been installed; in the Zoology Department several important alterations have been made in the gallery of vertebrates; and the modernization of the galleries has continued in the Archæology Department. The Department of Industry appears for the first time in the annual report, and the generosity of many firms interested in this work is gratefully acknowledged. In the Art Department little radical change has been made in the display of the collections. At St. Fagans, Cilewent was opened to the public, who quickly appreciated the ideal siting of the house and the environs laid out to represent the contours and vegetation of the original place.

European Barley Tests

THE ninth annual report of the Barley Committee of the European Barley Convention deals with trials carried out in 1958 in fifteen European countries. Unfortunately, the widespread bad weather conditions reduced the value of the trials results because of the small grain with high nitrogen content. The malting quality was consequently much impaired, and brewing tests were abandoned. Judged on malting quality, there were some interesting new varieties: thus, Beka, Union and Wisa gave higher extracts than Proctor, which was the variety used as the standard for quality. Nevertheless, the general quality standard was so low that the report avoids a detailed summary of the performance of each variety, although it does make special reference to the capacity of the three varieties mentioned above to produce high extracts in spite of the most unfavourable growing conditions. Agriculturally, the important result emerging from these trials was the higher yields from the new varieties compared with the standard Kenia, which, however, has been outclassed in yield for some years.

These co-operative trials are interesting in giving some indication of the range of varietal adaptability, and it is claimed that much information is being accumulated on the influence of climate on the quality and yield of barley. A special research worker has been appointed to analyse the data available on this matter and to make suggestions for further investigations. This is an important development in the activities of the Barley Committee and might provide interesting and valuable information on the requirements of different ecological conditions with respect to the most suitable types of barley for the highest expression of yield and malting quality.

Research in Veterinary Science

EVERYONE who wishes well to the veterinarian, in whatever country he practises, or maintains the fine quality of research which this profession is nowadays producing, will welcome the first number of *Research in Veterinary Science*, which appeared in January this year (1, No. 1; January 1960. Pp. 93. Published quarterly. Annual subscription: 90*s*. post free. Single issues, 25*s*. Oxford: Blackwell Scientific Publications, Ltd., 1960). Inaugurated by the British Veterinary Association, this new journal has, as its executive editor, the editor of the Association's well-known weekly, the *Veterinary Record*, who has, to assist him, three distinguished scientific editors and also an editorial board composed of experts in practically every field of veterinary science, many of whom have won, by the quality of their work, high distinction in the world of science.

The aim of the journal, explained in a foreword by the president of the British Veterinary Association, is to fulfil Article 3 of the Association, which requires it to ensure "the promotion and advancement of veterinary and allied sciences"; and those who have followed the progress of the veterinary profession in recent years will expect to see, in the articles published, not only the wide scope mentioned by the Association's president, but also that note of comparative medicine and surgery which is nowadays a feature of veterinary science everywhere. Though diseases of animals are by their very nature especially allied to the diseases of man, a fact which is expressed in the increasing and wholly admirable co-operation between the veterinarian and the medical man, the veterinarian also needs, and energetically pursues, other branches of science as well, and the training he nowadays receives must fit him well to co-operate also in research in these. This journal will therefore reflect in its pages research in many branches of science and it will, as its inaugurators desire, have an international appeal; for veterinarians in other countries as well as Great Britain are invited to contribute to it. One thing is certain—this journal will be essential to anyone who wishes to follow the rapid advances that veterinary science is nowadays making everywhere.

Genetical Research

WHEN the oldest British general genetical journal left the country with its editor, only one such journal remained. This was doubly unfortunate. Not only was it a time when the pressure on space for publication was rapidly increasing in all fields, but it was also a time when the belated recognition by British universities that the Americans were right in recognizing genetics as an essential part of biology was beginning to have results. One journal of general genetics could not be enough for a country such as Britain, not only because of the bulk of publication to be expected, but also because of the desirability of having more than one editorial policy, however broad-minded that editorial policy might be. A new journal, *Genetical Research*, has now been launched to meet this need. Published by the Cambridge University Press, it is edited in Edinburgh by E. C. R. Reeve, with an editorial board, under the chairmanship of C. H. Waddington, who have a wide range of genetical experience. Three parts are to be published annually at 40*s*. each, the subscription being £5 a volume. The first number, of 172 pages, was published this February, and contains twelve papers ranging in content from micro-organism genetics to developmental genetics and the results of selection experiments. It includes a number of important papers among which should be noted especially Pritchard's discussion of recombination, and Waddington's experiments on canalizing selection. The contents of this first number augur well for the future of a journal that was badly needed, and is most welcome. We wish it the long successful future that it clearly merits.

Darwin's Notebooks

IN Darwin's Journal the year 1837 contains an entry which runs, "In July opened first notebook on 'Transmutation of Species'—Had been greatly struck from about month of previous March on character of

S. American Fossils—and species on Galapagos Archipelago. These facts origin (especially latter) of all my views". Sir Gavin de Beer has now transcribed the notebooks and the first of them dealing with the period July 1837—February has been published in the historical series of the *Bull. Brit. Mus.* (*Natural History*) (2, No. 2).

The four "Notebooks on Transmutation of Species" are the first implementation of the suggestion put forward by Darwin in his "Ornithological Notebook" referring to his visit to the Galapagos Islands in September and October 1835. The "First Notebook" represents the state of Darwin's opinion as it developed six months after his return to England, the results of consulting the literature on the subject, and the first formulation of his conviction that the stability of species had been 'undermined'. This "Notebook" is important in tracing the course of Darwin's thoughts and the extent of his knowledge before his cognisance of Malthus's work.

Food Habits of Migratory Ducks

In the autumns of 1938, 1939, and 1940, duck gizzards totalling 4,977 were collected from hunting clubs and individual hunters at twenty-one sites along the Illinois River between Ottawa and Florence and eleven sites along the Mississippi River between Rock Island and Quincy. The following seventeen duck species were represented: mallard, pintail, green-winged teal, blue-winged teal, baldpate, gadwall, shoveller, black duck, wood duck, lesser scaup, ring-necked duck, redhead, canvas-back, ruddy duck, greater scaup, common goldeneye, and oldsquaw (Illinois Nat. Hist. Surv. Bull., 27, Article 4; August 1959). Analyses of the gizzard contents were made by Harry G. Anderson and indicated that, during the autumn, most species of ducks in Illinois are predominantly vegetarians, that most of them feed principally on native wild plants, and that the lesser scaup is the only species with a diet predominantly animal. Maize made up half of the organic contents of mallard gizzards. Native wild foods were present in relatively greater quantities in gizzards of the wood duck, pintail, redhead, baldpate, green-winged teal, and ring-necked duck, all of which included maize in their diets.

The relative positions of the important food plants changed from year to year as accessibility and availability varied. The importance of a plant species to a species of duck depended on the size of the duck and the type of feeding habitat of the duck. The dabbling ducks fed primarily on emergent and moist-soil plants and the diving ducks more frequently on submerged plants. Animal foods were more important to the diving ducks than to the dabbling ducks Snails and mussels provided the largest animal food volume and occurred in the largest number of gizzards. Insects were second in volume and occurrence. Grit constituted about 11–28 per cent of the gross contents of the gizzards of various duck species. Most of the stones were less than 2 mm. in size; the sizes ranged from minute to 19 mm. in size. More than two hundred of the gizzards examined contained lead shot pellets.

British Scientific Instrument Research Association

At a recent meeting of the Optical Panel of the British Scientific Instrument Research Association, the members expressed the opinion that, with the advent of electronic computers, the conventional optimization methods used for optical design had probably achieved their maximum efficiency, and that there was now a deep-felt need for re-thinking at the fundamental levels of the problem. The director endorsed this view, and suggested that what was required was a new approach to the mathematical statement of the problem, leading, if successful, to an operational calculus or algebra embracing the whole field of design of optical systems. To this end the Association is now proposing to appoint a mathematician of the highest calibre, who will be given an entirely free hand in this field.

Announcements

Ralph E. McBurney, former air vice-marshal in charge of Air Material Command, Ottawa, has been appointed head of the Technical Information Service of the Canadian National Research Council. The position at the National Research Council is made vacant by the retirement of F. G. Green, head of the section since 1950.

It is announced that Prof. C. Salvetti has been appointed director of the International Atomic Energy Agency's Division of Research and Laboratories. Prof. Salvetti has been a consultant to the Agency, and will now be in charge of the Agency's activities in the field of research and the laboratories now under construction at Seibersdorf.

Miss H. M. Bruce, of the National Institute for Medical Research, London, has been awarded the Oliver Bird Prize for 1959 for a series of papers submitted under the general title of "An Exteroceptive Block to Pregnancy". The Prize is given by the Oliver Bird Trust (secretary, Mrs. Clifford Smith, 64 Sloane Street, London, S.W.1).

Dr. F. V. Webster, of the Road Research Laboratory, has been given the Wolfe Award for 1959. This is the second of ten annual awards of £500 to be made under the terms of a bequest, to a research worker of the Department of Scientific and Industrial Research who makes an outstanding contribution to the research work of the Department during the previous twelve months. Dr. Webster has been concerned mainly with the general settings of traffic signals, and has included the use of signals on high-speed roads and at traffic roundabouts.

We are informed that "Principles of Organic Chemistry" by T. A. Geissman, noticed in *Nature* of January 16, p. 131, is now available from the English branch of the publishers, W. H. Freeman and Co., Ltd., Hyde House, West Central Street, London, W.C.1, price 48*s*.

The British Leather Manufacturers Research Association, Milton Park, Egham, Surrey, will open its laboratories to invited visitors during May 3–5; the annual lecture on the first day (heavy leather industry) will be given by Dr. K. W. Pepper, director of the Association; that on the second day (light leather industry) by Mr. F. R. Morgan.

The Società Italiana di Fisica is organizing an international school of physics during May 23–August 17 at Varenna in the Villa Monastero. It will consist of four courses: Ergodic Theories, May 23–31; Nuclear Spectroscopy, June 20–July 9; Physicomathematical Aspects of Biology, July 11–30; and Topics of Radio-frequency Spectroscopy, August 1–17. Further information can be obtained from Prof. Piero Calderola, Istituto di Fisica dell'Università Via Saldini, 50 Milano.

HOW MANY MORE NEW JOURNALS?

AT a recent meeting of the Scientific Publications Council held at the Ciba Foundation, London, problems arising from the rapid increase in the number of new scientific journals were reviewed. Dr. D. J. Urquhart (Department of Scientific and Industrial Research Lending Library Unit) said that the number of journals taken by the Science Museum Library is increasing at the rate of about 700 a year, or nearly two new journals a day. Present indications are that with the development of new research institutions in China, Japan and other countries, this number is likely to go up to 1,000 or more new journals a year. The reason for the increase is that more money is being spent on scientific research. The increase in the number of journals does not mean that scientists are reading more: inquiry has shown that few individual scientists read regularly more than three or four scientific journals. Most of the smaller libraries take 100–300 journals and the number taken by them has not greatly increased in recent years.

Mr. T. H. Clare (director of Edward Arnold, Ltd.) said it was his personal experience as a publisher that new journals were often started without any expectation of an immediate financial return. A publisher might agree to start a new scientific journal mainly for reasons of prestige or because it might bring him into contact with the prospective authors of profitable books. A journal is less seasonal than many other forms of publication and it provides a useful way of keeping the skilled compositors regularly occupied and so spreading the publisher's overheads. The capital outlay required for the publication of a new journal is relatively small, and there is often a quick return.

Dr. B. M. Crowther (Institution of Electrical Engineers, and editor of *Physics Abstracts*) said that the number of scientific publications is increasing by about 5–10 per cent a year. Scientific information has generally been like an iceberg—with more below the surface than appears on top: but recently we have seen an unfortunate tendency to bring everything to the surface by publishing all the information available. Scientists have recognized the need for order in certain matters such as scientific nomenclature: there is now a need for general agreement in introducing more order into scientific publication. One thing calling for discipline is the habit of some workers of publishing the same material several times. The same work may appear first in a preliminary communication, then in various papers in national and international journals and again, with minor modifications, in congress reports and symposium volumes. Many of the increasing number of conference publications now appearing seem unnecessary: they contain little that is of permanent value and it might be better if they were not published. Conferences might be arranged for discussing recently published work, without the publication of further papers. Some of the smaller foreign universities start new journals apparently for the sole purpose of acquiring other journals by exchange, and many of these are practically valueless. If more work needs to be published, why not increase the size of some of the existing journals?

Dr. D. Richter (director of the Medical Research Council Neuropsychiatric Research Unit) said that while some publishers may play a passive part, there are others who are active in persuading scientists to start new journals. Some of the journals started in this way have proved successful; but with others the editors have found it hard to get sufficient good manuscripts to keep them going, so that standards have tended to fall. There should be sufficient journals to ensure the prompt publication of any worthwhile research: but not so many that there is reduplication and a lowering of standards. There is no means of enforcing any kind of control, but when the problem is more widely appreciated, public opinion may help to keep the number of journals at a reasonable level.

Dr. G. E. W. Wolstenholme (director of the Ciba Foundation) said that a major cause of reduplication is the insistence by university and other committees that those attending meetings should give a paper in order to get their expenses: but some of the more enlightened grant-giving bodies no longer insist on this. Temporary research grants also cause unnecessary publication, since a research worker may feel he must publish a paper to ensure the renewal of his grant.

Mr. A. V. S. de Reuck (international relations secretariat, Royal Society) blamed a tendency in some circles to judge a man by the quantity rather than the quality of the work he published. A higher standard of refereeing is needed to check reduplication and raise the general standard of publication. Prof. G. W. Harris (Postgraduate Medical Federation) asked what would be the result if scientists could be licensed and permitted to publish only one paper and one preliminary report a year?

Dr. R. K. Callow (National Institute for Medical Research) said that the abstractor often finds himself abstracting the same work two or three times; and much of the work coming from some countries is practically worthless. There is a need to return to scientific ethics in ensuring that a paper accepted for publication is really worth publishing. One cannot generalize about the value of conference reports: some of them provide an up-to-date summary of a subject which is extremely useful for those who wish to discover what is going on without the tremendous labour of looking up all the original papers. Dr. C. C. N. Vass (honorary editor *International Abstracts of Biological Sciences*) felt that we are reaching a stage where there is so much printed matter that nobody will read anything. He advised people always to take volume 1 of a new journal, for all the best papers were there. Often it was the only one worth buying, and in any event it would soon be unobtainable. Symposium and conference volumes present a special difficulty for the abstractor, since these may contain a mixture of reviews, original papers and preliminary reports which are very hard to disentangle.

Mr. R. W. David (president of the Publishers' Association) said the problem of too many journals falls into two parts. There is first the problem of scientists writing too much; and this can only be solved by the scientists themselves. They must agree to resist the blandishments of the less scrupulous publishers, who cannot be controlled in any other way. It is natural that publishers should be keen to build up scientific lists, and they may not really be capable of judging quality. The other part of the problem is that even if the scientists agreed to exercise due restraint, there would still be, and increasingly so, more material than can be digested in its present form by those for whom it is written. A revolution in the means of communicating scientific knowledge therefore seems inevitable. This may take many different forms: microfilming to save library space, abstracting, and the compilation of bibliographies to guide the reader to the essential reading. It would be helpful if scientists and publishers could get together to consider the directions in which these developments could most usefully be trained. D. RICHTER

HUMAN GROWTH

THE recently formed Society for the Study of Human Biology holds each year a symposium on some topic bearing on the evolution, ecology or genetics of man, and these annual events bid fair to become of very wide interest. This year the subject was "Human Growth," and seven papers were given, under the chairmanship of the Society's president, Dr. A. C. Stevenson, and its vice-president, Prof. J. Z. Young. The Society's programme secretary, Dr. G. Ainsworth Harrison, who planned the programme, deserves much praise for his skill in so successfully composing the various views of human growth into a synoptic whole. Some points that the speakers made are given below: the full account of the proceedings is to be published this summer (Pergamon Press).

Prof. Adolph Schultz (Zurich) opened the proceedings with a paper on the comparison of changes during growth in man, apes and monkeys. He emphasized the great importance of such comparative growth studies, pointing out that phylogenetic change results primarily from a modification in the inherited plan of growth or development. Thus an understanding of the evolution of the specific characters of man was largely dependent upon knowledge of the ontogeny of these characters among primates. For example, the cranio-vertebral joint was situated farther forward in man than in any other primate or even any other mammal. But this became an exclusively human attribute only during postnatal life, for the fœtuses of all simian primates, in contrast to prosimians and other mammals, were characterized by occipital joints situated far towards the mouth. Post-natally in apes and monkeys the joints were moved backward in position by differential skull growth; but in man this happened to a lesser degree.

In discussing prenatal growth Prof. Schultz showed how in monkeys and man the full-term fœtal head fitted the birth canal precisely, whereas in apes the head was considerably smaller than the pelvic ring. Thus in contrast to the apes, neither monkey nor man could afford to go on growing longer *in utero*. The reasons were probably different, however, for monkeys reached a higher degree of skeletal maturity at birth than apes, and presumably birth waited on this. Man, however, was even less skeletally mature at birth than apes, and in this case it was the great growth of the fœtal head that was the limiting factor.

These skeletal ossification data served well to show how evolution worked through alteration in the relative timing of patterns of growth, for the general sequence of appearance and fusion of ossification centres was similar in all primates; it was the timing in relation to other events of growth that differed. Prof. Schultz left no doubt in the minds of his hearers that longitudinal growth-studies of sub-human primates were a high priority in the investigation of human evolutionary change.

Dr. Wilma Israelsohn (Institute of Child Health, University of London) described some of the modes of analysis of human growth data, taking many of her illustrations from the data of the Harpenden Growth Study, which included a number of children measured by the same anthropometrist every six months over a period of eleven years. Dr. Israelsohn stressed the difference between such longitudinal studies and cross-sectional surveys, and emphasized how statistical methods appropriate to the survey type of data became hopelessly inefficient if applied unaltered to longitudinal records. She described some of the recent attempts to fit useful curves to longitudinal growth data, and said that at least two curves were needed to cover the period from birth to maturity. Up to adolescence the simple formulation, stature (for example) $= a + bt + c \log t$ where t was age, gave surprisingly close fits to the data, and after the adolescent spurt of growth had begun the Gompertz curve, also with three parameters, fitted excellently. More complicated form changes involving not one but several measurements could be followed by the method of transformed co-ordinate grids.

Dr. J. M. Tanner (Institute of Child Health, University of London) discussed the genetics of human growth. Like Prof. Schultz, he stressed how species, and also individual differences in adult morphology, depended on genetically determined differential growth gradients during fœtal and post-natal growth. He quoted data showing that the fundamental control of the rate of development in man was genetical; thus the age of menarche, the first menstrual period, was probably determined in optimal environmental circumstances by many genes of small effect, like stature. Mother–daughter and sister–sister correlations were about 0·4, and the average difference between identical twins in reaching menarche was about 2 months, compared to about a year in sisters. Skeletal maturity appeared to be similarly inherited, as did many of the more intricate details of the growth curves of body measurements. Dr. Tanner described three regional growth gradients as occurring in man, the well-known cephalocaudad one, a distal–proximal one in the limbs, and a second-to-fifth phalanx one in hand and foot. He ended with a brief account of his own and his colleagues' recent work on the skeletal maturity of XXY and XO individuals which, he thought, showed that the retardation of development in the male as compared to the female, seen in all primates and perhaps all mammals, was due to genes on the Y chromosome, possibly closely related to those causing differentiation of the male gonad.

Dr. D. F. Roberts (Department of Human Anatomy, University of Oxford), discussed the effects of race and climate on growth, as exemplified in his studies of tribal African children. At all ages the African children had a lower weight for height than Europeans, and this, Dr. Roberts thought, could not by any means be ascribed simply to lack of nutrition. The degree of weight reduction and linearity of body build was closely associated with the mean annual temperature of the region studied and reached its maximum in the Nilotics. Whether climate exerted a direct effect upon growth, or whether the results came about through racial adaptation to habitat through selection, Dr. Roberts could not say. He stressed the need for more detailed investigations of the growth of children in tropical countries, and for the investigation of children exposed to varying climatic conditions during their growth period.

Dr. Roy Acheson (Guy's Hospital) described the effects of malnutrition and illness on growth. Though some of the social class differences in the height and weight of children and adults might be genetical in origin and due to social stratification and selective social migration, most were due to environmental causes. Studies in the Oxford Child Health Survey of the effect of adverse environment on height and skeletal maturity had convinced him that the former was more affected by illness than the latter, with the probable consequence that some degree of stunting of the adult would occur. The hormonal mechanisms by which this came about were obscure, and invited increased attention; they evidently involved the balance of secretions of growth hormone, adrenal hormones, insulin and thyroid.

Prof. T. McKeown (Department of Social Medicine, University of Birmingham) discussed influences affecting human prenatal growth. It seemed that up to 27 weeks fœtal weight was independent of the number of fœtuses in the uterus, but after that the growth-rate of twins fell below that of singletons. Growth began to be retarded when the weight of the fœtus or fœtuses was about 7 lb., and in singletons from the thirty-sixth week to birth retardation clearly occurred. Whether this maternal effect was due to local uterine factors or to systemic ones was not surely known, nor whether the degree of retardation suffered by the fœtus had any effect in later life. Prof. McKeown thought that the retardation period, that is the last four weeks before birth, was a period of considerable growth difficulty in man, and felt that increased attention should be paid to it, both prophylactically and therapeutically.

Dr. A. W. Boyne (Rowett Research Institute, Aberdeen) discussed some aspects of the well-known secular trend to higher weight and height of children at all ages. He quoted French and Scandanavian data, as well as British, which left no doubt that an increase in final adult height had been occurring as well as an earlier achievement of adolescence and full stature. Some evidence pointed to this increase in adult stature having been greater in the lower socio-economic groups than in those who had always been well fed and well housed. Dr. Boyne discussed the changes in 11-year-old intelligence quotient in some Scottish data, and in particular the increase of girls' intelligence quotient relative to boys' at this age. He suggested this might have the same explanation as a similar increase in sex difference in weight, which was certainly due to the earlier occurrence of the adolescent growth spurt. Though his premise demanded the existence of a growth spurt in intelligence quotient at adolescence, the consensus of opinion was against any such view.

Each of the papers was followed by a lively discussion. These discussions ranged over the manner of man's evolution by differential growth-rates of brain and other parts, the adaptation of different races to different habitats by differential patterns of growth, the occurrence of homeorrhesis in man and the greater stability of growth of the female under stress than that of the hemizygous male, and the relation of growth of the body to the development of mental skills.

A whole day's meeting to discuss human growth would have been unthinkable in Britain even ten years ago, and the Society for the Study of Human Biology is much to be congratulated for furthering the development of this important subject.

J. M. TANNER

THE ROCKEFELLER FOUNDATION

THE President's review, reprinted from the Annual Report, 1958, of the Rockefeller Foundation together with Dr. Warren Weaver's report, "A Quarter Century in the Natural Sciences", records appropriations by the Foundation during the year totalling 31,592,157 dollars, of which 6,274,205 dollars were for agriculture, 6,201,225 dollars for biological and medical research, 4,239,160 dollars for medical education and public health, 4,300,160 dollars for the social sciences, 3,620,582 dollars for the humanities, and 3,266,575 dollars for supporting services. The total included funds for 279 Rockefeller Foundation Fellowships in fifty-one countries for advanced study outside the recipient's own country, and 301 other Fellows continued their work in 1958 through earlier awards. Dean Rusk's general comments are appropriate to the increasing interest in economic and technical assistance to the underdeveloped countries. The expansion of such development programmes has compelled the Rockefeller Foundation to consider carefully where it can make its best contribution, and Dean Rusk maintains that the Foundation's own experience emphasizes the dependance of significant social and economic advance upon trained leadership and the severe limitation of large development programmes by the lack of qualified people. The need for professional competence is likely to be far greater than official development plans usually contemplated, and accordingly the Foundation's most significant contribution is likely to be in the preparation of competent men and women for roles of leadership and, so far as the underdeveloped countries are concerned, in the effective application of existing knowledge to their practical needs, with an emphasis upon fundamental research.

Dean Rusk points out that the 1958 awards bring the total of Foundation fellowships to 8,117, and that scholarships, training grants and other more directly administered training aids may be used where the more formal fellowships would not be appropriate. Grants are also made to permit other organizations to award fellowships and training grants in their special field and to permit other agencies to award fellowships within the recipient's own country. Travel grants totalling about 250 were made in 1958 to permit visits highly relevant to the recipient's plans and professional advancement; financial assistance was also given to key institutions, such as the Paulista School of Medicine in São Paulo, Brazil, which can assume roles of national and regional significance in developing leadership, as well as assistance to libraries, both in books and in the improvement of library techniques, and training within the Foundation's own operating programmes in agriculture and virus research. Among grants in 1958 in support of research highly relevant to development programmes, the President selects for mention those to Cornell University for research on crop yields, to Kyoto University for research on wheat, to the University of Alaska for studies of grasses and legumes, and to the National Research Council for research on foods rich in protein, while he emphasizes that the Foundation's most direct contribution to inter-cultural understanding takes the form of assistance to relevant university work in the humanities and social sciences. He also stresses the Foundation's consistent policy of supporting pioneering work along the growing edges of knowledge and its general policy not to accept responsibility for physical plant. The Foundation also tends now to a policy of broad longer-term support of research projects, although it can do so in only a few selected cases, believing that this is a responsible adjustment to current changes and the need for stabilization and that it leaves decisions about specific research to those most closely concerned. Although in the period 1953–58 just under 65 per cent of the Foundation's expenditure or commitments of 637 million dollars was for institutions, organizations, scientists and scholars in the United States, these funds have often strengthened American institutions from which it has drawn its own staff and in which its Fellows might be trained for increased responsibility. Finally, it is noted that the Foundation continues to draw upon its capital funds to the extent of 5 million dollars a year to do more in Latin America, Africa, the Middle East and Asia than would be possible within its annual income, in view of the crucial importance of these present years for the peoples of these areas.

Dr. Weaver's brilliant survey, which occupies some 115 pages compared with the President's 25, is intended to gave a general account of the state of scientific advance in 1932 as a background to the explanation of the reasons which led the Foundation in 1933 to place major emphasis in its support of science on studies of living things. The bulk of the Report is a summary of the Foundation's subsequent activities under its Programme in Experimental Biology—a survey which covers advances in techniques and instruments as well as in our knowledge of the behaviour and structure of living things. Finally, glancing at the future, Dr. Weaver gives reasons for his belief that we are on the threshold of what should be a new era in biology.

INTERNATIONAL CONTROL OF NARCOTIC DRUGS

SINCE the first international conference on the control of narcotics, which met in 1909 in Shanghai, there has been universal recognition of the importance of preventing the abuse of narcotic drugs. Before the Second World War, the League of Nations undertook the necessary measures for international control of illicit traffic in opium, morphine and other drugs used by addicts. Through its Health Committee, the League also dealt with the medical problems involved in such control. When the League of Nations was dissolved its functions were conferred upon two international organizations: the policy-making and administrative functions were transferred to the United Nations Organization and the specifically medical aspects came within the purview of the World Health Organization.

The World Health Organization advises on the medical aspects of drug addiction and addiction-producing drugs. It is empowered to decide whether a newly discovered product is liable to produce addiction and should therefore be subject to international control. The Organization takes such decisions on the advice of an Expert Committee on the Addiction-Producing Drugs, the activities of which include the examination of drugs suspected of having addiction-producing properties. Since its inception, that is, during the past ten years, the Committee has examined 73 drugs and preparations, 55 of which were found to represent a danger to public health. The proceedings of the Committee, accompanied by statements on special problems raised by drug addiction, have been published in nine reports. It also advises on products which, although not addiction-producing drugs, can readily be converted into them. The same Committee has also given definitions of 'drug addiction' and 'drug habituation', taking into account pharmacological, psychological and public health aspects. These definitions have found world-wide acceptance. Recently, the range of drugs which need continual survey has been increased by the inclusion of hypnotic and tranquillizing, as well as stimulating, agents, although these do not lead to addiction in the strict sense of the definition.

The World Health Organization has also started to take an active interest in the treatment of drug addicts. In 1956 a Study Group on the Treatment and Care of Drug Addicts examined the medical features of drug addiction caused by opium, opiates, morphine-like synthetic drugs and cannabis, and outlined general principles as well as recommending rational methods of treatment and rehabilitation.

The chewing of coca leaves, which is so widespread in many parts of Latin America, and the increasing abuse of *Cannabis* are other important problems dealt with by the World Health Organization, which has decided that both habits represent a considerable danger to public health, and it has suggested the form which international control of these types of addiction should take.

The problem is complicated by the introduction of new therapeutic substances which may have addiction-producing properties and, above all, the continual discovery of new narcotics, mainly synthetic, which are submitted for international control every year. The World Health Organization follows developments very closely and, at the request of the Economic and

R 320

Social Council, has undertaken studies on the chemical structure of synthetic substances with morphine-like effects, the relationship between their chemical structure and their analgesic action, and the relationship between the latter and their liability to produce addiction. The Organization has studied the therapeutic properties and side effects—especially the addiction-producing properties—of 30 drugs of practical importance which have been put on the market as substitutes for morphine and codeine*.

---

* *World Health Organization Chronicle*, 13, No. 12; December 1959.

MARRIAGE-RATE OF AMERICAN COLLEGE GRADUATES

COLLEGE graduates in the United States are now marrying at a much earlier age than their parents. They are having children much sooner, having more children, spacing them much closer together, and seem to be following the general trend of the younger generation by completing their families earlier than their parents.

During 1946–1956, the College Study Group of the Population Reference Bureau, Inc., reported that the fertility of the younger college graduates was higher than that of the graduates of a generation ago (*Population Bulletin*, Vol. 15, No. 6: Fertility of College Graduates, Pp. 101–116 (Washington, D.C.: Population Reference Bureau, Inc., 1959.) 50 cents). Additional results, gathered in 1955, have made it possible to measure the degree of these marriage and fertility differences in two college classes, those graduating in 1930 and in 1945. The average age at first marriage in 1955 in the United States was 23 for men and 20 for women. For the graduate class of 1945, the average age at marriage was 24 years for both sexes and it was 25 years for both sexes for the class of 1930. Ten years after graduation, fewer of the younger graduates remained single: 13 per cent of the men and 10 per cent of the women among the younger graduates, compared with 20 per cent of the men and 27 per cent of the women among the older graduates.

The proportion not married ten years after graduation continued to be higher among graduates of Roman Catholic colleges: 20 per cent of the men and 23 per cent of the women in the class of 1945, compared with 38 per cent of the men and 43 per cent of the women in the class of 1930.

When the survey was taken in 1955, the 10-year women graduates of the class of 1945 who were about mid-way through their family-building years already had a greater average number of children than the 25-year women of the class of 1930, who had reached the end of the reproductive span. The men of both classes were parents of still more children than the women in both groups. Although the younger graduates had babies at a faster rate than the older graduates, their contribution to the post-war rise in the birth-rate was not as great as either high school or grade school graduates. The differential birth-rate which has concerned eugenicists and others still persists. The 10-year women college graduates did not reach their fertility peak until 1952. Once they started having babies, they continued to have them over a longer period of time than other women of their age. These results confirm the belief that a great change in attitudes towards marriage and family has occurred in the United States, even among college graduates.

PLANT POPULATION AND CROP YIELD

By R. HOLLIDAY

Department of Agriculture, University of Leeds

GRAPHICAL examination of the relation between crop yield and the number of plants per unit area suggests that two distinct types of curve may be obtained. One, typified by work by Engledow[1] and Hudson[2] on grain yield in wheat, is approximately parabolic in shape. With this type of curve a certain plant population gives a maximum yield, while greater or less populations give lower yields. Other workers have obtained similar curves in the case of seed, fruit or inflorescence yield with other cereals, maize, sorghum, soya beans, peas, tomatoes, hops and both seed and lint yield in cotton.

Work at Leeds with wheat has given, in the case of straw yield, an increasing yield relation to a maximum but with no sign of yield decrease beyond this maximum up to populations established from 4 cwt. of seed per acre. This relation is referred to below as an asymptotic curve. In contrast, the yield of grain in most years showed a maximum at or about populations established from 1 cwt. of seed per acre. A similar contrast in dry matter yield–plant population curves was obtained with pure sowings of perennial ryegrass[3,4]. In the seeding year, with yield resulting from vegetative growth, the curve was asymptotic up to populations established from 160 lb./acre; in the following year, where yield was a product of reproductive as well as vegetative growth, the curve showed a maximum at or about populations established from 20 lb. of seed per acre. Donald[5] in Australia obtained the same kind of contrast with Wimmera ryegrass and subterranean clover; the seed–yield curve showed a maximum, while the vegetative yield was asymptotic up to populations of 180×10^6 plants per acre in the case of ryegrass experiments.

Although the range of populations covered are sometimes rather limited, references in the literature would suggest that sugar beet, kale, mangolds, fodder beet, tea and timber yields, all of which are products of vegetative growth, show an asymptotic type of yield–plant population relation.

Table 1

Seed rate lb./acre	Plant population at harvest (000's /acre(x))	D.M. yield (tons/acre (Ya))	D.M. yield per plant (tons $\times 10^{-6}$ (Yp))	Reciprocal of yield per plant ($1/Yp$)
1951 2	74	0·274	3 60	0·278
4	198	0·550	2·78	0·360
8	340	0·729	2 14	0·467
16	469	0 853	1 82	0·550
32	918	0·950	1·30	0·770
64	1,530	0·967	0 63	1 590
L.S.D.	178	0 118	—	—
1952 2	174	0·151	1·56	0·641
4	294	0·194	1·18	0·847
8	734	0·377	0 81	1·248
16	1,373	0·485	0·49	2·065
32	1,978	0·592	0·40	2 530
64	3,156	0·586	0 25	4·090
L.S.D.	218	0·112	—	—
1953 2	160	1·14	7·02	0·149
6	338	1·35	4·01	0·266
18	681	1 67	2·69	0·393
54	1,318	1·81	1·48	0·744
L.S.D.	186	0·202	—	—
1954 2	207	1·60	7 61	0·136
6	403	1·69	4·39	0 266
18	811	1·63	2·11	0 514
54	1,671	1·78	1·11	1 005
L.S.D.	126	N.S.	—	—

Several years of work have been carried out at Leeds on the rape crop with populations up to 3×10^{6} plants per acre, with marrow-stemmed and thousand-head kale up to $0·5 \times 10^{6}$ plants per acre and with potatoes up to $3·2 \times 10^{4}$ plants per acre. With each of these crops the dry matter yield has shown an asymptotic relation to populations. In the case of potatoes, this has applied to both top growth and total yield of tuber expressed on either a fresh or dry matter yield basis. The yield of ware-sized tubers, however, gave a curve with an observable maximum in it.

The evidence given above suggests that the parabolic type yield–plant population relation is typical where yield is some product of reproductive growth, while the asymptotic one is more characteristic where yield is a product of vegetative growth. Attempts have been made to analyse the form of the latter type of curve using the four crops mentioned above. Data from four-year experiments with the rape crop (Essex Giant rape) is given in Table 1. In 1951 and 1952 the crop was sown in late July and harvested in October as a 'catch' crop. In 1953 and 1954 it was treated as a full season crop, being sown in April and harvested in October. In the last two years three levels of nitrogenous fertilizer were included as a treatment factor, but as there was no significant interaction between the two factors, the figures given in Table 1 are the main effects of the population treatment. It should be mentioned that in each of the years covered by these experiments soil moisture was not severely limiting, and the same can be said of Donald's work in Australia.

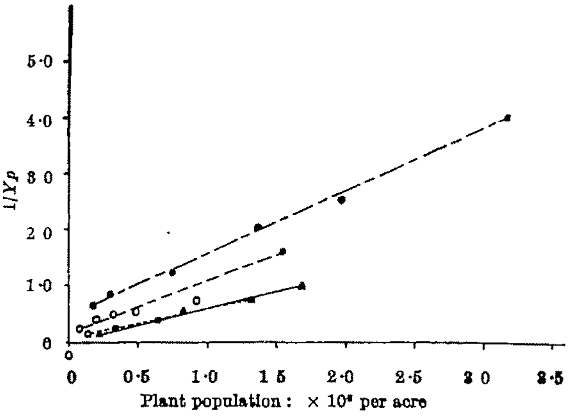


Fig. 1. Variation of $1/Yp$ with plant population (Essex Giant rape). ○, 1951; ●, 1952; ▲, 1953; ⊟, 1954

As yield per unit area (Ya) is a product of the number of plants per unit area (x) and the yield per plant (Yp), an examination of Ya starts logically with a study of Yp. The size of Yp decreases at a diminishing rate with increasing number of plants per unit area. Fig. 1 shows that Yp decreases in such a way that its reciprocal ($1/Yp$) forms a linear relation to plant population (x). Studies with potatoes, marrow-stemmed and thousand-head kale have shown the same feature:

Thus:

$$\frac{1}{Yp} = a + bx$$

Hence
$$Yp = \frac{1}{a + bx} \tag{1}$$

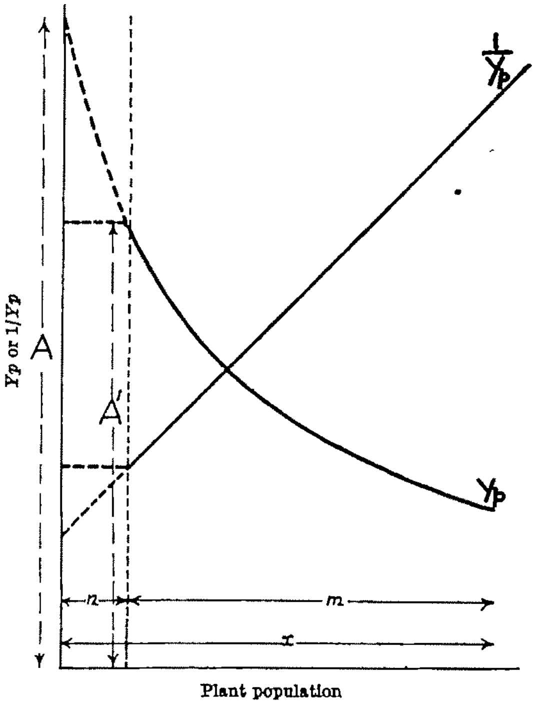
where
$$x = 0\,;\; Yp = \frac{1}{a}$$

Yp at $x = 0$ represents a theoretical situation where there is a complete absence of competition for environmental resources. Thus Yp should be at its maximum possible value. Let this 'apparent' maximum yield of Yp be represented by A and substitute this value for $1/a$ in equation (1), that is:

$$Yp = A \times \frac{1}{1 + Abx} \tag{2}$$

As yield per unit area is the product of yield per plant and the number of plants:

$$Ya = Yp \times x = Ax \times \frac{1}{1 + Abx} \tag{3}$$



Plant population

Fig. 2

Equation (3) describes the form of the asymptotic yield–plant population curve. In it the value A has been termed the 'apparent' maximum yield attainable by the isolated individual plant in the particular environment, because it was obtained by extrapolating the $1/Yp$ regression line to the ordinate. As such, A will be greater than the true maximum yield A'. The latter will apply up to some plant population n, at which plant competition for environment resources just commences. The reduction of yield per plant will thus operate over the remaining plant population $m = (x - n)$ (Fig. 2). The response curve formula may now be re-stated in terms of the true maximum yield per plant A':

$$Ya = (A'n + A'm)\,\frac{1}{1 + A'bm} \qquad (4)$$

or

$$Ya = A'x \,.\, \frac{1}{1 + A'bm}$$

Equation (4) is fundamentally more satisfactory than equation (3). Since n and m are terms which would change with increases in the size of A' through the growing season and hence will be difficult to determine experimentally, equation (3) will probably be of greater utility. This will also mean that the change of slope in the Yp or $1/Yp$ curve in Fig. 2 will be more gradual than is shown. It can be shown, however, that:

$$\frac{A - A'}{AA'} = b\,(x - m) = bn \qquad (5)$$

Thus, n may be determined if in any plant population experiment a treatment is included where plants are grown completely free from competition so that A' may be determined experimentally.

The value $1/(1 + Abx)$ in the simpler or $1/(1 + A'bm)$ in the more complex equation may be appropriately termed the 'competition function', since it shows the way in which Yp decreases with increasing competition for the finite environment resources available per unit area.

It is considered that the equations established above will have several uses in agronomic work. Inter-plant competition within a growing crop represents a relatively simple ecological situation. The treatment given above may, nevertheless, represent a first stage towards studying more complex situations where two or more species are in competition for environment resources.

Acknowledgment is made to Dr. B. L. Welch, reader in statistics, University of Leeds, for help and advice in the latter part of this article.

[1] Engledow, F. L., *J. Agric. Sci.*, 18, 1 (1928).
[2] Hudson, H. G., *J. Agric. Sci.*, 31 (1941).
[3] Holliday, R., *Agric. Progress*, 27, Pt. 2 (1953).
[4] Thompson, W., thesis for M.Sc. degree, Leeds (1956).
[5] Donald, C. M., *Aust. J. Agric. Res.*, 2 (1951); 5 (1954).

THE RESPIRATORY DEAD SPACE OF THE GIRAFFE

By PROF. EUGENE D. ROBIN*, DR. JOSEPH M. CORSON and
PROF. GUSTAVE J. DAMMIN

Departments of Medicine and Pathology, Harvard Medical School, and the Medical Clinics and Department of Pathology of the Peter Bent Brigham Hospital, Boston, Massachusetts

THE physiologist has always been fascinated by the problems inherent in the regulation of circulation and respiration of the giraffe, in which the brain and thorax are so widely separated.

One area of interest to physiologists is the respiratory dead space. The respiratory dead space is composed of all portions of the respiratory tract which are ventilated but do not participate in gas exchange with pulmonary capillary blood. For obvious anatomical reasons, the giraffe is required to ventilate a relatively large dead space. The problem of a large dead space is not unique to the giraffe. Human subjects with severe obstructive emphysema likewise have the problem of ventilating a large respiratory dead space. Unlike the giraffe, the increased dead space of emphysema is not a single anatomical entity. Rather, it consists of those portions of the lung which are relatively poorly perfused with blood for the amount of ventilation they receive.

Recently, the formalin-fixed trachea and lungs of a giraffe became available to us for study. It seemed of interest to make pertinent measurements of the volume of these organs to gain some insight into the mechanisms by which the giraffe solves the problem of a large respiratory dead space. Comparisons could be made with similar measurements in normal humans and patients with emphysema.

(*a*) *Case-history* (*Hi Hat*). The subject was a post-partum giraffe, gravida 1, para 1, which, until death, had lived at the Royal Oak Zoo. She had given birth to a giraffe, but shortly after birth the youngster died. Following the death of her calf, the subject became depressed and anorectic. Three weeks after the calf's death the subject died. (The general consensus of opinion was that *Hi Hat* died of a broken heart; gross and microscopic examination failed to confirm this.)

(*b*) *Dead space volume*. The tracheal volume of the giraffe was estimated by assuming the trachea was a cylinder. The total length and the mean radius were obtained by direct measurements. The volume was calculated by means of the standard formula for the volume of a cylinder, namely, $V = \pi r^2 l$, where V is tracheal volume in ml., r is mean radius in cm., and l is length in cm.

Because the total anatomical dead space includes not only the trachea but also the pharynx, bronchi and bronchioles, the volume obtained in this manner undoubtedly under-estimates the true respiratory dead space of the giraffe. However, the major component of giraffe dead space is made up of trachea, and this volume may be accepted as an approximation to the actual volume of dead space.

(*c*) *Total lung capacity*. The total lung capacity was estimated as follows. The specific gravity of lung tissue throughout the mammalian kingdom appears to be essentially the same. For this reason,

---

[*] Present address: University of Pittsburgh Medical School, Department of Medicine, Pittsburgh 13, Penna.

Table 1. A COMPARISON OF DEAD SPACE VOLUMES; LUNG WEIGHTS; TOTAL LUNG CAPACITIES; AND THE RATIO OF DEAD SPACE/TOTAL LUNG CAPACITY IN A GIRAFFE, A COW, A NORMAL HUMAN, AND A PATIENT WITH OBSTRUCTIVE EMPHYSEMA

	Dead space vol. ml. BTPS	Formalin-fixed weight of lung (gm.)	Total lung capacity L.	Ratio of dead space to total lung capacity
Giraffe	1,600*	6,260	47	0·34
Cow	380†	2,760	21	0·18
Normal adult human	175	800	6	0·29
Patient with obstructive emphysema	350‡		10	0·35

* Tracheal dead space only.

† Marked under-estimate of total dead space since this figure does not include pharyngeal dead space.

‡ Physiological and not anatomical dead space.

a ratio of lung weights is therefore equal to a ratio of lung volumes (assuming no major differences in the elastic properties of the lung).

Adult human lungs were obtained at post-mortem examination. They were fixed in formalin and then weighed. The ratio of the weight of formalin-fixed giraffe lung to the weight of formalin-fixed normal human lung was then obtained. Six litres is an acceptable value of total lung capacity in the normal adult human. By the use of a simple formula, the total lung capacity of the giraffe could be estimated:

$$\text{Total lung capacity of giraffe (litres)} = \frac{\text{Weight of giraffe lung}}{\text{Weight of human lung}} \times 6$$

(*d*) *Subjects for comparison.* Because of the greater mass of the giraffe as compared with man, it is difficult to make direct comparisons of the relative magnitude of dead space to total lung capacity in the two species. For this reason, it seemed important to make similar measurements on the trachea and total lung capacity of the cow. (From the point of view of comparative physiology, a cow may be regarded as a giraffe with a short neck.) The trachea and lungs of a cow were obtained and processed in the same manner that the organs of the giraffe had been.

Values were obtained from a normal human male at post-mortem; and by direct measurement using standard methods[1] in a patient with severe obstructive emphysema.

(*e*) *Gross and histological studies.* Gross examination and dissection were carried out in the usual fashion. Sections were taken from the hilar area and peripheral portions of each lobe. These sections were stained with hæmatoxylin and eosin, and with the Verhoeff–Van Gieson elastic tissue stain.

The results relevant to dead space volume, lung weights and total lung capacity are shown in Table 1. The volume of the dead space in the giraffe is 1,600 ml. This value is approximately nine times greater than the corresponding figure in normal man and approximately 4·5 times greater than the corresponding figure in the subject with obstructive emphysema.

The large dead space in the giraffe is balanced to some extent by the increase in total lung capacity, which is approximately eight times as large as the corresponding figure in normal man. The large total lung capacity of the giraffe does not appear to be simply a function of the size of the giraffe, since the total lung capacity of the giraffe is more than twice that of the cow, an animal which is roughly comparable in its size and organization.

Gross examination of the lungs of the giraffe in this study revealed no significant parenchymal, bronchial or vascular lesions. Microscopically, the alveolar structure of giraffe lung resembled that seen in normal human lung, except that the alveolar walls were thicker and the elastic fibres coarser. There were small foci of fibrosis, some with infiltration of mononuclear cells. Some of the bronchioles contained clusters of mononuclear cells, suggesting a recent inflammatory process. There was no obliteration of pulmonary vascular bed, nor was there obvious alteration in the individual pulmonary vessels. As compared with normal human lung, elastic tissue seemed to be increased in amount. This increase was most conspicuous in the pleura and in the submucosa of bronchi (see Figs. 1*a* and 1*b*). In the pleura, the elastic fibres were closely intermeshed in a thick, carpet-like fashion. For comparison, the microscopic appearance of lung from a patient dying with advanced obstructive emphysema is shown in Fig. 2 (*PBBH A*56-232). The pattern of elastic fibres here shows less density than that seen in the pleura of the normal human lung, in addition to a reduction of elastic fibres in the alveolar walls.

The giraffe apparently uses at least two mechanisms for the maintenance of adequate alveolar ventilation. One mechanism relates to the rate of ventilation. Observations of giraffes while standing quietly reveal

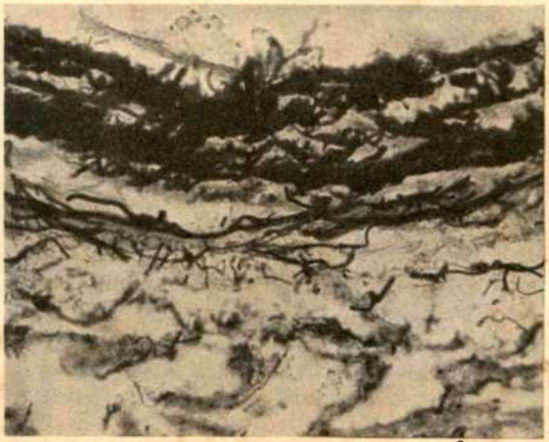


Fig. 1*a*. Giraffe lung with pleura and adjacent alveoli. The upper half of the field is occupied by the pleura with its dense meshwork of coarse elastic fibres (elastic tissue stain; × 230)

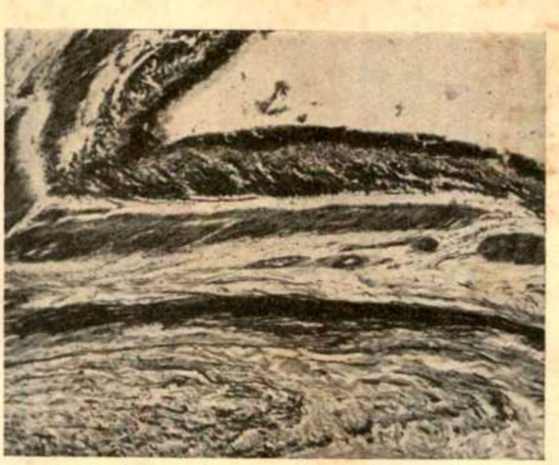


Fig. 1*b*. Giraffe lung. Bronchus with abundance of elastic fibres in the submucosa and deeper in the wall (elastic fibre stain; × 65).

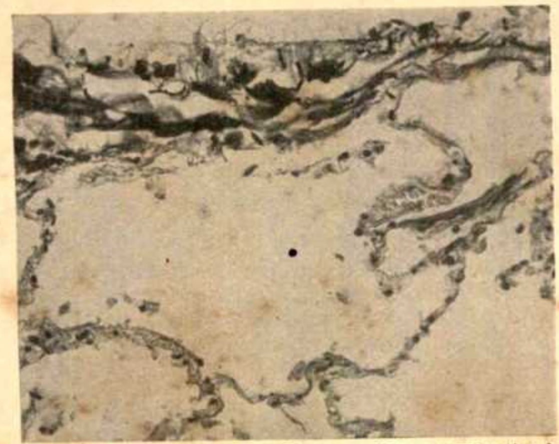


Fig. 2. Human lung with emphysema. Note magnification is same as in Fig. 1*a*. The pleura, at top of field, has elastic fibres in an attenuated pattern, and the adjacent alveolus is abnormally dilated (elastic tissue stain ; × 230)

that the average respiratory rate is 8–10 breaths per min. (personal and unpublished observation of E. D. R. made at the Bronx Zoo). For a given minute–volume, a slow respiratory-rate tends to increase alveolar ventilation, since it reduces the number of times per min. the dead space must be filled with air[2]. The second mechanism relates to the large lung capacity of this animal. It would seem that even considering its mass, the total lung capacity of the giraffe is disproportionately large. In these circumstances, the ventilation of a large dead space could easily be attained.

However, it should be emphasized that a large total lung capacity is not, by itself, adequate to ensure an effective volume of ventilation. The patient with obstructive emphysema may have an increased total lung capacity and still suffer from severe pulmonary insufficiency. The increase in total lung capacity in emphysema is chiefly brought about by an increase in the residual volume of the lung. This increase cannot be used to provide additional ventilation as needed. The increase in the total lung capacity of the giraffe is presumably an increase in inspiratory and expiratory capacity, and thus can serve to supply additional volumes of ventilation as needed.

This fact may be documented in another way. For the purpose of adequate ventilation, the lung volumes must not only be adequate in amount, but also the lung tissue must be functionally and structurally sound. The histological appearance of giraffe lung as shown in Fig. 1*a* shows an apparently normal, but by comparison with man, a very thick pleura with an abundance of heavy elastic fibres. Fig. 1*b* shows not only a heavy meshwork of elastic fibres in the deeper portion of the bronchial wall, but also a similar abundance of elastic fibres in the submucosa. Such a lung would seem to be admirably suited for the extra work that might be required to ventilate a large dead space. In the emphysematous patient (see Fig. 2), the elastic fibre pattern is attenuated and lacking in continuity.

The adequate size of the giraffe lung may also be illustrated by considering the ratio between total lung capacity and tidal volume in the two species. Patterson and Warren[3] have reported that the resting tidal volume of the giraffe is approximately 4 litres/breath. Normal man has a resting tidal volume of approximately 0·6 litre. Therefore, both men and giraffes use approximately one-tenth to one-twelfth of their total lung capacity under basal conditions for the maintenance of adequate ventilation.

We are grateful to the Director of the Royal Oak Zoo, Royal Oak, Michigan, for making the trachea and lungs of *Hi Hat* available for study, and for supplying the details of the clinical history.

This investigation was supported in part by research grants (*H*-2243, *H*-1771) from the National Heart Institute of the National Institutes of Health, Public Health Service, and in part from the Massachusetts Heart Association.

[1] Comroe, J. H., Forster, II, R. E., DuBois, A. B., Briscoe, W. A., and Carlsen, E., "The Lung" (Year Book Publishers, Inc., Chicago, 1955).

[2] Burwell, C. S., Robin, E. D., Whaley, R. D., and Bickelmann, A. G., *Amer. J. Med.*, **21**, 811 (1956).

[3] Patterson, jun., J. L., Warren, J. V., Doyle, J. T., Gauer, O., Keen, T., and Goetz, R. H., *J. Clin. Invest.*, **36**, 919 (1957).

PROTON MAGNETIC RESONANCE IN A SERIES OF DIMETHYL SILOXANE POLYMERS. A SPECIFIC LONG-CHAIN EFFECT?

By DR. J. G. POWLES and A. HARTLAND

Physics Department, Queen Mary College (University of London), Mile End Road, London, E.1

WE have measured the proton magnetic resonance effects in a series of dimethyl siloxane polymers $\{(CH_3)_3SiO[(CH_3)_2SiO]_nSi(CH_3)_3\}$ of various molecular weights, and these results will be discussed in greater detail elsewhere[1]. We feel that the results are of sufficient interest to justify a brief preliminary report, and we shall refer mainly to the measurements on one polymer, a silicone grease (Midland Silicones, *MS* 200, viscosity 10^6 centistokes at 25° C., $n \simeq 2{,}200$).

We have measured the longitudinal and transverse decay of proton magnetization by transient methods[2,3] using equipment described elsewhere[4]. The resonant frequency, ν_r, was 21·5 Mc./s. The longitudinal decay was always exponential within experimental error, and so we give in Fig. 1 the decay constant, T_1. The transverse decay was exponential in the temperature-range below approximately $-42°$ C. (but see below) and is represented by a decay constant, T_2, in Fig. 1. Above $-42°$ C. the decay of transverse magnetization was non-exponential, but it was found it could be represented by a decay of the form $h = h_1 \exp. (-t/T_{21}) + h_2 \exp(-t/T_{22})$ with the values of T_{21}, T_{22} and $h_1/(h_1 + h_2)$ as shown in the graph. In presenting the results in this way, we do not wish to imply necessarily that there are two distinct proton signals.

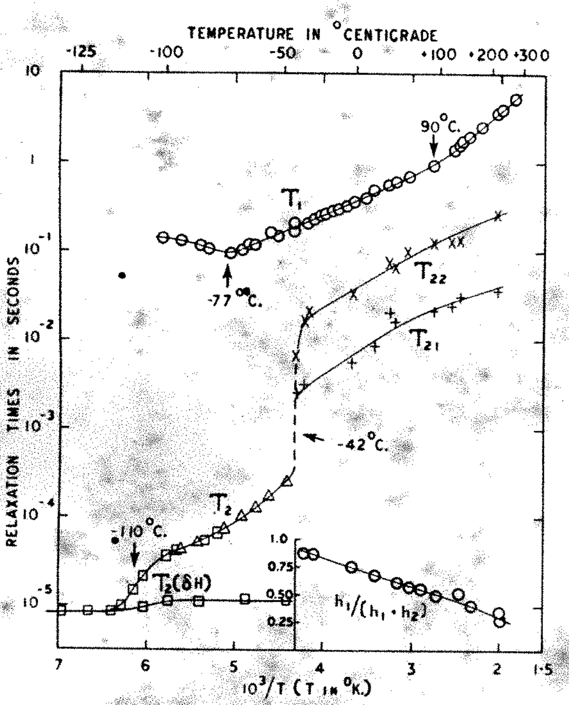


Fig. 1. Proton magnetic resonance relaxation times as a function of temperature for a dimethyl siloxane polymer grease characterized by a viscosity of 10^6 centistokes at 25° C.

The measurements of broad lines were made by Mr. J. A. E. Kail by conventional methods using apparatus which has been described elsewhere[5] and afterwards improved. We give in Fig. 1 the T_2 values for the grease indicated as $T_2(\delta H)$ obtained from the line-width, δH, by the formula $T_2 = \frac{2}{\sqrt{3}}\,\gamma\delta H$. The measurements of broad lines show interesting features, including evidence of crystallinity (approximately 90 per cent at − 90° C.) and of methyl group reorientation even at very low temperatures, and they will be discussed in detail elsewhere[1]. They are similar in outline to those reported for a dimethyl siloxane rubber[6]. It is probable, therefore, that the transient measurements below − 42° C. have failed to reveal the signal from the crystalline phase.

A rather shallow minimum of T_1 of 9×10^{-2} sec. is observed at − 77° C., and on general grounds[7] it is reasonable to deduce that the relevant correlation frequency, ν_c, for motion of the protons is given approximately by $\nu_c = \sqrt{2}.\nu_r = 3 \times 10^7$ c./s. at this temperature. However, we note that the ratio T_1/T_2 at the minimum of T_1 is 1,300, whereas according to theory[7,8], it should be approximately 2. This is an even larger discrepancy than was found in poly*iso*butylene[9], where $(T_1/T_2)_{\min T_1}$ was 100 and contrasts with the theoretical value being found in materials containing smaller molecules[10,11]. This large ratio may be explained as due to a distribution of correlation frequencies or by the effect of multiple interactions which may affect T_1 and T_2 differently at the same temperature. If it is assumed to be due to a distribution of correlation frequencies of uniform intensity on a logarithmic scale in the range ν_G/b to $b\nu_G$[10], then $\nu_G = 3 \times 10^7$ c./s. and b = 1,300, which is a rather wide and unlikely distribution. The actual value of $T_{1\,\min}$ and the variation of T_1 with temperature will be discussed elsewhere[1].

Some motional information can also be obtained from the variation of T_2 near its 'rigid lattice' value using a formula of the type[7] $(T_{2r}/T_2)^2 = \frac{2}{\pi}\tan^{-1}(1/\sqrt{3}\,.\,\pi\nu_c T_2)$, and so we deduce that ν_c (or possibly ν_G) is of the order 3×10^4 c./s. at about − 110° C., both for the amorphous and crystalline regions. The behaviour is evidently complex.

It would now be of interest to compare these values with the values of correlation frequency for dielectric loss (motion of the SiO bonds). The only measurements available to us which might be relevant[12] are not on exactly the same material, but on a silicone grease designated *MS*4 (a dimethyl siloxane polymer of viscosity 500 cs. containing 12 per cent 'Aerosil' and traces of boron compounds; the latter should not affect the results appreciably), in which the dielectric correlation frequency is 4×10^3 c./s. at − 110° C. The agreement with the frequencies predicted from nuclear resonance is not impressive, but the behaviour with temperature is similar. Measurements on the identical material are desirable. We note in passing that the dielectric measurements show only a small distribution of correlation frequencies, if any (Reddish, W., private communication), so that it is unlikely that a broad continuous distribution exists at the higher temperature for the principal motion and so this explanation of $(T_1/T_2)_{\min T_1}$ is less favoured than a multiple interaction explanation if the dielectric results are relevant.

Further information in this region is obtainable from measurement of shear stress relaxation. The only data we have been able to find is on a dimethyl siloxane rubber (polymer cross-linked with 2·5 per cent dibenzylperoxide, no filler) which shows a peak at − 110° C. for a few tens of cycles per sec. (Wolf, K., private communication). The meaning of this measurement may be obscured by crystallization processes occurring as the temperature varied. Another change in mechanical properties near − 42° C. is evidently related to the 'melting' and is not directly a relaxation effect. The interpretation of the measurements in this temperature-range is complicated by the occurrence of the two phases[1].

At a temperature in the region of − 42° C. the character of the transverse decay changes dramatically, but there is no effect at all discernible on T_1. The change-over occurs within a few degrees and is more reminiscent of a first-order phase-change than the behaviour near a glass transition. The change, therefore, corresponds closely to the melting point in materials of low molecular weight[1,12]. It seems likely that crystallization sets in at this temperature but not above (Holmes, D. R., private communication). The transverse decay is not far from exponential just above − 42° C. and is again not far from exponential at the highest temperature (270° C.), with a uniform change-over from the shorter to the longer T_2 value. Even so, T_2 is very much less than T_1 at the highest temperature attained, and there is no sign they are approaching in value, as expected from theory[7,8], and which is, in fact, observed in the lower molecular weight polymers[1], so that a slow interaction still exists. We were unable to get to higher temperatures owing to decomposition of the material. We have also measured the shapes of lines directly, around the transition region, with similar results (we are grateful to Mr. D. J. Neale for making these measurements). Dielectric loss measurements on rather lower molecular weight polymers with n = 0–365 (ref. 13) in the temperature-range + 150° C. to − 35° C. show a loss peak at $2 \cdot 5 \times 10^{10}$ c./s. which is reported to be independent of temperature and molecular weight. This presumably means that, for the present grease, the absorption is in the region of 10^{10} c./s. and varies only slowly with temperature. Evidently more dielectric measurements are desirable, particularly in the region of the transition temperature. Some preliminary measurements of shear stress relaxation at 30° C. (ref. 14) also suggest a ν_c of order 10^{11} c./s. in this temperature region, and in addition a much lower frequency process. The possibility of two processes, one with $\nu_c \gg \nu_r$ and one with $\nu_c < \nu_r$ at 30° C., is in accord with the interpretation of the nuclear resonance measurements given below.

Non-exponential decay of transverse magnetization has been observed also in poly*iso*butylene[9] and in polyethylene[15] under similar conditions. It has been suggested[15] that the two T_2's in polyethylene correspond to two signals from protons in different 'phases'. We find this difficult to understand, particularly in poly*iso*butylene and in silicone polymers at these temperatures. The silicone grease shows no evidence of crystallinity above − 42° C. (Holmes, D. R., private communication), and poly*iso*butylene only crystallizes on stretching. The probability of two distinct phases at higher temperatures, even in polyethylenes, seems rather small. Moreover, we have been unable to find multiple T_1's in this region as expected for more than one phase, although it must be admitted that T_1 values are less sensitive than T_2 values and so multiplicity may not have been resolved. Further, we have found transverse decay requiring to be represented by at least three exponential terms in a dimethyl siloxane polymer gum together with an inexplicable dependence upon temperature[1]. For these reasons, we prefer to regard the absorption line above − 42° C. as a single line with structure, which arises because it is controlled by a weak but slow (that is, $\nu_c < \nu_r$) nuclear dipole interaction. This 'narrow broad' line is only observed when the principal interaction within the methyl groups and between nearby methyl groups has been substantially motionally averaged.

We suggest tentatively that the interaction in question is that between chains, as has already been suggested for poly*iso*butylene[9], and that it may be characteristic of long-chain compounds.

Our measurements (Fig. 2) suggest that the effect appears in dimethyl siloxane polymers of chain-length between approximately 700 and 1,700 atoms[1]. T_1 and T_2 at 25° C. as a function of viscosity at 25° C. are shown in Fig. 2 and there is clearly a change in character at a value of viscosity of about 3,000 cs., that is, a chain-length of about 1,000 atoms. This change is not explicable by viscosity change alone, since the same result is obtained over a wide temperature-range. A somewhat similar situation exists in the polyethylenes[15] in the temperature-range 120–200° C., where multiple T_2's appear at a molecular weight between 5,800 and 9,600, that is, for chain-lengths between 410 and 680 atoms. It is interesting to speculate whether the present results are connected with the viscosity anomaly at approximately 1,000 chain atoms which is observed in the dimethyl siloxane polymers[16] and which is thought to be connected with chain entanglement[17] (we are indebted to Dr. E. R. Howells for this suggestion). It is not known whether molten polyethylenes show a similar effect. However, it is not clear how chain entanglements, as such, explain the present results; they are at first sight more suitable to a 'two-phase' interpretation, though not with the observed relative intensities. The appearance of the nuclear resonance anomaly at a similar chain-length may be because the entanglements affect the motion of all parts of the chains. On the other hand, it may be that the parameters simply become favourable for it at about that chain-length. It will be of interest to search for a similar effect in other polymers in which the temperature can be raised sufficiently without degradation.

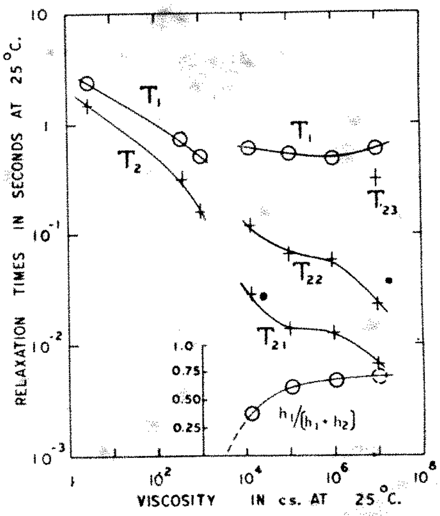


Fig. 2. Proton resonance relaxation times at 25° C. for a series of dimethyl siloxane polymers as a function of molecular weight which is characterized by the flow viscosity at 25° C. Note the abrupt change in character of T_2 in the region of 3,000 centistokes, which corresponds to a chain-length of approximately 1,000 atoms. T_1 also shows an anomaly

The marked change in slope of the T_1-temperature curve at + 90° C. corresponds to no discontinuity in the nature of the transverse relaxation, nor indeed have we been able to find any other physical quantity having an anomaly at this temperature.

We wish to thank Dr. E. R. Howells (Imperial Chemical Industries, Plastics Division) for many helpful discussions and for pointing out the possible relevance of chain entanglement. We also thank Dr. D. R. Holmes for making calorimetric and X-ray tests, Mr. W Reddish for supplying unpublished dielectric measurements, and Dr. K. Wolf (B.A.S.F., Ludwigshafen) for showing us some unpublished mechanical measurements.

[1] Powles, J. G., Hartland, A., and Kail, J. A. E., *Proc. Phys. Soc.* (to be submitted for publication).

[2] Hahn, E. L., *Phys. Rev.*, **80**, 580 (1950).

[3] Carr, H. Y., and Purcell, E. M., *Phys. Rev.*, **94**, 630 (1954).

[4] Luszczynski, K., and Powles, J. G., *J. Sci. Instr.*, **36**, 57 (1959).

[5] Powles, J. G., *Proc. Phys. Soc.*, **69B**, 281 (1956).

[6] Rochow, E. G., and LeClair, H. G., *J. Inorg. and Nuclear Chem.*, **1**, 92 (1955).

[7] Bloembergen, N., Purcell, E. M., and Pound, R. V., *Phys. Rev.*, **73**, 679 (1948).

[8] Kubo, R., and Tomita, K., *J. Phys. Soc., Japan*, **9**, 888 (1954).

[9] Powles, J. G., and Luszczynski, K., *Physica*, **25**, 455 (1959).

[10] Luszczynski, K., and Powles, J. G., *Proc. Phys. Soc.*, **74**, 408 (1959).

[11] Kail, J. A. E., Luszczynski, K., and Powles, J. G., *Proc. Phys. Soc.*, **75**, 243 (1960).

[12] Midland Silicones Technical Data Sheet *Gl* (Oct. 1959), and Reddish, W. (private communication).

[13] Hartshorn, L., Parry, J. V. L., and Rushton, E., *Proc. Inst. Elect. Eng.*, **100**, *IIa*, 23 (1953).

[14] Barlow, A. J., and Lamb, J., *Proc. Roy. Soc.*, A, **253**, 52 (1959).

[15] McCall, D. W., Douglass, D. C., and Anderson, E. W., *J. Chem. Phys.*, **30**, 1272 (1959).

[16] Fox, T. G., Gratch, S., and Loshack, S., in "Rheology", (edit. Eirich, F. R.), **1**, 444 (Academic Press, New York, 1956).

[17] Bueche, F., *J. Chem. Phys.*, **20**, 1959 (1952).

LETTERS TO THE EDITORS

PHYSICS

Action of Graphite as a Lubricant

THE lubricating properties of graphite have considerable practical importance and scientific interest. The explanation often quoted for the mechanism is based on the assumption that the loosely bound graphite layers slide easily over each other like a pack of cards when graphite is used as a lubricant between moving surfaces[1]. In this communication we report briefly on experiments which indicate that a hitherto unconsidered mechanism might be important.

Samples of graphite were prepared for examination by electron microscopy by rubbing a grid on a block of graphite of reactor grade or by dusting peened powder or powder rubbed between glass plates on a grid. Photographs were taken using Philips *EM* 100 or Siemens Elmiskop I microscopes.

In every case, the picture showed a rolling up of sheets of graphite in regions thin enough to be observed by transmission. The sheets formed plain or spiralled rolls of external diameter of $0{\cdot}1$–1μ. Figs. 1 and 2 show typical pictures. On examination, the dark broad lines are seen to be foils which have peeled off from the rest; this is illustrated schematically in Fig. 3. Fig. 4 is a photograph of one roll. The structure of these rolls is similar to that of graphite whiskers[2], which are also composed of rolled-up sheets of layer planes. From our pictures, the thickness of the sheets may be estimated as of the order of 100 planes.

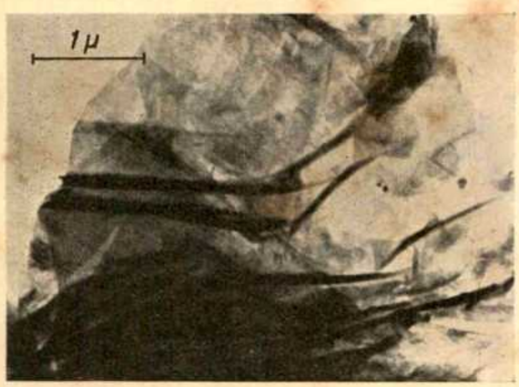


Fig. 1. Complex roller system. × 15,000

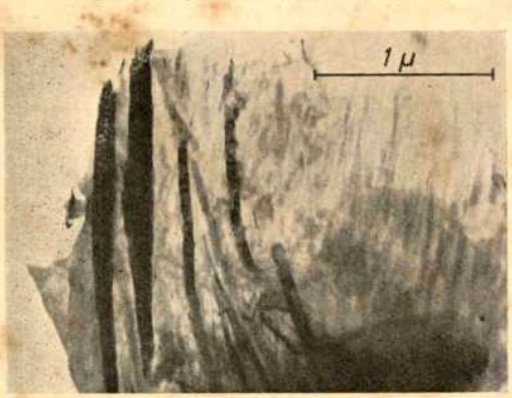


Fig. 2. Parallel rollers near edge of a crystal. × 24,000

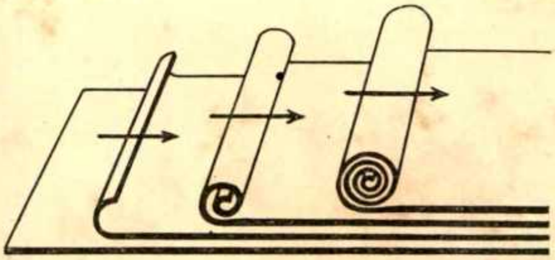


Fig. 3. Schematic illustration of rollers

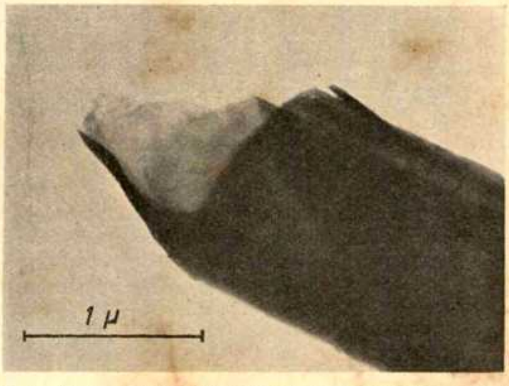


Fig. 4. Photograph showing structure of a large roller. × 24,000

We suggest that the lubricating properties of graphite are due essentially to the rolling up of packets of layers, which then act like roller bearings. Using a roller mechanism, it is possible to reconcile the experimental results of other workers[3], which indicate that: (*a*) a relatively high friction coefficient at room temperature is obtained if graphite is first outgassed at 800° C. *in vacuo*; (*b*) the vapour of water, or ammonia, acetone, etc., must be present for good lubrication at room temperature, whereas in a vacuum or in the presence of a very dry gas the friction coefficient is high and wear is rapid; (*c*) in dry helium at 600° C., wear is negligible.

Given the roller mechanism, the influence of water vapour at room temperature may be understood as a loosening of the interlayer binding forces, first at the edges of crystals and later inside them. (The friction coefficient decreases over a considerable period of time if water vapour is admitted to a previously outgassed sample *in vacuo*.) At high temperatures in dry atmospheres, temperature-loosening might be sufficient. Although Tsuzuku[4] has observed the sliding of graphite planes in small single crystals, it is difficult to imagine the lubrication of graphite in terms of layers slipping over each other for large flakes and polycrystalline arrays. The conventional idea of layer lattice crystals slipping by shear appears unlikely if compared with the roller mechanism in which the layers are pulled apart by breaking successive bonds between them. An explanation of the lubrication in terms of gliding planes would involve the movement of a series of dislocations which would be stopped at grain boundaries or run out at the pores; also such a mechanism would not be expected to show the observed sensitivity to the atmosphere, as dislocations usually tend to be locked by foreign atoms. The roller mechanism would be expected to hold for other layer lattice crystals—we have also observed rollers in molybdenum disulphide.

W. BOLLMANN
J. SPREADBOROUGH

Battelle Memorial Institute,
Geneva.

---

[1] See, for example, Bowden, F. P., and Tabor, D., "The Friction and Lubrication of Solids" (Clarendon Press, Oxford, 1950).

[2] Bacon, R., "Growth and Perfection of Crystals", edit. by Doremus, Roberts and Turnbull (John Wiley, 1958).

[3] Bowden, F. P., Young, J. E., and Rowe, G., *Proc. Roy. Soc.*, A, **212**, 439 (1952). Savage, R. H., *J. App. Phys.*, **19**, 1 (1948). Carter, R. L., quoted by Hove, J. E., *Trans. Met. Soc., Amer. Inst. Met. Eng.*, **212**, 7 (1958).

[4] Tsuzuku, T., Proc. Conf. on Carbon, 433 (Pergamon, 1957).

Effect of Cathode Surface Roughness and Oxidation on Arc Movement

AN arc established between two metal electrodes in the presence of a transverse magnetic field moves in a direction mutually perpendicular to the magnetic field lines and the axis of the arc current. At atmospheric pressure movement is in the Amperian direction but at low pressure it is in the opposite or retrograde sense.

Previous experiments[1,2] have shown that for both Amperian and retrograde motion the seat of arc movement is at the cathode or in the cathode fall region (provided that the cathode spot moves in a regular manner and not by a series of jumps) and therefore it is to be expected that cathode conditions would markedly affect the arc velocity. The effect of different materials has already been reported[1], but up to the present time there appears to be little conclusive evidence relating to the role of surface roughness or oxidation.

Recent experiments, however, have indicated that the degree of surface roughness and oxidation of the cathode influences the arc velocity in a well-defined and reproducible manner. The effect of roughness is illustrated in Fig. 1, which shows the arc velocity as a function of time from arc initiation for two cathodes of the same material but which had been subjected to different surface treatments. Two identical cup-shaped brass electrodes were polished mechanically and one was then etched, yielding a surface which was distinctly rougher than that of the electrode, which had been polished only. The electrodes were used in turn as cathodes with a brass anode in a low-pressure test cell, and opposed coils were arranged to produce a transverse magnetic field across the electrode gap. An arc was allowed to run on each cathode for three minutes in an atmosphere of nitrogen and the velocity was measured during this period. At the end of the time the appearance of the two cathode surfaces was identical. Whereas the initial arc velocities on the two electrodes were greatly different, the final values were almost identical, corresponding to the similarity in the final state of the two surfaces. The characteristic shape of the velocity–time curves is believed to be due to a progressive reduction of the oxide layer on each electrode by the nitrogen gas filling of the test cell.

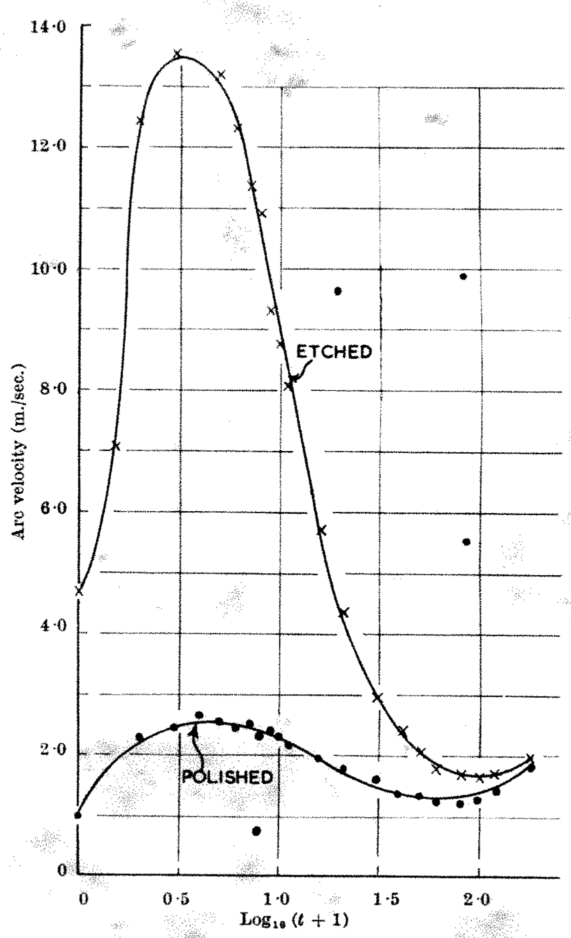


Fig. 1. Arc velocity on etched and non-etched electrodes as a function of time t seconds from arc initiation. Arc current 2·2 amp., magnetic flux density 0·015 Wb./m.^{2}, nitrogen pressure 25 mm. mercury. Inter-electrode gap 2·2 mm.

The effect of cathode oxidation is shown in Fig. 2. Polished cylindrical brass electrodes were etched and then allowed to oxidize in dry air for various times before mounting in a low-pressure test cell, parallel to a polished brass anode. An arc was initiated at one end of the electrode system and its movement along the electrodes under the influence of a transverse magnetic field recorded photographically. Before each arc run the breakdown voltage between the cathode and an auxiliary anode was measured at the Paschen minimum in order to give an indication of the effective work function of the cathode surface[3]. It is seen from Fig. 2 that for tests on electrodes oxidized for 40 min. or less the arc velocity and the effective work function of the cathode are directly related, a decrease of the effective work function corresponding to an increase in the arc velocity. For oxidation times exceeding 40 min. the simple relation is no longer valid, indicating that the effective work function under the conditions of the breakdown voltage tests was not the same as that operative during the arc velocity measurements. This change in effective work function on relatively thick oxide layers may be explained by considering in detail the emission mechanisms for the two cases.

An explanation of the results of experiments on surface roughness and oxidation may be attempted with the aid of a simplified arc model. The cathode 'spot' is believed to consist of a number of emitting sites, electrons from which are accelerated through the fall region and ionize at the base of the arc column. The ions so formed drift to the cathode, but because of the transverse magnetic field they strike the cathode on the Amperian side of the spot. (For modification of this model to account for behaviour at low pressure where retrograde motion occurs, see ref. 4). This ion bombardment ahead of the existing cathode spot conditions suitable sites to take over the arc current when the emission efficiency of the existing sites decreases. Thus arc movement would occur by a series of micro-jumps of the individual sites and the magnitude of the arc velocity should be a function of the ease of conditioning new sites, and of the rate of decay of emission efficiency of the existing sites. It should be pointed out that the mechanism of electron emission from a site at the instant of current transfer to it need not necessarily be the same as that when the site has become established. It is believed that the conditioning of new sites occurs by a process of surface charging due to positive-ion bombardment, which lowers the effective work function, and that at the instant of current transfer a field emission process predominates. Thus a roughening of the cathode surface could lead to localized high-field regions due to asperities and the sites ahead of the existing spot should then require less conditioning. In addition, surface oxide layers which alter the effective work function will also control the emission. The rate of surface charging for various thicknesses of oxide layer cannot be explained simply, and to obtain a realistic picture it is necessary to consider the mode of electron transfer through a semiconductor oxide film with a surface charge of positive ions. It is then possible to explain the shape of the velocity and breakdown voltage curves shown in Fig. 2.

Further experiments on stainless steel, copper and platinum, in air, nitrogen and hydrogen, for both Amperian and retrograde motion, have yielded considerable evidence in support of the mechanism of motion postulated. It is hoped to publish a far more detailed account of these investigations elsewhere.

The considerable contribution of Dr. A. E. Guile to the earlier stages of this work, and his continued advice and encouragement, are gratefully acknowledged. One of us (P. E. S.) wishes to thank the Department of Scientific and Industrial Research for a maintenance allowance and the Institution of Electrical Engineers for the recent award of an I.M.E.A. Scholarship.

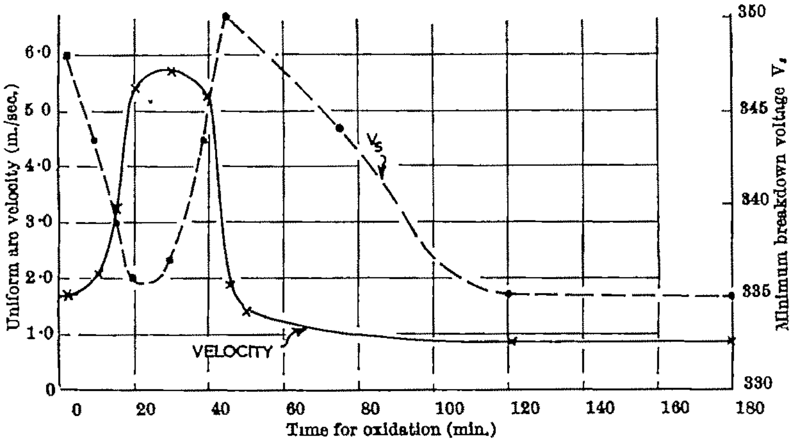


Fig. 2. Variation of uniform arc velocity and minimum breakdown voltage with time of cathode oxidation. Arc current, 70 amp., air pressure, 25 mm. mercury, magnetic flux density, 0·024 Wb./m.^{2}, inter-electrode gap, 6·4 mm.

T. J. Lewis
P. E. Secker

Queen Mary College
(University of London),
London, E.1.

[1] Guile, A. E., Lewis, T. J., and Mehta, S. F., *Brit. J. App. Phys.*, 8, 444 (1957). Secker, P. E., and Guile, A. E., *Proc. Inst. Elec. Eng.*, 106, A, 311 (1959).
[2] St. John, R. M., and Winans, J. G., *Phys. Rev.*, 98, 1664 (1955).
[3] Davies, D. E., and Fitch, R. K., *Brit. J. App. Phys.*, 10, 498 (1959).
[4] Ecker, G., and Muller, K. G., *J. App. Phys.*, 29, 1608 (1958).

Bulk Conductivity in Organic Crystals

One of the basic problems in the study of bulk conductivity phenomena (dark- and photo-conductivity) in organic crystals is the apparent energy deficit in the difference between the ionization energy of the molecule in the crystal and the energy supplied by the exciting radiation. An excellent review of this problem is given by Garrett[1]. All current efforts to resolve this difficulty have been concerned with the energy balances within the crystal, excluding the electrodes, with the goal of explaining how a charge separation is produced inside the crystal.

There is, however, another mechanism for explaining the observed conductivity, and that is to assume that the carriers are produced at the electrodes. This process in organic crystals would be classified mainly as one of hole injection into the adjacent crystal from the electrode. The experimental basis for this picture has been given in a preceding paper[2].

In these experiments an anthracene crystal was provided with electrolyte electrodes. One electrode compartment was filled with 1 *M* sodium iodide solution saturated with iodine, while the other electrode compartment was filled with 1 *M* sodium iodide solution without iodine. The dark current which flowed when the iodine compartment was made electrically positive was 22 times that when the iodine compartment was negative and 80 times the dark current when neither compartment had any iodine. These results were explained by assuming that the iodine extracted an electron from the adjacent anthracene crystal, becoming an I^- ion, thereby injecting a positive hole into the anthracene.

The energy balance for the process of hole injection can be described as follows: I_A is the energy required to take an electron out of solid anthracene, creating a positive hole A^+ (*s*) in the solid and freeing an electron e^- in the gas. If, further, W_E is the energy required to remove an electron from the electrode and E_X the energy externally supplied (optically or thermally), we have the following energy balance for the process of hole injection:

$$W_E + E_X - I_A > 0 \qquad (1)$$

In the same way, one can describe the condition for electron injection into anthracene. If W is the energy freed when an electron is absorbed in anthracene, then the condition for electron injection is:

$$W_A + E_X - W_E > 0 \qquad (2)$$

I_A is given in the literature[1] as about 6 eV.; our estimate is between 5 and 6 eV.

Applying equation (1) to the case of hole injection from an unilluminated I_2 electrode, E_X is small, of the order of thermal energy: W_E is about 6·2 eV., calculated as follows:

$$\mathrm{I(aq)} \rightarrow \mathrm{I}(g) + \sim 0 \text{ eV.}^{4} \qquad (3)$$

$$\mathrm{I}(g) + e^-(g) \rightarrow \mathrm{I}^-(g) + 3{\cdot}2 \text{ eV.} \qquad (4)$$

$$\mathrm{I}^-(g) \rightarrow \mathrm{I(aq)} + 3{\cdot}0 \text{ eV.} \qquad (5)$$

$$\mathrm{I(aq)} + e^- \rightarrow \mathrm{I}^-\mathrm{(aq)} + 6{\cdot}2 \text{ eV.}; \; W_E = 6{\cdot}2 \text{ eV.} \qquad (6)$$

The energy balance is seen to be favourable for the extraction of an electron from the anthracene, and the injection of a positive hole into the anthracene. At the opposite electrode, the process is the discharge of the positive hole, similar to the discharge of an ion at a metal electrode, probably producing free iodine.

When external radiation is absorbed by I_2 (and also I_3^-), its dissociation into iodine atoms is greatly increased[3]; on the above basis, hole injection should also be increased, as is indeed the case[2]. Thus, when 4360 Å. radiation was used, the enhanced dissociation when the iodine electrode was at a positive potential increased the current by a factor of 16,000 over the dark current.

This radiation does not excite the anthracene crystal and need not contribute directly to the electron extraction process. This process of hole injection can occur with any electrode, for which the energy balance is positive as indicated in equation (1). For example, the replacement of I_2 by Ce^{4+} solution produces a large increase in the dark current.

The case where the external radiation is absorbed by anthracene in contact with salt solutions containing no iodine produces hole injection in a similar way. It is assumed that when the exciting radiation is absorbed (3650 Å.), excitons are produced. Most excitons are found near the illuminated electrode, frequently colliding with the electrode. During a collision, the injection of positive holes is possible if equation (1) is satisfied.

The energy balance at the electrode in contact with the excited anthracene (A^*) surface is:

$$A^*(s) \rightarrow A(s) + E_X; \; E_X = 3{\cdot}3 \text{ eV.} \qquad (7)$$

$$e^-(g) + \mathrm{H_2O(aq)} \rightarrow \mathrm{H_2O^-(aq)} + W_E; \; W_E = 3{\cdot}8 \text{ eV.} \qquad (8)$$

If these values are placed in equation (1), using a value of 5·5 eV. for I_A, there is an excess in energy of about 1·5 eV. for the injection of a positive hole into the anthracene.

Step (8) involves the capture of an electron by a water molecule[4]. The resulting ion is unstable and will dissociate, probably forming hydrogen and hydroxyl. At the opposite electrode, the discharge of the positive hole is accomplished as at an ordinary electrode.

The major influence of the positive electrode on the bulk conductivity is further indicated by the comparison of the electrode efficiencies of Cl^- and I^- solutions[5]. The replacement of Cl^- by I^- decreases the positive current flowing away from the adjacent anthracene surface by a factor of 13. This reduction clearly indicates that most of the current is produced at the electrode adjacent to the excited region of the crystal.

Some conclusions may also be drawn about the nature of the current ($i-$) which flows when the illuminated side of the crystal is at a negative potential. The injection of negative carriers into the anthracene is probably also energetically feasible, but apparently this process is not probable ($i-$ is small). This may be due to the low mobility of the electron in anthracene. Our results, moreover, lead to the conclusion that most of this negative current is actually due to the interaction of fluorescent light with the electrode–anthracene surface not directly illuminated by the incident light. This interaction produces positive holes which then flow to the negative electrode.

This conclusion is based on the following observations: the magnitude of $i-$ is markedly affected by the nature of the electrode distant from the light, and in the same way that the positive current is affected; the $i-$ has almost the same dependence on the exciting light intensity as the positive current; both negative and positive currents are saturated at about the same voltage, although at greatly different currents. The latter result cannot be explained by assuming the formation of an internal space charge, since in this case an increase of the field would cause a large increase in the photocurrent; this does not occur.

The existence of a true negative current within the anthracene is, however, not excluded. Internal polarization experiments by M. Silver[6] and M. Pope[7] on polycrystalline layers and single crystals, respectively, of anthracene can best be explained by assuming the existence of trapped negative charge within the crystal. No equivalent positive charge distribution was ever observed. These results, in conjunction with those on photoconductivity, show that the true negative current carried by electrons exists but is exceedingly small.

Most dark currents differ in behaviour from the conductivity described in this communication. They do not become saturated, as do the photocurrents and the dark currents with I_2 electrodes, and they also do not depend on the nature of the electrode.

For the normal dark current, the criterion for positive hole injection would be satisfied if the difference between W_E and A_A can be supplied by thermal action. The extent to which this occurs is as yet unknown.

These considerations do not exclude the possibility of hole and electron production within the anthracene itself by some process of charge separation. Internal polarization experiments indeed indicate that charges are also produced inside the crystal to some extent. However, the findings of this communication show that charge injection can easily occur and is frequently responsible for the large currents observed. For organic materials other than anthracene, calculations also show the possibility of hole injection.

Grateful acknowledgment is made of the assistance of the Office of Naval Research (*NONR* 285(41)) in this work and of the Air Force Cambridge Research Center, Contract *AF* 19 (604)-3888.

H. KALLMANN
M. POPE

Washington Square College of Arts and Science,
New York University,
New York, 3.
Jan. 15.

[1] Garrett, C. G. B., in "Semiconductors", Hannay, N. B., 634 (Reinhold Pub. Co., 1959).

[2] Kallmann, H., and Pope, M., *J. Chem. Phys.*, 32, 300 (1960).

[3] Kistiakowsky, G. B., "Photochemical Processes", 64 (Chemical Catalog Co., 1928).

[4] Pauling, L., *Phys. Rev.*, 34, 954 (1929).

[5] Kallmann, H., and Pope, M., *Nature*, [185, 753 (1960)].

[6] Silver, M., Ph.D. thesis, New York University (1959).

[7] Kallmann, H., and Pope, M. (unpublished results).

CRYSTALLOGRAPHY

Growth of Single Crystals of Copper

DURING experiments on the effects of alternating deformation on the hardening of single crystals of spectrographically pure copper[1], difficulties were experienced in obtaining reproducible hardening behaviour under the same conditions of alternating straining from 2-cm. long specimens taken from opposite ends of longer crystals. A brief discussion of experiments made to investigate this disparity follows.

The method of crystal growth described by Andrade and Roscoe[2] did not yield a long coherent length of crystal, and growth experiments were therefore confined to a Bridgman-type apparatus[3] inclined about 25° from the vertical. Moulds were prepared from spectrographically pure graphite rod by drilling a 1·6-mm. diameter hole, which was then reamed to a slight taper (1 : 3,000); the reaming also provided a smoother bore. Moulds were baked *in vacuo* before use.

Crystals 25 cm. long could be readily grown using a rate of furnace travel of 3·8 cm./hr., but they were firmly stuck in the moulds at the lower end, due to impregnation of the graphite with copper to a depth of about 0·5 mm. Shorter crystals 14 cm. long were then grown, and these could be removed from the moulds by tapping. However, the yield stress and the initial rate of hardening of a specimen taken from the lower end of a crystal orientated for easy glide were both about three times larger than for a specimen from the top end; the yield stress for the upper specimen was usually about 27 gm./mm.^{2}.

The orientation difference between upper and lower specimens was not obviously greater than the error of orientation determination by the Laue method used[4]. Moreover, spectrographic analysis showed that there was no significant difference in analysis between the two ends of the crystal.

Crystals 10 cm. long were then prepared, and were perfectly free in the moulds. Specimens taken from each end of a crystal gave yield stresses and hardening curves which agreed to within 10 per cent between themselves and with those of the upper specimens of 14 cm. crystals. Further reduction in crystal length did not improve this variability, which was attributed to minor variations in lineage structure (cf. Diehl[5]).

The disparity in results obtained from longer crystals appears to be due to impregnation by molten copper of the porous graphite moulds, resulting in deformation during removal of crystals from the moulds. The extent of impregnation decreases as crystal length decreases, and becomes insignificant in crystals 10 cm. long or less. The effect of the accidental deformation on hardening behaviour is more apparent in alternating straining than in unidirectional testing, since the length of the easy glide region is greater and the rate of hardening is lower[1,6].

This work was carried out at the Australian National University during secondment from the Aeronautical Research Laboratories, Department of Supply, Melbourne. Acknowledgment is made to the Chief Scientist, Department of Supply, for permission to publish this communication.

D. S. KEMSLEY*

The Queen's College,
Oxford.

* Formerly, Department of Geophysics, Australian Nationa University, Canberra.

[1] Kemsley, D. S., and Paterson, M. S., *Acta Met.* (in the press).

[2] Andrade, E. N. da C., and Roscoe, R., *Proc. Phys. Soc.*, 49, 152 (1937).

[3] Bridgman, P. W., *Proc. Amer. Acad. Arts Sci.*, 58, 165 (1923).

[4] Greninger, A. B., *Trans. Amer. Inst. Min. Met. Eng.*, 117, 61 (1935).

[5] Diehl, J., *Z. Metallkunde*, 47, 411 (1956).

[6] Paterson, M. S., *Acta Met.*, 3, 491 (1955).

GEOPHYSICS

Motion of Geomagnetic Field Lines

PRIMARY auroral particles, from the Van Allen radiation belt or interplanetary space, travel down to the upper atmosphere along lines of force of the geomagnetic field. Hence they strike the atmosphere in regions which move with the field lines when these are distorted. The purpose of this communication is to show that this motion of the impact regions can only be very slow, because the high conductivity of the Earth's interior limits the field distortion. This throws serious doubt on the hypothesis of Rees and Reid[1] that a diurnal motion of auroral hydrogen emission through many degrees of latitude may be explained by distortions of the Earth's field. Rees and Reid's theory considers particles from the radiation belt, the orbits of which drift in longitude. Using Alfvén's perturbation method[2], it may be shown that the drifting orbits of this model pass through the same magnetic field lines on each circuit of the Earth and so follow the motion of these lines.

The distortion involved is the horizontal displacement of a force-line at auroral altitudes, say 100 km. For, however distorted the lines at greater heights, this is the displacement of the primary particles where they are observed. The Earth's conductivity may be taken[3] as negligible to 700 km. depth, and as more than 10^{-11} e.m.u. below 800 km. For a period of one day, this latter conductivity gives a skin-depth of 150 km. Thus the displacement of the field lines may be approximated by that for an Earth non-conducting to about 900 km. depth, with an infinitely conducting core below. The lines are immobile in the core, and their displacement in the first 1,000 km. height above that is required.

To maximize the displacement, the magnetic disturbance field is assumed perpendicular to the average or undisturbed field. Consider first the case where the disturbance at all levels equals its value measured at the surface ; this implies a very extensive current source in the ionosphere. In this case it can be shown that the displacement of a field line, in the auroral zone, at 1,000 km. above the conducting core, is about 0·015 Δ km., where Δ is the disturbance in γ (10^{-5} gauss) units.

In the case of more localized ionospheric currents Δ increases with altitude, and the overall effect of this, for a given surface value of the disturbance, is to give a smaller displacement than that above. Consider an overhead cylindrical current causing the disturbance. Then Δ is (A/d), d being distance from the current and A a constant. Therefore, Δ is less than (A/h) where h is the vertical component of d. Taking Δ as (A/h) the desired displacement of a line in 1,000 km. height can readily be found, and it increases slowly as the current diameter is reduced. For a current of diameter greater than about 0·1 km. the calculated displacement is less than the 0·015 Δ km. found before. But for such small diameters, replacing (A/d) by (A/h) causes a gross overestimate of the displacement ; and furthermore, ionospheric currents have a much larger scale than 0·1 km. Adding the disturbance due to the induced current in the core does not alter this result.

Thus the displacement of 0·015 Δ km. (Δ in γ) is an upper limit to the movement of auroral phenomena due to field distortion. This distance is very small. It equals 50 km. (almost ½° of latitude) only if Δ has the extreme value of 3,300γ ; while if Δ is less than 1,300γ, as in most magnetic storms when the K index does not exceed 7, the displacement is less than 20 km. Only by very slow changes, such as those with the period of the sunspot cycle, can the lines of force be moved through great distances at low altitudes.

Observations of the radiation points of auroral coronæ[4] show that the displacements of the field lines between the Earth's surface and the auroræ are well within the limits expected from the foregoing.

This work is part of the research programme of the Dominion Physical Laboratory Auroral Station, of the New Zealand Department of Scientific and Industrial Research.

C. J. LOUGHNAN

Dominion Physical Laboratory Auroral Station,
Awarua Radio, Invercargill,
New Zealand.
Feb. 3.

---

[1] Rees, M. H., and Reid, G. C., *Nature*, **184**, 539 (1959).

[2] Alfvén, H., "Cosmical Electrodynamics", Chapter 2 (Oxford, 1950).

[3] Lahiri, B. N., and Price, A. T., *Phil. Trans. Roy. Soc.*, A, **237**, 509 (1939).

[4] Abbott, W. N., *Canad. J. Phys.*, **36**, 643 (1958).

GEOCHEMISTRY

High-pressure Phase Transformations in Laboratory Mechanical Mixers and Mortars

THE mechanical action of simple laboratory grinders, mortars and similar devices has occasionally been used to assist in chemical reactions in addition to performing their primary physical functions. Among these chemical reactions are phase transformations. That the effect is due to some kind of a pressure component in the mechanical action may appear obvious, but the magnitude of the pressures is not readily appreciated, nor can it be calculated or measured. However, in the course of work in this laboratory on the high-pressure polymorphism of lead dioxide (PbO_2), the information that a phase identical with the new high-pressure polymorph, which had been shown to be stable only in the region above 10,000 bars, had been formed by simple grinding[1] was noted with no little surprise. The observation was promptly confirmed by grinding a small amount (2 gm.) of the common rutile form (I) of lead dioxide in a mechanical mortar and pestle combination of laboratory pattern. Grinding in air for a few hours converted an estimated one-third to the denser orthorhombic form (II). After preliminary work, it transpired that nothing new in principle had been added to some similar results which had been reported by Burns and Bredig[2] on the transformation of calcite to aragonite by grinding in a mortar. The high-pressure phase was formed from the low-pressure one, the amount of change was dependent on time, and subsequent heating would form the low-pressure phase. A significant difference is that phase equilibrium and thermochemical studies[3] place the calcite–aragonite transformation at about 3,000 bars at room temperature, which is considerably lower than the 10,000 bars necessary for the lead oxide $\mathrm{I} \rightleftharpoons \mathrm{II}$ transformation.

The obvious question that arises is whether or not the high-pressure types are actually being formed in their field of stability, or whether the shearing stresses so dominant in such an environment either alter the relative free-energy relations of the two forms or permit metastable nucleation of the high-pressure phase. Therefore, other substances with known p–t relationships between polymorphs (work in this laboratory, with L. Azzaria and W. B. White) were chosen for further study : MnF_2, BeF_2, SiO_2, PbO, Sb_2O_3, B_2O_3 and $BAsO_4$. Their transition pressures at room temperature (extrapolated from our equilibrium data obtained at higher temperatures) are near 9,500, 15,500, 13,500, 5,500, 10,000, 18,500 and 30,000 bars respectively. It was found that grinding for several hours in the mortar assembly under air or nitrogen (where oxidation was a possibility) would produce varying amounts (as determined in every case by X-ray diffraction) of the high-pressure phases of PbO, PbO_2, $CaCO_3$, MnF_2, Sb_2O_3 and BeF_2 (questionable) in decreasing order. Also of new but related interest is our finding that the 'quenchable' transitions in calcium carbonate and lead dioxide and in many other selected phases could be effected (partially), in a few minutes to 2 hr., by the action of a small rapidly vibrating mixer-grinder. The type used (trade name 'Wig-L-Bug') is common in spectroscopic laboratories and was used with a metal vial and ball and 50–100 mgm. of sample. Furthermore, it was found that the same (*vide supra*) relative effectiveness in forming detectable amounts of the high-pressure phases was evident in the action of the 'Wig-L-Bug'. Of the highest-pressure phase, BeF_2 (cœsite), only a trace was formed. Making allowances for the very sluggish nature of the quartz-cœsite transition of silica and the more complex relation[4] and serious hydration problem in the new high-pressure B_2O_3 polymorph, it appears that pressures in the region of 10–20,000 bars are being

(*Continued on p.* 71)

Supplement to NATURE

No. 4718 APRIL 2, 1960 Vol. 186

MEDICINE IN SHAKESPEARE'S WRITINGS

Shakespeare and Medicine

By R. R. Simpson. Pp. vii+267. (Edinburgh and London: E. and S. Livingstone, Ltd., 1959.) 25*s*. net.

According to Chambers's bibliography on authorities on books on Shakespeare, comprising some 450 volumes, only one deals with the medical aspect of Shakespeare's writings, that by Dr. John Bucknill, which appeared just a century ago. The present book by Mr. Simpson is therefore opportune. It is based on lectures to various medical societies and its object is "to record the medical references in the plays and poems, to assess Shakespeare's knowledge of the medicine of his day, to consider the uses to which he put it and to discuss some of the possible sources of his medical knowledge". Although the study was undertaken primarily from the medical point of view, it should be of interest to the literary reader even though it makes no purely literary contributions. Any fresh study of Shakespeare is of interest and value.

The author has collected more than seven hundred medical references, major and minor, and classifies them under twenty pertinent headings. The discussion of these entails some overlap and consequent repetition which detracts from the interest if the book is read as a whole. This drawback would not appear if various sections were used for reference or for lectures.

Mr. Simpson emphasizes that Shakespeare often uses a medical image to illustrate a point, or a medical situation at a moment of dramatic intensity. Among notable passages he recalls is the brilliant description of death in the typhoid state as it befalls Falstaff in "Henry V". Also the quite remarkable description of tertiary syphilis in "Timon of Athens", IV, 3.

It is not possible to say whether Shakespeare was acquainted with the literature of contemporary Elizabethan medicine, but that he was certainly aware of current medical thought is evident from numerous quoted passages. This inevitably leads to the question of how much Shakespeare learned from and was influenced by Dr. John Hall, the physician who married his daughter and who lived and practised in Stratford. In an interesting chapter on this subject, Mr. Simpson proves quite definitely from a chart giving the plays in their chronological order and the numbers of medical references in each that any influence must have been slight. Hall did not enter Shakespeare's life until 1600, and up to that year the plays contain 215 major medical references; after 1600 there are 225.

Shakespeare's references to almost all aspects of human activity and life are so rich and so strikingly apt that one could make a fair comparison with almost any important profession or calling just as with medicine, and this would not necessarily imply he had special connexions. His genius enabled him to embrace so much with clarity, ease and conviction.

Any doctor with literary interests will profit by reading this book. Any non-medical student of Shakespeare should be familiar with its presentation of an important aspect of the plays and poems. It is a good reference book for the doctor and a useful bedside book also.

RUSSELL BROCK

THE ROYAL COLLEGE OF SURGEONS OF ENGLAND

The Royal College of Surgeons of England

A History. By Sir Zachary Cope. Pp. xii+360+78 figures. (London: Anthony Blond, Ltd., 1959.) 63*s*.

Since his retirement from active surgery, Sir Zachary Cope has become a well-known and trusted public servant. He has also produced a series of learned writings on the history of his own profession, not the least of which is the surgical record of the Second World War. In all these works he has shown good sense, good temper and good judgment. Here he displays these qualities towards a famous corporation of which he has long been a prominent member. Its story is by no means one of continual progress nor always even wholly edifying, yet he makes no attempt to cover the bad patches. But the record has had a happy development in the last generation under the guidance of men of temperament comparable to that of the author himself.

It must be remembered that until about a hundred years ago, in England—and in England alone of the Western countries not excluding Scotland and Ireland—serious instruction in the practice of medicine was not held to be any part of the duty of our ancient universities. These had, of course, nominal professors of medicine, of anatomy, and of other para-medical subjects, but their teaching—so far as it existed—was of book-learning and not on practical lines. By this time certain of the 'new universities' were giving medical degrees. But before the rise of the new universities, almost the usual way to become an effective practitioner was through apprenticeship to a surgeon with the view of becoming a Member of the Royal College of Surgeons of London. This body was instituted as such in 1800. To it were consigned, by Act of Parliament, the magnificent collections of John Hunter.

The College thus constituted had a very defective constitution. Its Council was self-elected and elected for life. It thus came to consist largely of aged and often eccentric men, though it also contained some of the highest eminence. This Council acted as examiners, and the examination was entirely oral. There was not even a syllabus for several decades. The result of all this was that the process became a rather sour joke. Mr. Bob Sawyer and Mr. Benjamin Allen must have been fairly average students of those bad old days. The process of transforming the type of student began when the Society of Apothecaries, in 1815, succeeded in becoming incorporated and introducing a reasonable examination of its own. About this time the term 'general practitioner' was introduced. The best qualification for such men was membership of the Royal College of Surgeons and licentiate of the Society of Apothecaries (M.R.C.S., L.S.A.). The weakest point in the curriculum was inadequate attention to what is now called 'internal medicine'. Yet such are the delaying possibilities of institutions that it was not until 1885 that the Royal College of Physicians joined the Royal College of Surgeons in establishing a 'Conjoint Board', the diploma of which (M.R.C.S., L.R.C.P.) covered all aspects of general practice. This became the standard qualification of such gentlemen until the beginning of the present century.

The major operations of surgery were naturally always undertaken mainly by a special class, usually attached to teaching hospitals. The status both of these and of the College itself was raised by a charter of 1843 under which certain Members of the College became Fellows. This distinction was conferred from 1844 onward by a special examination, and the diploma F.R.C.S. remains evidence of high competence in the art and was almost necessary for the coveted 'honorary' surgical appointments at the larger hospitals. These Fellows themselves elected the Council, membership of which became, in itself, a high professional distinction.

In the early twentieth century it looked as though the medical degrees of the new universities might take the place of the diplomas of the Conjoint Board, and this process is continuing. But under the wise and genial leadership of the late Lord Webb-Johnson, who presided over the College of Surgeons from 1941 until 1948, that institution was transformed from being mainly a diploma-granting body into one of higher surgical education. It has since attracted great numbers of students, especially of those who seek the diploma of F.R.C.S., and has become the chief place in Britain and, indeed, of the Commonwealth, for the training of such men. Thus the functions of the College have become largely, if not mainly, changed almost beyond recognition.

Sir Zachary's account of the College is supplemented by one of its great library by its librarian, Mr. W. R. LeFanu, and of John Hunter's Museum by its anatomical curator, Miss Jessie Dobson, who knows more about that institution than anyone living. The importance of the Hunterian Museum can be judged by recalling that its staff has included Richard Owen, Arthur Keith, Frederick Wood Jones and many other great men of science. Sir Zachary has provided a readable and often amusing account of a great and characteristic national institution.

CHARLES SINGER

EARLY SCIENCE IN CHINA

Science and Civilization in China

By Dr. Joseph Needham, with the collaboration of Dr. Wang Ling. Vol. 3: Mathematics and the Sciences of the Heavens and the Earth. Pp. xlvii + 877 + plates 21–95. (Cambridge: At the University Press, 1959.) 150*s*. net.

THE first two volumes of this monumental work introduced the reader to the intellectual background of scientific thought in China from the earliest times to, roughly, the Newtonian era; in this third volume Dr. Needham discusses in great detail the beginnings and developments of Chinese mathematics and natural science within the same temporal span. To many students of the history and philosophy of science, this volume will be a revelation of the achievements of a civilization isolated almost entirely from Western and other Eastern influences until the arrival of Jesuit missionaries at the end of the sixteenth century. For this immense and astonishing work of erudition no praise can be too high; the author has an impressive knowledge of Chinese culture to add to his eminence in the field of natural science; and so we have a volume authoritative, fascinating and illuminating, sure in the unravelling of the complexities of the evidence, and with a shrewd appraisal, on appropriate occasions, of contemporary Eastern and Western progress in the sciences.

First and briefly as to the section on mathematics. Dr. Needham points out that, whereas Greek mathematics was deductive in character, particularly in geometry, the Chinese approach was mainly arithmetical and algebraic in essence and concerned to a large extent with utilitarian problems in mensuration, the calendar and so on. It is not surprising that, handicapped as they were by an unwieldy notation, the Chinese were unable to develop purely algebraic—as distinct from arithmetical—methods in dealing with such problems as the solution of quadratic and cubic equations and the method of finite differences. But, within these limitations, their progress was anything but negligible, however uninterested as they apparently were in abstract inquiries.

The longest section of the book is on astronomy; here the story is different, and a complete refutation of the dogmatic and ill-informed statement of Whewell, the famous Master of Trinity, who declared a little more than a century ago that: "We find no single observation, or fact, connected with astronomy in the Chinese histories, and their astronomy has never advanced beyond a very rude and imperfect condition". A substantially similar statement appears in a very recent "History of Astronomy". The fact is that, as Needham says and as is borne out by the evidence, the Chinese were the most persistent and accurate observers of celestial phenomena anywhere in the world. It is noteworthy that for several centuries before the tenth century A.D. the Chinese astronomical records are the only ones available; again, Laplace paid considerable attention to the ancient and medieval determinations of the obliquity of the ecliptic—the oldest going back several centuries B.C.—in his researches on the secular changes in the obliquity.

Chinese astronomy differed in one marked respect from Greek astronomy. In the latter, the ecliptic was the fundamental plane, for the main interest centred on the positions and movements of the Sun, Moon and planets, the stars being relegated to a hypothetical crystalline sphere. The Chinese, on the other hand, adopted the celestial equator as the fundamental plane for their observations, particularly of circumpolar stars; from this followed two important advances in instrumental design. First, the invention of the equatorial mounting applied to such instruments as the armillary sphere, and second—and most remarkable—the invention in A.D. 132 of the clock-drive, when an armillary sphere was rotated by means of a water-wheel controlled by a clepsydra or water-clock. Against this, the choice of the equatorial system of co-ordinates—and most of all, the non-deductive character of their mathematics—militated against any real progress being made in the understanding of planetary motions.

Large number of eclipses were recorded in Chinese annals from 720 B.C. onwards, and the dates of many of these have been corroborated in recent times, to the great advantage of modern studies.

We owe to Chinese (and Japanese) astronomers the recording of the first super-nova (now identified with the Crab Nebula) which, at its brightest was visible in daylight. Novæ, the earliest of which was observed about 1300 B.C., were described as 'guest-stars' and as such were believed to show the approval of the heavens for the dynasty in power.

Bare mention can only be made of the observations of sunspots, comets, meteors and meteorites, variable stars and, in the final sections of the book, to the study of meteorological phenomena, cartography, seismology (including the earliest known form of seismograph), palæontology and mineralogy.

In conclusion, one can only refer in a word to the magnificent photographs which lavishly adorn the book.

W. M. SMART

HERBERT SPENCERISM

The Integration of Human Knowledge

A Study of the Formal Foundations and the Social Implications of Unified Science. By Prof. Oliver L. Reiser. Pp. xvi+478. (Boston, Mass.: Porter Sargent Publisher, 1958.) 8 dollars.

HERBERT SPENCERISM is the persistent and mistaken idea that apart from particular scientific investigations for particular purposes there is yet another subject, a super-science, which consists in doing something with the results of these special investigations. Reiser wants to have colleges of integration, staffed by people doing this. The trouble is that it is never made clear what they would be doing. Scientists investigate definite hypotheses, but what would super-scientists do? Would they produce and synthesize abstracts all day, and if they did, what exactly would this work of synthesis be? Reiser complains that in previous centuries universities used to do this synthesizing but that now they fall short of it. But surely all that has happened is that so much more has been found out. This raises no problem other than that of getting an efficient abstracting service.

It is not possible to gather what Reiser means by 'integration', either from his precept or his practice. He defines integration as the extraction of common principles from the special sciences and the use of these in developing a universal world view (p. 387). This sounds like a proposal to use methodology for the purpose. But he also tells us that integration has a social basis, namely, cultural unity, and it is not easy to see how the study of methodology could give rise to cultural unity. To tell us that the social basis of integration is cultural unity is to tell us that when people think alike they think alike. This brings us no nearer to an understanding of his use of 'integration'. Elsewhere integration is defined as putting together information from different fields; and the task of philosophy is defined as that of integration (p. 7). It follows that a philosophical problem is a problem about how to put bits of information together. But the integration, we are told, has to be based on the use of materials from those fields which are relevant to the philosophical problem. So the integration has to be based on what is relevant to the integration. This tells us nothing.

The book itself is cited as an example of integration. It should be possible, therefore, to gather what is meant by the term by looking at Reiser's own practice. The plan of the book is to pass chapter by chapter from the foundations of knowledge (logic, mathematics, methodology, semantics, epistemology) through the special sciences to a final synthesis. In each chapter the main points of view on a given field are outlined and then 'synthesized'. Again, reading the results of this procedure brings us no nearer to an understanding of Reiser's use of 'integration'. For his procedure is that of eclectic collation of views based upon his own approval and disapproval.

It might be asked why we need this synthesis. Reiser's answer is that it is essential for the establishment of a unified world society. He admits that it is also essential that the Russians should adopt his views. He says that society will remain confused until we know the answer to the question "What is knowledge for?" and that this question cannot be answered until our knowledge is complete (p. 258). But in that case, the question never will be answered. We do, in fact, already know the answer. For knowledge is valued both as a means and as an end. We need no institute of integration in order to find this out. We also know that a question as general as this will admit of an answer only in equally general terms. If this is felt to be unsatisfactory, the solution is not to produce yet further verbalisms but to ask more specific questions.

There is a unity of science already, all the unity that there need be. All that is needed to obtain it in any given case is to get a group of specialists working together on one project. It is up to those who say that such a group stands in need of further 'unification' to specify intelligibly what they mean. The fallacy involved in the demand for synthesis is a Platonic fallacy. It is the view that knowledge is contemplative; that in order to 'know' science someone has to acquire and put together (in a manner which is never specified) all the results from all the sciences. But science consists in the exercise of certain manual and conceptual skills, and the unification of these skills is attained by the co-operation of specialists for definite purposes. There is nothing else in the way of synthesis to be done. Reiser's book illustrates the effects of nevertheless trying to do it.

JOHN TUCKER

HUMAN RITES

The Rites of Passage

By Arnold van Gennep. Translated by Monika B. Vizedom and Gabrielle L. Caffee. Pp. xxvi+198. (London: Routledge and Kegan Paul, Ltd., 1960.) 23s. net.

FOR many years the author of this book was professor of ethnography in the University of Neuchâtel and particularly well known as an authority on popular traditions, legends and folk-lore. In 1909 he published his ideas on these subjects in a book entitled "The Rites of Passage" and this arresting title has now established for itself a place in the vocabulary of the anthropologists. In our journey through space-time we have to pass through many passages which lead from one period in our lives to another period. For example, there are the passages from infancy to childhood, from childhood to adolescence, adolescence to adulthood, and finally the abrupt passage through the doorway of death, either to annihilation or to an entirely different form of life beyond the grave.

Gennep has noted two facts about these transition periods of man's life. The first is that each of these movements has its appropriate rules and rites and that the ceremonies which accompany them are very much the same in all civilizations and cultures. He also directs attention to the fact that these cultures accentuate the existence of two particularly sharp divisions in society, the first being the sexual division between the men and the women and the second the magico-religious division between the religious members of society and the profane members. He gives a description also of the secondary groupings of the various age-groups, the family units and the politico-administrative and territorial units.

Life entails for everybody many separations followed by subsequent re-unions, and one of the author's main purposes in writing this book was to investigate the precise significance of the rites which are, and which always have been, associated with these passages of separation and re-union. This led him to investigate the various initiation rites in the mystery religions of Egypt and Greece, religions which exerted a great influence on the ceremonies and rituals of the Christian Church in its early formative years. Indeed, it may be said that the rituals of the Catholic Mass are representations of a number of transitions and incorporations, the only difference between these and the initiation rituals of the old mystery religions being that the initiation ceremonies of the Mass are never final but are always being renewed.

Arnold van Gennep's book covers a great deal of ground, and it should be of interest not only to anthropologists but also to students of religions. Its appearance in an English edition is to be welcomed.

KENNETH WALKER

AFRICAN CULTURES

Continuity and Change in African Cultures

Edited by William R. Bascon and Melville J. Herskovits. Pp. vii+309. (Chicago: University of Chicago Press; London: Cambridge University Press, 1959.) 52*s*. 6*d*. net.

THIS is one of the better collections of essays on Africa that have appeared in recent years. The introductory essay by the editors is an excellent summary of the problem, directing attention to some of the basic approaches to the subject which are too often lost sight of in the hurry of modern research. Four essays deal with "Africa as a Linguistic Area" (Greenberg), "African Art" (Cordwell), "African Music" (Merriam), and "The Factor of Polygyny in African Demography" (Dorjahn). The remaining nine are regional or tribal studies, two of them dealing with eastern Africa, one with the north-western Belgian Congo, and the rest with west Africa. Though there are three maps, illustrating language groups, culture groups, and music areas, it would have been helpful if a map had been included showing where the peoples studied are to be found.

Although the subject of the book is specifically "continuity and change in cultures", there is none the less a good deal of information about various aspects of the peoples represented; and unlike so much modern work on Africa, the book is mercifully free, to a great extent, from the jargon and involved writing that seems to be considered a necessary element in social anthropology to-day.

Of particular interest to historians should be the essay on "Ethno-History in the Study of Culture-Change in South-east Africa", which is an interesting, informative, and well-documented study, though it needs a map of its own; in fact each of the regional essays would have benefited by a map.

In his account of the Pakot (better written Pokoot), Prof. Schneider might have added the story of how Chaundy managed to persuade the people to use their stocks of cow-dung for fertilizer instead of keeping them merely as visible indicators of wealth, but gave up doing it when he had gone.

Although the book is intended as a study of various aspects of acculturation, it forms quite a useful introduction to the peoples with which it deals. The essay on "African Art" is a comprehensive survey of art throughout the continent, concentrating mainly, as is to be expected, on West Africa; but there are short sections on Eastern and Southern Africa and the Congo, and on modern African art. The author notes that "there are few African cultures where the concept of 'art for art's sake' seems to have existed"; I wonder if this is really true. The essay which follows this, on African music, is equally comprehensive.

At a time when so many anthropological studies of Africa tend to be of the 'social anthropological' kind, it is good to come across a book like this which deals with facts, and allows the facts to retain their importance. Though some of the essays in the book are within the field of social anthropology, the importance of the facts on which they are based is not minimized. This book is altogether to be recommended to those who wish to know more about certain aspects of African cultures before the countries in which they are found become independent and possibly undergo change in a different direction.

G. W. B. HUNTINGFORD

SELF-REGULATION FOR CHILDREN

The Free Family

A Creative Experiment in Self-Regulation for Children. By Paul and Jean Ritter. Pp. 269+4 plates. (London: Victor Gollancz, Ltd., 1959.) 18*s*. net.

THE authors of this book were inspired by the teachings of Wilhelm Reich and the example to A. S. Neill to bring up their five daughters in accordance with the principle of 'self-regulation'. According to this principle, children should be left to work out for themselves how they shall behave; when and what they shall eat, when they shall sleep, when eliminate, and so on. Adult interference is kept to the minimum necessary for the children's safety, and to prevent them from becoming too much of a social nuisance. Their lives begin with the birth procedures advocated by Dr. Dick Read.

On their own evidence, the authors appear to have carried this principle into action as successfully as is possible in a society which advocates quite different principles of upbringing. But their success seems to have depended on their being highly cultured, reasonably well-to-do and enjoying a good deal of leisure; and, what was more important, on being intelligent and exceptionally well-balanced and loving, so that they were able to tolerate the discomfort and mess which the children's self-regulation entailed. Although 'tension' inevitably arose, they were willing to accept this and to acknowledge that they were the probable cause—in their own words "everybody is silly sometimes". Even then, it is clear that the children experienced considerable difficulty in adapting themselves to the society of children very differently brought up.

This book is not of course a scientific document. We need independent evidence as to whether the children did in fact emerge with the degree of spontaneity, poise and stability which their parents claim for them. To prove the authors' thesis, studies must be made of many more and different families employing self-regulation. Only then shall we know whether self-regulation can be practised successfully by more than the fortunate few. By all means let parents be stimulated to try these methods; but let them realize well in advance what they are setting out to do.

M. D. VERNON

MOTIVATION

Motivation

A Systematic Reinterpretation. By Prof. Dalbir Bindra. Pp. vii+361. (New York: The Ronald Press Company, 1959.) 5.50 dollars.

IT has been clear for at least a decade that our ideas on motivation have been muddled and unable to accommodate some of our data. One way or another the notion has persisted that organisms are inert machines made to behave by instincts, drives, libido, *élan vital*, etc. Many contemporary learning theorists and psychotherapists still hold to this kind of view. Dr. Bindra persuasively marshalls a great deal of research evidence in the hope that they can be brought to change their minds.

The alternative he has to offer translates many motivational concepts into terms of stimulus and habit. We do not have to ask why an organism is active because activity, or irritability, is the property of living matter in virtue of which it is recognized as living. There are biochemical problems here but not psychological ones. What we are concerned with are those aspects of activity which are, or seem to be, purposive.

Not so long ago 'purposive' was shut away in a cupboard with 'consciousness', 'philosophy', 'introspection' and similar skeletons. The biologists, with their comparative freedom from methodological anxieties, have helped to bring it back into use. We can be objective here even though we cannot measure. Purposive behaviour is appropriate, persistent and searching. At the mammalian level, Dr. Bindra claims, most of this behaviour is learned. He suggests two generalizations.

"1. Some degree of repeated or continued exposure to a situation is a necessary condition for the development of activities that are goal-directed with respect to some features of that situation.

"2. Behaviour becomes goal directed by virtue of the fact that certain movements or component responses (occurring in a matrix of general activity) that are accompanied by a given goal are selectively strengthened or reinforced . . .".

This does not sound revolutionary, but the shift of emphasis from the drive to the goal, which is not necessarily set up by a drive, liberates subsequent theorizing, and makes it possible to handle data which traditional learning theory is apt to ignore or explain away.

There is some circularity involved in the new definitions of 'goal' and 'reinforcement', but Dr. Bindra sticks as closely as he can to his evidence and points to experiments instead of verbalizing when he wants to make his meaning clear. Socrates might not have approved, but the method works well enough when we are only groping towards a few empirical formulations.

What does seem clear is that we learn to avoid painful objects. We learn to be hungry (that is, develop a food addiction), and so the old drives cease to be available to us when we try to explain learning.

Dr. Bindra has written a timely and important book. It can bear comparison with Hebb's "Organization of Behaviour" from which it stems. The mixture of theoretical boldness and empirical bias which characterizes work in the McGill Department seems to be what is needed at our present stage in psychology.

J. DREVER

MEMORY AND LEARNING: A NEUROLOGIST'S POINT OF VIEW

Brain—Memory—Learning

A Neurologist's View. By Dr. W. Ritchie Russell. Pp. xii+140. (Oxford: Clarendon Press; London: Oxford University Press, 1959.) 18*s*. net.

THIS book gives the views of a well-known neurologist on the physical basis of memory and learning, to the better understanding of which he applies his extensive and critical appreciation of the effect of brain injuries, on which he is the leading medical (as opposed to surgical) authority in Great Britain. The theme is important and fascinating, for ever since the dawn of history man as a sentient being has pondered the secrets of his mastery of this mysterious universe in which we live. This further approach to our understanding of the brain as the bodily organ of mind is presented with considerable ease and felicity of expression.

Mental processes—themselves dependent upon brain cell activity—are considered in the light of recent neuro-physiological knowledge, which is also applied to a study of their impairment following concussion and focal traumatic lesions of the brain; the result is an enrichment of our understanding of the cerebral mechanism whereby man's dominant position in the universe has been achieved.

The book opens with a survey of some aspects of neuronal physiology, indicating that human thought and reason depend, not on the presence within the nervous system of any special features of the nerve cells themselves, but on the vastness of their numbers and on the utter complexity of their inter-connexions through synaptic knobs on their surfaces and special spikes on their dendrites, whereby potential synaptic activity must be increased to an incredible extent. Much cerebral activity is concerned with the analysis of afferent stimuli in relation to previous experiences composed of memories and their emotional associations. This development of memory and the recognition of the familiar is believed to be effected through a process of neuronal facilitation with the ultimate result that what has been done once can more easily be done again. Intelligence presumably depends upon the capacity of the mind to associate together, rapidly and effectively, vast numbers of such memories, and this can only be if the brain is in a state of what amounts to almost ceaseless neuronic activity. Attention, memory, habit-formation, learning and intelligence all have their emotional aspects which are supremely powerful during early life, and it is the successful control, refinement and integration of these qualities that make possible the subsequent development of the balanced adult personality with perhaps unforseeable possibilities for the future. Considerations of speech and of such pathological states as epilepsy, pain and phantom limb sensations all yield additional information concerning the sensory-motor aspects of the brain–mind relationship.

This stimulating, provocative and at times speculative book is eminently readable and warmly to be recommended, especially for the wisdom of its concluding chapters.

GILBERT HALL

60 YEARS OF LEARNING THEORY

Theories of Learning

By Prof. Ernest R. Hilgard. Second edition. Pp. ix+563. (London: Methuen and Co., Ltd., 1959.) 45*s*. net.

THE first edition of this book appeared in 1948. In the intervening years, a considerable amount of experimental and theoretical effort has been devoted by American psychologists to the study of learning with, so it seems, no very radical advances being achieved. The work begins with E. L. Thorndike and proceeds by way of chapters on the major stimulus-response theorists, notably Skinner and Hull, and on the other group of theorists which the author designates the cognitive. The latter include those making use of gestalt conceptions with their implication of an emergence of qualitative differences in learning and problem-solving, as between lower and higher organisms, rather than a quantifiable dimension from simple to complex. These tend to infer more freely the existence of central brain (ideational) processes in accounting for observed behaviour modifications, whereas the former tend to explain in terms of peripheral intermediaries such behaviour as the goal-directed sequence of a rat running through a maze to a distant food-box.

The author makes clear that these two groups of theories each include a diversity of points of view around the central distinguishing characteristic of peripheral or central explanations. He points out that probably the major issue, which cuts across both groups, is that of the role of reinforcement and drive in learning. Some writers have supposed that, in the first instance, learning may occur simply through associative contiguity, the achieving of a reward or the avoiding of a punishment serving merely to facilitate the occurrence of the learned behaviour on subsequent occasions. Others have maintained that learning does not occur at all unless some kind of reinforcement is available to the organisms in the learning situation. The crux of the matter between these two points of view lies perhaps in the kind of definition given to the term 'reinforcement'. It need not consist merely in obtaining a primary goal, such as food or avoidance of electric shock, or secondary (acquired) goals such as counters or verbal praise or punishment. It may also derive from the reduction of tensions set going, for example, by the animal's propensity to explore its environment. The discussion of these problems, together with other current developments, including the role of mathematical models in the construction of learning theories, is contained in three new chapters which constitute an important addition to the first text.

Changes and additions to the historical core of the text are to be found in the chapter on Hull, where his later postulate system is assessed, in the discarding of the chapter on Wheeler's organismic psychology, and in the inclusion of a new chapter of 38 pages on Freud's psychodynamics. Wheeler's omission represents a loss of little significance, but it is not clear that Freud's irruption into a historical text dealing with theories derived almost entirely from experimental data constitutes a substantial gain. The author says: "If there is any teaching which has come from Freudian psychology it is that motives are organized in some sort of hierarchy within the individual, resulting in a value-system expressed in behaviour" (p. 348). But the key to this inclusion seems to be the awareness that motivation, whether in its conditioned or its instinctive form, is very inadequately dealt with by most learning theorists.

In considering the organisms from which learning data and theory are derived, it is common knowledge that the animal favoured by psychologists has been the rat. Index references confirm the rat's priority over all other laboratory animals in the ratio of about 2 to 1. References to human learning make up a poor second to the rat. Allowing for the experimental conveniences of rats as learning-apparatuses, this still must constitute a severe restriction upon the general and comparative significance of the learning theories discussed. Indeed, it would seem justifiable to describe most stimulus–response theories as rat-derived, most cognitive theories as primate-oriented. This is a defect, not in the author's scope, but in the range of the work which he is very ably sampling. A vital corrective to this species-restriction is necessary, and much may be learned by learning theorists from the experimental–ethological studies of Thorpe, Tinbergen, and others.

We are left with the view that there may turn out to be several different types of learning which, at the present stage of theory construction and experimental evidence, cannot be resolved by single theory treatment, even of the promising mathematical model variety. But, although our reading of this book should lead to a critical dissatisfaction both with the theories and with the supporting evidence, the author has, in general, produced an invaluable historical survey and appreciation of current trends which merits the careful study of every student of behaviour.

K. R. L. HALL

SOCIAL SCIENCE, CRIMINOLOGY AND PSYCHIATRY

Social Science and Social Pathology
By Barbara Wootton, assisted by Vera G. Seal and Rosalind Chambers. Pp. 400. (London: George Allen and Unwin, Ltd., 1959.) 35*s*. net.

THE discrepancy between the brilliant achievements of the natural sciences and the slow progress of social science is one of the most disturbing features of our civilization. Recently there has been a good deal of stocktaking among social scientists. What is the scope of this field of study and what are its methods of research? Is there only one social science or are there several social sciences? What ought to be the relationship of social science to the two fields of study most closely concerned with human behaviour, that is to say, psychology and psychiatry? Lady Wootton tries to answer some of these questions in this book written in anger and without pretence of scientific detachment. It is addressed to the interested lay person.

The work falls into three parts. The first presents a critical survey of contemporary research into the origins of crime. Twelve hypotheses are listed and found wanting. Theories about the role of the broken home and the lasting effects of maternal separation or deprivation on behaviour come in for special criticism. Many of the strictures are justified, but none of them is new. Lady Wootton believes that criminological research has achieved very little and that progress is unlikely unless social science rids itself of evil influences. She regards the rise of psychiatry as its greatest danger. Her book can be viewed as a desperate attempt to halt this threat.

Lady Wootton detests imprecision and uncertainty. She insists on clear boundaries, especially between the bad and the mad. Unfortunately, such boundaries do not exist in Nature. She blames the psychiatrists for the existing confusion. In Part 2, which is entitled "The Contemporary Attitude to Social Pathology: the Social Implications of Psychiatry", Lady Wootton sets out to show psychiatrists up for what she thinks they are, namely, unscientific, ignorant and power-hungry empire builders. She deplores the intrusion of psychiatric concepts into social science. She has nothing good to say about psychiatry, except that it has had a humanizing influence. She takes a great deal of trouble to show that the concepts of mental health and mental hygiene are ill-defined and influenced by ethical premises and value judgments. She is particularly severe on the notion of adjustment.

All this amounts to the statement that there is no clear boundary between mental health and mental illness. Lady Wootton presents this as if it was a discovery which ought to disqualify psychiatry from having a say in the study of antisocial behaviour. The reader is led to believe that those uncertainties are specific to mental health and illness. In fact, they also exist in physical health, which is a concept equally elusive of definition and no less 'value-soaked' than mental health.

The intelligent reader will take heart from the knowledge that medicine has not done too badly even without such a definition. Nor has the scope of physical medicine remained static. Many conditions which are now treated by the physician were not so long ago outside the scope of medicine. Lady Wootton has a simple explanation for the widening of the scope of psychiatry. Moral problems have been incorporated into medicine "for no other reason than that doctors have decided to enlarge their empires so as to include territory formerly regarded as belonging to morality rather than to medicine, and so as to make a place for psychiatry in the medical curriculum". This statement shows a lack of historical insight which is most disturbing in one so eminent. Lady Wootton has not taken the trouble to find out why psychiatry is no longer confined to the 'insanities' but has become the study of abnormal behaviour. If she had given some time and thought to this problem, she would have learned that this change of the scope of psychiatry was due not only to psycho-analysis but also to the discoveries of the effects of brain lesions on behaviour.

Lady Wootton is alarmed about the vagueness of the concepts of psychopathy and mental deficiency. It is, of course, true that moral and medical judgments often overlap and are difficult to disentangle. There are still very few objective criteria of mental illness, and often the first and only indication of its presence is social failure. A considerable time may elapse in an individual case before other signs of illness can be demonstrated. All this is rather confusing, and sometimes the doctor, by introducing his own uncertainties, makes it difficult to administer the law; but this is an inevitable complication where knowledge is incomplete.

Lady Wootton is ultra-conservative concerning the safeguards against conviction for offences committed in a state of mental disorder. She does not think that the McNaghten rules, which reflect the medical knowledge of 1843, can be improved upon and she is opposed to the concept of diminished responsibility. She resents the 'privileged' position of the medical profession. It is a pity that Lady Wootton has not heeded her own warning that "in social research generally, constant vigilance is necessary against the risks of prejudice". Her attitude against the medical profession has a Shavian flavour, without being entertaining.

Lady Wootton condemns the emphasis on personal relationship in social work. The social worker ought to concern himself only with economic and not with personal difficulties, which, she believes, can be kept apart. The chapters dealing with the role of the social worker appear the most unenlightened of the whole book, probably because here the author speaks as an expert.

The concluding chapters make gloomy reading. Lady Wootton re-states her poor opinion of social pathology in its present immature state. Like everybody else, she wants more facts and more sophistication in the formulation of hypotheses. She believes that for some time to come the destruction of myths is going to be the chief pre-occupation of the social scientist.

It has been said that the main characteristic of the scientific attitude is the scientist's devotion to the detection of his own errors. Scientists must also undertake the task of proving others wrong. Lady Wootton has dedicated herself to the latter, but in doing so she has neglected the former, which is the true test of the scientific outlook. This is why this book gives a distorted picture of the state of social pathology. E. STENGEL

A DIVERSITY OF TRENDS IN MEDICINE

Ciba Foundation Symposium on Significant Trends in Medical Research

Edited by G. E. W. Wolstenholme, Cecilia O'Connor and Maeve O'Connor. (Tenth Anniversary Symposium.) Pp. xii+356. (London: J. and A. Churchill, Ltd., 1959.) 50*s*. net.

THIS account of the transactions of a special symposium arranged in June, 1959, to celebrate the tenth anniversary of the Ciba Foundation is the fiftieth major volume published for the Foundation. The aim in selecting the thirteen original papers, here printed together with the discussions on them, was to pick out the advances in medical research in the past ten-year period which would prove to be most significant in the next ten years. The speakers fortunately eschewed prophecy and talked about the work they were interested in personally. Distinguished as the participants were—they included seven Nobel laureates—it seems doubtful if any of them could have taken a sustained interest in everything that went on, or understood the whole of a terminology which included nuclear-spin and electron-spin magnetic resonance, genome, the ascending reticular system and co-arctation of the aorta. Few active scientists to-day are polymaths, and trends in medical research may diverge too widely to be the focus of a single gathering.

The Ciba Foundation has done such admirable work in providing hospitality for visiting scientists and arranging symposia of groups of experts that one must not grumble at an occasional *Festschrift* or express a perhaps purely personal prejudice against studying so many topics at once. Some of the subjects dealt with were general neurophysiology, hormones, pancreas and insulin, chronic pulmonary disease, clinical nutrition, and the organization of research in the United States. The remaining papers, which are concerned with such subjects as molecular structure in relation to biology and medicine, enzymes, the chemical basis of virus multiplication, population dynamics of body cells, genetics and medicine, malignant transformation, and the quantitative approach to disease as exemplified by essential hypertension, are a more homogeneous collection. They have in common the transmission of cellular characteristics, the disturbances which avoidably or unavoidably occur in this process, and the manifestations which these produce in the organism as a whole. The subject interests a wide range of workers, from electron microscopists to population research workers, and it will undoubtedly form a major trend in medical research in the next decade.

Pauling, Burnet and Medawar briefly indicated their own important contributions, discussing in particular the mechanism of antibody formation, and the question whether the relationship between stimulus and response should be described as 'instructive' or 'evocative'. Similar ideas were shown to underlie our notions of embryonic differentiation, ageing, and malignant disease. Waldenström (his Figs. 2 and 3 have unfortunately been transposed) emphasized the need for greater precision in the description and interpretation of inherited disease in man if human genetics is to support its theoretical superstructure, and Pickering reviewed his work on the incidence of hypertension and the quantitative approach to disease. Not all his audience agreed that the ability to arrange the blood pressures of a population in a normal frequency distribution curve tells us much about the etiology of essential hypertension. Moreover, it is doubtful whether many scientific clinicians to-day believe, as he suggests they do, that "a patient with a specific disease has a single basic fault". Indeed, I think the majority will be rather encouraged to learn that Waddington thinks the one-gene, one-enzyme hypothesis is an abstraction.

The book has been produced with remarkable speed, considering the inclusion of the discussions and the intervention of the printing strike, and it is a testimony to the experience and skill of the editors in this field.

L. J. WITTS

THE EYE AND VISION

The Eye in Evolution

By Sir Stewart Duke-Elder. (System of Ophthalmology, Vol. 1.) Pp. xvi+843 (902 figures)+15 plates. (London: Henry Kimpton, 1958.) 126*s*. net.

Documenta Ophthalmologica

Advances in Ophthalmology, Vol. 13. Edited by G. von Bahr, G. B. Bietti, J. ten Doesschate, H. Fischer-von Bünau, J. Francois, H. Goldmann, H. K. Muller, Jean Nordmann, A. J. Schaeffer and Arnold Sorsby. Pp. xii+516. (The Hague: Dr. W. Junk, 1959.) 75 guilders.

BOTH these books are directed towards ophthalmologists. One is written by a clinician, the other records the work and opinions of men many of whom are clinical ophthalmologists. It is significant that the material is largely made up of the basic sciences upon which ophthalmology is built.

Sir Stewart Duke-Elder explains why he has preferred to initiate the preparation of a "System of Ophthalmology", of which he will be editor, to the production of a second edition of his own comprehensive, internationally renowned and sought-after "Text Book of Ophthalmology". Much of the material in its seven volumes is now out of date and the earlier volumes out of print. But while this new book, written by Duke-Elder himself, is the first of fifteen planned volumes to cover ophthalmology it is an entity in itself which can be read and entirely enjoyed not only by clinicians but also by anyone interested in natural history, and in man. Its pattern is perhaps best shown by extracts from the epilogue and introduction in that order.

"This is the story of the development of the eye from the primitive undifferentiated protoplasm of the simplest protozoon to become the most highly efficient sensory mechanism in the animal kingdom in the eyes of Birds. It is the story of the development of the sense of vision from an autonomic response associated at some stage with a vague awareness, to the capacity to be enraptured by a rainbow or to create a thing of beauty".

"It is a fascinating story extending back to where life started, a story mostly of steady progress, now in this direction, now in that, as one expedient after another was tried, this one to be discarded, that to be perfected".

"We begin with a drop of viscid protoplasm the reactions of which we do not understand and we end lost in the delicacy of the structure of the eye and the intricacies of the ten thousand million cells of the human brain".

"If, indeed, the proper study of mankind is Man, and if (as we must agree) his behaviour and his contact with the outside world are mediated through his senses, what can be more fundamental than the study of the sense which, more than any other, determines his intelligence and regulates his conduct . . . ?"

To tell this story of the evolution of the eye and of vision through the animal world a vast amount of learning has been sought, assembled and arranged. It is presented in the same delightfully readable way that characterized the "Text Book of Ophthalmology". Not only is the reading easy, it seems easy to absorb the facts, and the lightness and grace of the writing tend to eliminate any text-book impression.

It is profusely and beautifully illustrated, and attractive marginal line drawings of many creatures have been added to supplement and enliven the text. The pleasant practice of opening a chapter with the photograph of, and notes about, an authority in the subject of that particular section has been carried on from the "Text Book". The layout and the production of this volume are excellent and clinicians at least will look forward eagerly to those which are planned to follow it.

Most of volume 13 of "Documenta Ophthalmologica" is given to the papers and discussion at a symposium on glaucoma held in Liège by invited participants from Europe and the United States. The papers are in English, French and German, and some of the mathematics and hydrodynamics will be beyond the ordinary ophthalmologist. But the reported work and the discussions which followed each paper provide a most interesting and instructive review of the research, basic and clinical, which in many centres is focused on aspects of the physiology and anatomy of the eye and the earliest evidences of an insidious disorder which accounts for much blindness, and which may well have its start earlier in life than has been generally thought. The last paper is an interesting, if abstruse, review of published ideas on frontal reference surfaces of binocular visual space commonly referred to as horopters.

R. C. Davenport

EARLY ETHOLOGY

Instinctive Behaviour

The Development of a Modern Concept. Translated and edited by Claire H. Schiller. Contributors: D. J. Kuenen, Konrad Lorenz, Nicholas Tinbergen, Paul H. Schiller, and Jakob von Uexkull. Pp. xix + 328. (London: Methuen and Co., Ltd., 1959.) 45*s*. net.

During the past twenty-five years very considerable progress has been made in the study of instinctive behaviour. This has been due largely to the work of Konrad Lorenz in Germany and Niko Tinbergen in Holland and England. They in turn owe some of their inspiration to a small number of earlier workers—Heinroth and von Uexkull, Whitman and Craig, J. Huxley and Eliot Howard. Their work has resulted in the development of ethology—a discipline characterized not by any strict boundaries to its subject-matter (indeed most ethologists are busy attempting to establish bridgeheads with related fields such as physiology, psychology, ecology and genetics), or by a formal theory, but rather by the orienting attitudes of its research workers. These attitudes reveal the influence of a zoological background, and include an interest in problems of the function and evolution of behaviour as well as its causation, an emphasis on the importance of the description and classification of behaviour as a preliminary to analysis, and an interest in comparative studies.

"Instinctive Behaviour" is a collection of some of the earlier ethological papers, translated into English by Claire H. Schiller. As such, it is not to be taken as representative of modern ethological views, but rather as showing the sources from which they developed. The first essay, first published by von Uexkull in 1934, is concerned with the relation between an animal's perception of its environment and its sensory capacities. This relationship is obvious enough now, but needed emphasizing at the time: the paper contains a number of interesting observations, as well as some rather far-fetched speculations.

The greater part of the book consists of six essays by Lorenz, Tinbergen and Kuenen, alone or in combination, including Lorenz's (1935) "Kumpan" paper and the classic papers on the egg-rolling of the greylag goose and the begging of young thrushes. The extent of Lorenz's and Tinbergen's genius is shown by the fact that many of the ideas which have proved useful in ethology were fully developed in these essays written twenty years ago. The use of fixed action patterns in comparative study, the evolution and function of social releasers, the nature of animal language, the integration of discrete actions into functional sequences of behaviour, and many other topics are discussed here in detail; and later workers on such subjects have had to do little more than fill in the details. At the same time, these papers contain much of the earlier theoretical background to ethology which is now discarded by most ethologists as well as by Lorenz and Tinbergen themselves. Lorenz's discussions of the innate/learning controversy, releasing mechanisms or the precise nature of 'action-specific energy' make curious reading now; though in their day they were fertile in provoking observation and experiment.

The last essay, by Lorenz, in this book (1952) contains a summary of Tinbergen's hierarchical scheme of nervous centres. This model embodied many of the earlier ethological ideas, and will probably come to mark the end of a phase in ethological thinking. Since then Lorenz and Tinbergen have developed new approaches and produced fresh ideas; but these are not represented in this book. In their later writings the distinction between the valuable general principles on which ethological work is based on one hand, and its earlier rather loose theoretical concepts on the other, becomes apparent.

This volume was planned and begun by the late Paul H. Schiller. It contains one previously unpublished essay by him on the importance of 'innate' organization in determining the course of learning in chimpanzees, in which he emphasizes that a knowledge of this organization is essential for analysing the acquisition of skills. This paper provides an example of the way in which ethology must develop—by inter-action with other fields of study in which ethological observations and methods can be applied.

R. A. Hinde

A NINETEENTH-CENTURY BOTANIST

Asa Gray, 1810–1888

By Prof. A. Hunter Dupree. Pp. x+505+9 plates. (Cambridge, Mass.: The Belknap Press of Harvard University Press; London: Oxford University Press, 1959.) 60*s*. net.

THE story of Asa Gray is told against a background of history concerned with the intellectual development of America during the nineteenth century. These pages should appeal not only to botanists, who know of its subject as one of the pioneers in the study of the geographical distribution of the American flora, but also to all those interested in the growth of the fruitful scientific collaboration between the New World and the Old in which Asa Gray played a notable part.

Born in 1810 of farming stock, Asa Gray was reared in the beautiful valley of Sanquoit and worked in the bark mill of his father's tannery. He was eighteen when plants caught up his interest, and he began to make a herbarium during his apprenticeship, for like so many of the earlier botanists he was educated as a medical practitioner. At the age of twenty-eight he was appointed professor of botany to the new University of Michigan and was enabled to visit Europe, which gave him the opportunity of forming the contacts with William and Joseph Hooker, George Bentham, Lyell and Charles Darwin that were to have a profound influence upon his subsequent career as an investigator.

While the author of this work emphasizes how Gray's scientific activities were chained to the results of American expansion and exploration, these nevertheless provided both the opportunities and the means. It was Asa Gray's good fortune to discover in the eastern States single representatives of Japanese genera previously regarded as monotypic, thus confirming his conclusions that while the European connexions are most marked on the side of the American continent nearer Europe, those with Asia are greatest on the remote side. It was these observations and his wide grasp of the North American floristics which attracted the attention of the Hookers and later of Darwin when he turned his attention to the botanical field.

From these pages we get the impression of their subject as a vigorous character, but quite incapable of estimating what he could, in fact, accomplish so that during his more active period 'the incomplete works of Asa Gray' continued to augment. It is an interesting sidelight on his personality that antagonism to the views of Agassiz would seem to have been an important stimulus, just as it was Alphonso Woods publications that appear to have provided the requisite catalyst for Gray to write his "Manual", that was his most important work, and which might otherwise never have been completed.

The Gray Herbarium was a vast collection that bore tribute to his drive; and the difficulties he had with the collectors, upon whom he relied for the new plants he described, are well portrayed as well as the impediments that these pioneer workers had to overcome in the tasks of identification.

The author of a biography may be forgiven a partiality for his subject and to such bias we may perhaps attribute the statement that Gray "shewed the qualities of mind and character necessary to rise to Darwin's level". But even though the reader may scruple to accept this assessment he cannot but be grateful to the author for this fully documented presentation of the man and his environment.

E. J. Salisbury

MASTER OF MICROBIOLOGY

Albert Jan Kluyver

His Life and Work: Biographical Memoranda, Selected Papers, Bibliography and Addenda. Edited by A. F. Kamp, J. W. M. La Rivière and W. Verhoeven. Pp. xv+567. (Amsterdam: North-Holland Publishing Co.: New York: Interscience Publishers, Inc., 1959.) 80*s*.

THIS book contains a record of the life and work of a great microbiologist—perhaps the last we shall see of those encyclopædic men whose field was the study of micro-organisms as a whole. Micro-organisms have an increasing role in human activities: as agents of soil fertility and in the production of prophylactic, therapeutic and other economically important materials, and as agents in animal and plant diseases and in the spoilage of stored products. The utilization and control of micro-organisms will be increasingly important as populations grow, with their increasing demand for food and for the prevention of disease. Applied physics may steal the headlines for a while, but when all is said, the problems of food production and of health will remain, and in these micro-organisms must play an important part. The concepts of the 'unity of biochemistry' and of 'comparative biochemistry' which Kluyver enunciated so clearly are cardinal in modern biological studies. Micro-organisms multiply quickly and we now know that it is often possible by studying them to gain information of general biological importance more easily and rapidly than by studying more complex organisms. Kluyver's work in microbiology is an example *par excellence* of that interweaving of biochemistry and biology which is now proving so fruitful in biological studies. The line of Dutch microbiologists such as Leeuwenhoek, Beijerinck and Kluyver forms one of the great arteries of microbiology; this school has been particularly concerned with fundamental studies of microbial physiology. Another equally important line comes, of course, from the Pasteur school, which developed particularly the study of disease-producing organisms and the prevention of their effects. Both lines of development lead, in the end, to study of the biochemistry of the modes of action of specific micro-organisms. An important feature of the work of the Dutch school has always been the study of micro-organisms in general, of what they do and how they do it: general microbial physiology.

The book is divided into three parts; most of it is in English.

Part 1. Biographical memoranda. This begins (pp. 3–67; illustrated by 23 photographs) by giving the outline of Kluyver's life, with a very interesting section about Kluyver as seen by his pupils. There follows (pp. 68–155) a masterly survey by C. B. van Niel of Kluyver's contribution to microbiology and biochemistry. This part closes with two moving funeral orations.

Part 2. Selected papers (pp. 165–524). The papers selected are, with two exceptions, those of which Kluyver was the sole author. They are mainly the general articles and lectures in which he displayed his masterly grasp of, and wide-ranging thinking about, microbial physiology, and are written in his characteristically vivid personal style. In these writings Kluyver established himself as a great thinker and teacher about microbiology: the experimenter who related his findings to the advance of his field of science as a whole. Every one of these papers should be read and digested by anyone who is concerned with the future trends of microbiological science and its mode of progress.

Part 3. Bibliography and addenda (pp. 527–563). This contains detailed lists of joint papers by Kluyver and co-workers, of doctoral theses supervised by him, of papers from the laboratories at Delft and Utrecht which he influenced; lists also of the members of the staff at Delft during Kluyver's directorship, of the many honours conferred upon him, and of obituary articles. This simple documentation of his work and influence strikingly illustrates his energy and breadth of interests.

Kluyver was a splendid man and a splendid scientist of the kind most fitted to this epoch. He was never content only to deepen his studies of micro-organisms, but was always conscious of, and able to explain clearly, the relations of the work of his school to the advance of microbiology as a whole. His work and influence continue to shape that science. What better memorial could a man wish than that people will return again and again to his writings to seek refreshment and inspiration. This beautiful volume should be possessed by every university library and every department of biological science.

B. C. J. G. KNIGHT

DIAGNOSIS OF HUMAN GROWTH

Growth Diagnosis

Selected Methods for Interpreting and Predicting Physical Development from One Year to Maturity. By Leona M. Bayer and Nancy Bayley. Pp. xiv + 241. (Chicago: University of Chicago Press; London: Cambridge University Press, 1959.) 10 dollars; 80s. net.

PHYSICIANS concerned with the treatment of children and adolescents will be glad to see a book which provides them with a set of blue-prints for assessing growth. In a number of research centres, and particularly in the United States, the individual progress of hundreds of boys and girls has been documented from birth to maturity. Based on these studies, the details of growth have been precisely delineated to show increases in individual parameters and changes in proportions as well as in certain more superficial and subtle aspects of body covering and contour.

Since deviations in growth pattern may reflect corresponding physiological abnormalities, accurate recognition of deviations can be an important diagnostic aid. An exact description of the morphological and temporal aspects of a growth deviation may thus provide a reliable guide to its probable ætiology.

Before establishing deviations, however, it is necessary to define norms, and this the authors do by selecting examples from a population which is ethnically homogeneous, clearly described and numerically adequate; the norms can also be statistically defined. These anthropometric norms have been derived mainly from American children of European origin who have been nurtured under favourable conditions; in most cases they have been expressed in means and standard deviations.

The great value of this book is that it is very practical. Elaborations of anthropometric measures and indices are limited to five each, and have been chosen for their simplicity and for their usefulness over the whole span of childhood and adolescence and for their special relevance to sexual differentiations. Most physicians wishing to make use of the extensive lists of charts and tables should be prepared to take three measurements in addition to the conventional heights and weights.

Although a different presentation might have been required, it is unfortunate that Prof. Bayer and Dr. Bayley have not rounded off such an eminently useful work by the inclusion of relevant information for babies up to the age of one. This is the age-group which commands greatest interest and which could act as a starting point whereby British physicians might take a greater interest in the subject of growth diagnosis.

This book would be appreciated by members of school medical services, maternity and child welfare officers, general practitioners, Service and industrial medical officers, and all students of human biology who are interested in promoting the positive health of children and teenagers.

K. M. HAWKINS

RED, ROE AND FALLOW

Wild Deer

By A. J. de Nahlik. Pp. 240 + 26 plates. (London: Faber and Faber, Ltd., 1959.) 70s. net.

IN the past five or six years there has been a great increase in interest in the wild deer of Britain, both by naturalists and by sportsmen. The Deer Group of the Mammal Society of the British Isles focuses the naturalists' interest and the St. Hubert Club the sporting interest. Squadron-Leader de Nahlik is a member of both, and his book links the two interests, but leaning rather on the sporting side.

He confines himself to three species out of the five or six that are at present running wild in British woods, namely, the native red and roe deer and the probably introduced fallow. The three aliens which he ignores are the widespread sika, the locally common (in the Midlands) muntjac or barking deer, and the much more local Chinese water deer. The book is the fruit of many years field experience of deer, both in Britain and on the Continent, and no doubt the reason that the sika and muntjac are omitted is because the author has not wished to write about animals of which he has no personal experience.

Into the natural history of the red, roe and fallow the author goes reasonably fully, dealing especially with their annual breeding cycle, antlers and how to recognize them at various stages of their development. He tackles next the problem of damage by deer to farming and forestry, and the various methods of control, including the use of chemical repellents. These last have been much more fully investigated on the Continent than in Britain, and it is most useful to have a full list of them, their uses and manufacturers, for the first time in any book on British deer. Other chapters discuss the various niceties of deer shooting and stalking, and so are of less interest to the naturalist, except in so far as the management of a deer forest needs to be done scientifically. However, even naturalists enjoy venison, so the appendix of various ways of cooking this delicacy will doubtless have a wide appeal. There is also a valuable glossary at the end, in which not only are such technical terms as 'beam', 'gralloch', 'tine' and 'trey' explained, but also their equivalents are given in five European languages: German, French, Spanish, Italian and Polish. The book is well illustrated with black-and-white photographs and there are some thirty diagrams in the text.

R. S. R. FITTER

THE ARADIDAE

Classification of the Aradidae (*Hemiptera-Heteroptera*)

By Robert L. Usinger and Ryuichi Matsuda. Pp. vii+410. (London: British Museum (Natural History), 1959.) 80*s*.

THE Aradidae are a small family of mycetophilous bugs mostly occurring on or in wood of forest trees. Before the appearance of this book they comprised some 64 genera and 685 species, and had not been comprehensively studied since the time of Stål. As Prof. Usinger points out, accident and mischance held back taxonomic advances in this group; but the dispositions made in the present work result so extensively from the study of new material that it would seem unlikely that they would have been anticipated had earlier work been completed on the basis of existing collections.

The arrangement is logical and the presentation easy to comprehend. At the beginning, 28 pages, illustrated with 20 figures and two plates, are devoted to morphology, and facilitate interpretation of the descriptive text. This section is furnished with a separate bibliography. Seven pages are devoted to the biology of Aradidae, and as most of these are occupied by a long table of plant associates, it is evident that almost everything has yet to be learned about the preferences of species for their fungal substrates. Nevertheless this section is tersely written, and conveys a substantial amount of information. Geographical distribution is treated in the eight pages which follow, in which a tabular synopsis of generic distribution between seven zoogeographical areas is followed by a discussion of salient points. The reader will find it necessary to seek amplification of the data in the descriptive part of the text, especially with regard to the genera pigeon-holed in the 'Neotropical' column.

The classification itself occupies 326 pages, and (to quote Prof. Usinger) "is, in effect, a generic classification . . . with new species described only when necessary to validate new generic names or when desirable to elucidate little-known groups". The new matter comprises two subfamilies, fifty-nine genera and about eighty-two species, and almost doubles the number of genera hitherto known, and increases the number of species by nearly 12 per cent.

In Aradidae, as elsewhere, it is not easy to recognize close relationship through common ancestry as opposed to parallel evolution, and the authors have judiciously used zoogeographical data as a criterion of natural relationship. This serves to throw into prominence the anomalous cases which remain, such as the distribution of species of *Ctenoneurus* (Australasia and West Africa). Lists of species are provided after each genus, and sometimes keys, but "only where they are up-to-date or complete on the basis of work done by the senior author in European Museums in 1948–49". The descriptions are uniform and exhaustive; but the bizarre contours of an aradid give especial point to the dictum that a drawing, however crude, is better than a torrent of the most carefully selected adjectives, and the authors have percipiently illuminated the text with superb line illustrations. In large part their inclusion was made possible by a grant from the Trustees of the British Museum, and readers will applaud their action. The book is completed with a bibliography of eighteen pages and an index to all taxonomic categories in the family.

R. G. FENNAH

PARASITES, IMAGINARY AND REAL

Parasites and Parasitic Infections in Early Medicine and Science

By Prof. R. Hoeppli. Pp. xiv+526+23 plates. (Singapore: University of Malaya Press; London: Oxford University Press, 1959.) 25 Malayan dollars; 63*s*. net.

REINHARD HOEPPLI is known to parasitologists as the author of many papers on helminthic and other parasites and various aspects of parasitism. His work during the past forty years has been concerned with experimental parasitology and pathology as well as morphology and taxonomy, but sometimes he has written, with or without collaborators, on ancient knowledge in this field. Such papers on the history of his subject have appeared more often during the past ten years and they seem to have formed the basis of this meticulous book, which is divided unequally into three parts.

Part 1 (11 chapters and 269 pages) deals with the earliest period up to the middle of the seventeenth century, covering such topics as the knowledge of parasites, clinical symptoms, imaginary and false parasites, the doctrine of spontaneous generation, therapeutic and cosmetic uses to which parasites have been put and the treatment and prevention of infection.

Part 2 (12 chapters and 198 pages) concerns special parasitological subjects of historical interest such as malaria, dysentery, leeches and scabies in Chinese medicine, some early views shared by the people of Borneo, Malaya and China, and ancient opinions held by the indigenous populations of Fiji and Tahiti. One chapter discusses exchange of ideas concerning infections, and it may well indicate some of the ways in which parasites themselves were spread.

Part 3 is a very short outline of 16 pages concerned with the increase in knowledge of parasites from the middle of the seventeenth century to the middle of the nineteenth, and this contains so many names of parasites and persons that other readers may also wish that the author had amplified this portion of his text. The book ends with a short conclusion, an appendix of 8 pages on the role of parasitic diseases in history, a subject index, an index of names, and 23 plates illustrating ancient conceptions of parasites, imaginary parasites, magic treatment and various kinds of indigenous medical treatment in Sarawak.

The author's aim has been "to give a picture of early parasitology by showing the actual knowledge of parasites and parasitic infections of the time together with prevailing ideas, common beliefs and errors formerly connected with parasites".

The book is largely anecdotal and discursive, and the author has given many quotations from early Chinese, Greek, Roman, Italian, French and German authors, together with translations of them. Much ancient lore about fears and superstitions, materia medica and whimsical forms of treatment is displayed, and it ranges from the horrific to the mildly amusing.

Imaginary parasites included the corpse worm, supposedly undergoing six transformations before finally appropriating the soul and leaving the patient's body to infect a close relative with the wasting disease phthisis. Another was the echoing worm, which produced an abdominal echo whenever the patient spoke. One patient read the herbal "Pen Ts'ao" as far as the description of Lan (indigo plant), when the echo subsided. He then took some juice of Lan and was sick, and the echo was heard no more! Another patient read on as far as thunder pills, took some of these, and likewise cured himself. Silence was essential during the preparation of the medicine, because the parasite would refuse to emerge should it hear any word about the drug to be used.

The reader is also reminded that pseudo-parasites flourished long after the compound microscope was pressed into service. For two centuries spermatozoa were regarded as Infusoria, and von Baer considered them to be a kind of cercaria. The doctrine of spontaneous generation is considered in its application to parasites and the possible origin of parasites as inborn entities is also reviewed. The Preformationist Vallisnieri believed that all future helminths, as well as all future human beings, were contained in the ovaries of Eve!

As reading proceeds, however, the impression lingers that this is not so much a book as a somewhat restricted and disjointed collection of papers. Indeed, 12 chapters of Parts 1 and 2 are based on previously published papers, although this is indicated only by footnotes. Some chapters are scarcely worthy of the name, because they are short topics which would scarcely be missed if deleted. Chapters 6, 7 and 8 in Part 1 and Chapter *G* in Part 2 are examples. The book contains much that is not strictly parasitological, for example, Chapter *K*, Part 2, which deals with the role of the Moon in biology and medicine. In only the short third section (3 pages of notes) are parasites mentioned, and the chapter ends with the conclusion that "no such (supposed) influence has ever been proved", reported cases falling down under "scientific criticism" or being "pure superstition".

Yet, Prof. Hoeppli's book deserves to be widely read by parasitologists, as no doubt it will be, though its theme fosters the view that there is something horrific about parasites, which work towards the discomfiture and often the destruction and death of their hosts. This may well be true of many of the parasites of man and domesticated animals, but it is an inaccurate conception of parasitism. The book does show that many errors of judgment have gone in procession down the ages, which may have a salutary effect on parasitologists who accept over-readily what has passed before as irrefutable truth. In such a way, this book may act as a spur to further research.

BEN DAWES

PROGRESS IN PLANT PATHOLOGY

Plant Pathology

Problems and Progress, 1908–1958. Edited by C. S. Holton, G. W. Fischer, R. W. Fulton, Helen Hart, and S. E. A. McCallan. Pp. xix+588. (Madison, Wisconsin: University of Wisconsin Press, 1959. Published for the American Phytopathological Society.) 8.50 dollars.

Plant Pathology

An Advanced Treatise. Edited by J. G. Horsfall and A. E. Dimond. Vol. 1: The Diseased Plant. Pp. xiv+674. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 22 dollars.

In design and purpose these two books are very different but each reflects the progress in plant pathology that has taken place during the present century, and each is the result of an international effort to present an accurate picture of the stage reached. One is the published record of the 1958 golden jubilee meeting of the American Phytopathological Society, which took the form of a series of seven major reviews and nine academic symposia chosen to cover all the important facets of plant pathology. The meeting and the book were carefully planned in advance, with the written part subject to certain manuscript specifications that controlled the form but not the content of the contributions. The other was designed to present an integrated synthesis of the parts of plant pathology for the advanced student. Its framework was constructed with enthusiasm by two distinguished editors with unconventional ideas, who have left their impress in greater or less degree on the content as well as on the form of the contributions. The jubilee volume is self-contained, and is essentially a record, if a selective one, of research carried out: the treatise, with a text about two-thirds the length of the other and decidedly more expensive, is only the first of three volumes which together are intended to provide a comprehensive theoretical treatment of plant pathology.

The first part of the jubilee volume is devoted to addresses given by Prof. E. C. Stakman and six other American plant pathologists of international standing. They review the status and role of plant pathology in the scientific and social development of the world, its growth in North America and the part played by the American Phytopathological Society, as well as certain landmarks in control of disease through host resistance and by the use of chemicals. The symposia, which make up the rest of the book, cover such diverse topics as the physiology of parasitism, the genetic mechanisms governing pathogenicity and disease resistance, soil fungi, the structure and multiplication of viruses, epidemiology, fungicides, and the concepts and problems of nematology. It is only meet and right that most of the contributions should issue from North America, but there are eleven from Britain, including five from Rothamsted, together with a few from Australia, South Africa, Germany and the Netherlands. The inclusion of a section on nematology in a work on plant pathology is no longer the surprise it was to the British plant pathologist, who is likely to find heavier going in the plant virus section, though once again F. C. Bawden displays his great skill in lucid presentation. The history of the American Phytopathological Society and of its journal *Phytopathology* makes interesting reading. The Society, which began with a subscription of 50 cents and 130 charter members, is now nearly 2,000 strong. Its originator, C. L. Shear, was the first secretary-treasurer and L. R. Jones the first president. The book is very good value for money.

In the "Treatise" the diseased plant is the important object and the pathogen takes second place. Indeed, it is relegated to a second volume which will focus attention on the pathogen, on techniques inhibiting it, and on pathogenicity, while the third volume will cover the public health aspects of the subject, including disease epidemics and their control. In this first volume there are a few introductory chapters on the history of plant pathology, its relationship to other scientific disciplines, and losses caused by disease, but the text is largely devoted to the suffering plant, to pathological processes, defence mechanisms, predisposition and therapy. As the editors make clear in their prologue the main theme revolves round the pathological processes, and it is on these processes that diseases must be classified. Thus we read about tissue being disintegrated instead of about necrosis; about growth being affected rather than morbid anatomy; and about water deficiencies rather than wilts; but the result is not always very different from what one is used to. The general standard of the text is high, though rather diffuse in places. Nearly half of it was written in the United States, but there are five contributions from Europe and Asia, with the promise of substantial British participation in the two volumes still to be published.

W. C. Moore

MYCORRHIZA

The Biology of Mycorrhiza

By Dr. J. L. Harley. (Plant Science Monographs.) Pp. xiv+234+11 plates. (London: Leonard Hill (Books), Ltd., 1959.) 55*s*. net.

THIS publication is an important event in the progress of research on mycorrhiza. Dr. Harley provides us with a clear account of what is known in this field (hitherto notorious for its confusion) and shows also where the considerable gaps in our knowledge lie. It will be surprising and disappointing if this stimulating monograph does not benefit both the quantity and quality of future research on mycorrhiza.

It is about eighty years since Frank first noted the widespread association of root and fungus which he termed 'mycorrhiza'. Since then a great deal of work and thought has been given to these organisms, but perhaps without commensurate increase in understanding. Difficulties are obvious: the structures are hidden in the soil; the small scale, especially of some of the fungus partners, hinders anatomical study; culture of one partner without the other is often difficult or impossible; and certain appropriate techniques have only recently become available. Apart from such technical difficulties, this complex subject seems to have attracted an excess of sterile hypothesis and slipshod thought.

It is the virtue of Dr. Harley's monograph that it carefully points out these areas of imperfect experimentation and thought (and language: the index includes "Thamniscophysalidophagy, term not used on page 195"). Having done so, it avoids further treatment of these aspects, and concentrates on the firmer ground, incidentally revealing outstanding problems where research may most usefully be applied. In several fields Dr. Harley has been able to develop arguments that enhance our appreciation of the significance of mycorrhizal phenomena; for example: (1) he has pointed out that all roots growing in soil are inevitably surrounded by and interacting with special local populations of micro-organisms, and that the mycorrhiza is a special case of this general relationship; (2) studies made by Dr. Harley and his students using labelled phosphate and excised beech mycorrhizas enable him to outline the general mechanism by which ions are actively absorbed and accumulated by the fungal sheath and afterwards transferred to the root; (3) by stating the evidence for and against nitrogen fixation by the fungi of ericoid and orchid mycorrhizas, he makes it clear that the widespread acceptance of the hypothesis that these organs fix nitrogen is unjustified.

The literature of mycorrhizas is scattered, since it enters the fields of plant physiology and anatomy, mycology, forestry, and soil science. Some of the publications are not easily available, and a number are in languages that most workers cannot read. Consequently the collection of recently published material in this monograph will be particularly useful to those embarking on research. For students, too, this book is bound to be valuable, though it would have been more attractive and useful to them if the plentiful illustrations promised by the publishers were in fact present. The only anatomical figures are a transverse section and partial longitudinal section of beech mycorrhizas, and three figures of aseptate hyphæ and vesicles. This deficiency is only partially alleviated by some plates.

The mycorrhizal condition is not merely an absorbing problem for academic research. It is a condition that is "at least as usual amongst the seed plants as the uninfected state"; and phycomycetous mycorrhiza, of which astonishingly little is known, occur in many important crop plants—date-palms, cocoa, tea, coffee, legumes, cereals, and grasses. If the symbiosis is highly integrated it may be satisfactory, for ecological and agronomic purposes, to treat the dual organism as a single unit; but it is not certain that integration is as complete as this. For applied purposes, therefore, as well as in its own right, mycorrhizal research is needed; and for such research this excellent book will be a stimulus and guide.

J. Warren Wilson

THE BANANA

Bananas

By N. W. Simmonds. (Tropical Agriculture Series.) Pp. xvi+466+93 photographs. (London: Longmans, Green and Co., Ltd., 1959.) 45*s*. net.

A VAST amount is now known, and has been written, about many of the major crops. When that crop is an exotic one like the banana, cultivated virtually throughout the tropical belt and also in many sub-tropical regions as a prime source of food and other commodities, then we have indeed an unusually rich and varied subject for the scientific writer, especially if his interests are liberal. Bananas, in their considerable variety and diversity, afford interesting materials not only for the professional botanist and agriculturist but also for those who concern themselves with the early history of man and his migrations. In some parts of the world bananas are, of course, very big business. An adequate account of all these aspects, and many others, is now available in the up-to-date book prepared by Mr. N. W. Simmonds, formerly senior cytogeneticist at the Imperial College of Tropical Agriculture, Trinidad.

The book contains chapters on the general botany, morphology, anatomy, composition, and systematic position of species of the genus *Musa*. Other chapters deal in a very thorough manner with the classification and nomenclature of wild and cultivated varieties, and with the cytology, genetics and breeding of commercially useful hybrids. These constitute the most important scientific parts of the book, including as they do much of the author's personal contribution. There are also accounts of the agricultural management of the crop, its major diseases and pests, and the handling and ripening of the final product—the bunch and individual fruits. Of course, the banana is a very remarkable plant and the general reader will almost certainly derive both pleasure and interest from the chapters dealing with the history of the industry and the uses to which the fruit can be put; for bananas can not only be eaten as dessert fruits: they can be cooked in various (?) attractive ways, made into sweets and powder (flour), dried into 'chips' and 'figs', brewed into beer, and so on. Such a commodity could scarcely fail to have many medico-magical uses. The book is handsomely illustrated by plain and coloured photographs and line drawings, while certain general phenomena are depicted by means of ingenious diagrams.

By his novel and attractive treatment of this major tropical plant, Mr. Simmonds has contributed an important work of scholarship, rich in its botanical and scientific content; and because of its directness and lucidity, it may well have a more general appeal.

The book will certainly be read with appreciation by members of the planting community and by research workers. Indeed, in my opinion, no book on the banana of equal status and content has hitherto been published. C. W. Wardlaw

TROPICAL ANIMAL HUSBANDRY

An Introduction to Animal Husbandry in the Tropics

By G. Williamson and Dr. W. J. A. Payne. (Tropical Agriculture Series.) Pp. xix+435+48 plates. (London: Longmans, Green and Co., Ltd., 1959.) 48*s*. net.

THIS is a book with a large number of facets. While written for the animal husbandman in the tropics, for whom it will be invaluable, it incidentally gives much information of physiological, zoological, nutritional and sociological interest.

The earlier chapters are devoted to scientific information on conditions in the tropics—a description of climates and the direct effects of them on the animal through solar radiation, temperature, humidity and daylight hours, as well as the indirect effects through feed supply. Prevalent infections and insect-transmitted diseases with remedial measures are described. Nutrition is approached from a wider angle than is to be found in the usual text-book. Prominence is given to things such as water supply—the number of days different species can do without it and the amount they drink. Types and nutritional value of vegetation to be found under different climatic conditions are described. The rapid growth and seeding of plants in the tropics and the longer growing period in many areas which lead to practices such as burning and standing hay are discussed and better methods suggested.

In the chapters devoted to husbandry some typical tropical breeds in each species are described. The whole range of husbandry practices from the very primitive to modern methods is detailed—from the kraaled cattle at night in Africa, where short-day grazing limits production, to the modern methods adopted by the Aarey Milk Colony in Bombay; and from the primitive fermentation method of hatching hens eggs to the use of the modern incubator. Comparisons of production in temperate as compared with tropical zones are also given. While in Western Europe 660 lb. of milk are produced per capita of the human population, Africa only produces 46 lb.; again, there are five times as many sheep, only half as many goats and twice as many pigs in the temperate as compared with the tropical zones.

Of particular interest are the chapters written by experts on special subjects. The buffalo produces most of the milk consumed in India and Egypt in spite of the fact that its heat-regulating powers are not so good as those of the zebu. Camels produce a calf only every other year and the period of rut in the male, induced by lengthening days, lasts only for a period of about three months; if deprived of water they can drink up to 20 gallons at a time, an amount which would result in water intoxication in other species. An account of the African nomad, the circumstances which cause his mode of life and ways in which he could be settled are also outlined.

Throughout the book references are given to the more important original papers dealing with livestock production in the tropics. John Hammond

ORGANIZATION, CONTROL AND SYNTHESIS IN MICRO-ORGANISMS

Annual Review of Microbiology

Vol. 13. Edited by Charles E. Clifton, in association with Sidney Raffel and Mortimer P. Starr. Pp. viii+553. (Palo Alto, Calif.: Annual Reviews, Inc., 1959.) 7 dollars.

THE past two decades have seen the transformation of microbiology from an 'applied science' to a subject which is making fundamental contributions to many and varied fields of biological research. As the ever-increasing mass of publications so amply testifies, it is a subject still in its logarithmic phase of growth and thus the demand for concise and critical surveys of recent advances becomes greater year by year; for the past twelve years "Annual Reviews of Microbiology" have met this demand. The thirteenth volume in this series will disappoint no one; it contains twenty-one articles which cover aspects of microbiology ranging from the biosynthesis of macromolecules to the intriguing subject of 'unicellular clocks'.

Microbiological research in recent years has been dominated by the problems of biosynthesis, intracellular organization and mechanisms of biological control; one third of the contributions in this volume are concerned with these questions. Roberts, McQuillen and Roberts, in an article entitled "Biosynthetic Aspects of Metabolism" present an admirable account of current views on the synthesis of protein, ribonucleic and deoxyribonucleic acids. They discuss recent advances under four headings: first, those made by using purified enzyme preparations, second, reactions which are observed with cellular fragments, third, reactions of intact cells, and finally, the effect of various inhibitors and certain biological or physical disturbances on biosynthetic reactions. A more specialized aspect of the biosynthesis of macromolecules, the synthesis of antibodies, is discussed in an article by Bussard.

Genetic control of biosynthesis forms the subject-matter of two reviews. The first, by Demerec and Hartman, surveys knowledge of the complex structure and chromosomal arrangement of gene loci concerned with sequential steps in biosynthesis. In the second, Hartman and Goodgal deal with the transfer of genetic material in bacteria, mediated either by cellular contact, free deoxyribonucleic acid or bacteriophage. The genetics of bacteriophage are discussed in a separate contribution by Bresch. Another aspect of biological control is presented by Hastings under the heading of "Unicellular Clocks", in which he discusses the persistent diurnal rhythms which influence phototaxis, luminescence, sexual activity and cell division in certain flagellates and ciliates.

Ultimately, the biochemists' concepts of synthetic mechanisms and the geneticists' views of controlling mechanisms must be correlated with the cytologists' interpretation of intracellular organization. Clearly much remains to be discovered before such a correlation can be completed; however, Mitchell has attempted to fit together many of the available pieces of the 'jig-saw puzzle' under the title "Biochemical Cytology": this is a most stimulating contribution.

Catabolic aspects of metabolism surveyed include: fermentative metabolism (Rabinowitz), sulphate reduction by bacteria (Postgate) and aspects of terminal respiration in micro-organisms (H. L. Kornberg). This latter review provides a valuable survey of evidence for the occurrence of the tricarboxylic acid cycle in micro-organisms and indicates some of the difficulties and pitfalls encountered in the study of microbial oxidative processes.

Other topics reviewed include: plant diseases (three articles); new antibiotics and the use of antibiotics in food preservation; the biology of Tetrahymena; the physiology and development of Phycomycetes; non-specific resistance to infections in animals; immunological tolerance; new viruses; microbiological aspects of tissue culture.

There can be no doubt that this volume will be of value to all who observe the devious ways of micro-organisms. The editors are to be congratulated for selecting such a wide and interesting range of topics and the reviewers for their courage and skill in attacking, sorting and surveying such a formidable mass of data. B. A. NEWTON

BIOCHEMICAL DATA

Data for Biochemical Research

Edited by R. M. C. Dawson, Daphne C. Elliott, W. H. Elliott and K. M. Jones. Pp. xiii+299. (Oxford: Clarendon Press; London: Oxford University Press, 1959.) 63*s*. net.

SCIENTISTS owe much to the patient endeavours of authors and editors of reference works such as "The Handbook of Chemistry and Physics", "Documenta Geigy Scientific Tables" and the "Merck Index". In the present book information which is of particular interest to biochemists has been collated.

The subject-matter is sub-divided into fifteen sections, namely: table of biochemical compounds; enzymes commonly used as laboratory reagents; buffers and physiological media; methods for the detection of biochemical compounds on paper; the properties of some ion-exchange resins; isotopic data; manometry; nomograms for manometer constants; ammonium sulphate solutions; miscellaneous reagents, tests and recipes; acid-base indicators; table of normalities; autoclaves: temperature-pressure conversion table; miscellaneous formulæ; international atomic weights, 1955.

More than half the book is devoted to the first section, which tabulates various features and properties (structural formula, molecular weight, solubility, optical rotation, etc.) of about one thousand compounds of biochemical interest. The compounds are arranged in nineteen different groups, beginning with amino-acids, peptides and related nitrogenous compounds and ending with macromolecules. The type of information provided varies according to the particular needs of the group. Thus, spectral data are provided for porphyrins and related compounds but not for lipids and fatty acids. Wherever possible, general group references and references to methods of preparation and estimation are given and a column of general remarks provides additional useful information.

The chief merits of the book appear to lie in the first section and that on methods for the detection of biochemical compounds on paper. In the latter section the compounds are grouped appropriately, numerous references are given and the information is presented in a readily accessible form. Some of the remaining sections are of less-certain value and material sometimes appears to have been selected in an arbitrary manner.

The editors have wisely stated that the book is not intended to be an exhaustive work of reference and, indeed, many readers will be disappointed that their own particular interests are not catered for. In spite of the editorial proviso it is surprising, for example, that such well-known compounds as fibrinogen, chitin, hyaluronic acid and chondroitin sulphates *A*, *B* and *C* are not listed under 'Macromolecules' in the first section. The important phosphato-sulphate nucleotides, discovered in 1956 by Lipmann's group, are not listed with other nucleotides or, indeed, anywhere in the book. The section on properties of some ion-exchange resins could surely have been extended to provide information on the important cellulose ion-exchangers.

Several authors have contributed to the book and it is perhaps not surprising that some inconsistencies appear. Thus in the first section, under "Carbohydrates and Related Compounds", the Haworth ring-form is used to formulate the compounds. In contrast, under "Phosphate Esters, including Nucleotides", the less appropriate Fischer-Tollens ring structure is generally used. Hydroxymaleic and hydroxyfumaric acids are correctly formulated in *cis* and *trans* forms respectively. The unsubstituted acids, however, are given identical structures.

As a complete reference work for biochemists the book has obvious limitations. However, as an adjunct to the works mentioned in the opening paragraph of this review, the book will undoubtedly be of value to most biochemical laboratories.

K. S. DODGSON

GENERAL BIOCHEMISTRY

Traité de Biochimie Générale

Par M. Javillier, M. Polonovski, M. Florkin, P. Boulanger, M. Lemoigne, J. Roche et R. Wurmser. Tome 1: Composition Chimique des Organismes. Premier Fascicule: Pp. iv+1–706. Deuxième Fascicule: Pp. iv+707–1475. (Paris: Masson et Cie., 1959.) Broché 22,000 francs; Cartonné toile 24,500 francs les deux volumes.

THE undertaking of a five-part treatise on general biochemistry is a formidable enterprise. The rapidity with which the subject is developing at the present time sometimes induces in potential authors of books on it a continued temptation to procrastinate. Their answer to a suggestion that they might write a book often follows this sort of pattern: "The subject, particularly those parts of it in which I am most closely concerned", they say, "is so rapidly advancing at the present time that no general review of it is worth while recording in a book" . . . "But in one year's time, perhaps two, the air should have cleared and I shall be able to write an account which is much more satisfactory than anything that can be produced to-day". It is always to-morrow that there will be jam for tea; never to-day.

Fortunately, not all are so faint-hearted or cautious. It is perhaps natural that, in the language of the country which bred the first modern encyclopædists, a group of distinguished French-speaking biochemists, most from France itself, should have decided to undertake the task of imprisoning within the limits of a few thousand pages the essentials of a subject which, perhaps more than any other, resembles Proteus in modern guise.

The Board of Editors consisted of Profs. M. Javillier, M. Polonovski, M. Florkin, P. Boulanger, M. Lemoigne, J. Roche and R. Wurmser, with P. Boulanger and J. Polonovski acting as secretaries. Although Prof. M. Polonovski was killed in a road accident soon after the plans had been agreed, and M. Javillier also died before the completion of the work, the remaining editors decided to continue along the agreed lines, and the first section, in two parts, is now published. The complete work will fill three tomes, totalling five parts altogether.

The two parts of the first section are devoted to a survey of the chemical composition of living matter. Introductory chapters deal with the elementary composition of organisms and their mineral constituents, and then follow chapters on carbohydrates, lipids, in which are included sterols, steroids, carotenoids, terpenes and terpenoids, and on organic acids and phenols. Some of Part 1 and most of Part 2 are taken up with treatises on amino-acids, peptides and proteins. A section on substances attached to proteins includes a useful review of alkaloids. Part 2 concludes with a discussion of the associations formed between the substances dealt with, for example, lipid-protein complexes, antigen-antibody and enzyme-substrate complex formation, and a brief discussion of the borders of biochemistry with respect to organization and morphology.

The editors and authors aim to present the principles of biochemistry which in their view are essential for students of chemistry and physiology, pharmacy and medicine, agriculture and technology. How far such an aim has been achieved will be clear from the completed work; but on the basis of the first two parts it can be said that no reason has yet emerged why the authors should not succeed in their ambitious enterprise.

F. G. YOUNG

ANTIGENS, TRANSPLANTATION AND TOLERANCE

Biological Problems of Grafting

A Symposium sponsored by the Commission Administrative du Patrimoine Universitaire de Liège and the Council for International Organizations of Medical Sciences. Pp. xii+453. (Oxford: Blackwell Scientific Publications, 1959.) 50*s*. net.

A SYMPOSIUM on the biological problems of grafting was held in Liège during March 18–21, 1959, under the chairmanship of Prof. P. B. Medawar. The number of participants was limited and most of them presented papers which, together with the relevant discussions, are now published in full. A total of twenty-nine papers was given, ranging over most of the current controversial problems in transplantation. These include the identification of the transplantation antigens, the investigation of the mechanism of the homograft reaction, the means by which tolerance may be induced and its attendant difficulties of the runt syndrome and homologous disease.

A review by P. B. Medawar on iso-antigens gives a very useful introduction to this subject, and the papers by P. A. Gorer and J. H. Berrian and R. J. Jacobs detail important recent experimental work on transplantation antigens. The similarity between skin transplantation immunity and hypersensitivity of the delayed type in guinea pigs is discussed by Brent, Brown and Medawar; they consider that their results support the hypothesis that reaction against skin homografts is mediated through cells rather than through serum antibodies. In a very interesting paper R. T. Prehn describes the effects of antigen dosage, route of administration and splenectomy on homograft reaction. He speculates that the spleen may play an important part in the prevention of auto-immunization as well as in the 'enhancement' phenomena by producing an immunity-inhibiting antibody.

Hasek reviews the various methods of inducing tolerance, and Haskova reports that although transplantation antigens are present in cell-free extracts such extracts fail to induce tolerance. Mitchison describes some original experiments on blood transfusion in the fowl and shows that in this system the persistence of tolerance is dependent upon the persistence of the antigen. This paper provoked interesting and stimulating discussion on the nature and mechanism by which tolerance is induced and sustained.

Several papers dealt with the allied problems of the runt syndrome and homologous disease, and ample evidence is presented to support the thesis that both these phenomena are due to the immunological reaction of foreign cells against a tolerant host. Simonsen and Jensen describe an ingenious graft versus host assay, and Gorer and Boyse suggest that the destruction of host lymphoid cells and tissues may be in the nature of an allergic reaction.

One gains the impression that this symposium was of great interest and benefit to those who participated, since many of the most interesting ideas and speculations were brought out in the addenda and discussions. The editors, organizers and publishers are to be congratulated on the speed of publication (the book was available at the end of last year) although the presentation of the book has suffered thereby. There are several errors in the list of contents and the absence of an index is a marked disadvantage both to the general reader and to those seeking a work of reference. The composition and arrangement of the twenty-nine papers varies considerably; only eleven had summaries and of the four papers in French only two had summaries in English. The collection of the material under appropriate subject headings would have been advantageous. For example, although the problem of overcoming the practical difficulties inherent in transplantation is considered in some papers the data are not presented in such a way as to be readily accessible to surgeons and others with little time to read all 453 pages.

However, this is a comprehensive volume of papers for workers in this field and the reviews of recent work would be useful for those already familiar with current trends.

D. M. V. PARROTT

GENERAL PHYSIOLOGY

Principles of General Physiology

By W. M. Bayliss. Fifth Edition by Dr. L. E. Bayliss. Vol. 1. Pp. xiii+520; Vol. 2. Pp. xxii+848. (London: Longmans, Green and Co., Ltd., 1959 and 1960.) Vol. 1, 55*s*. net. Vol. 2, 90*s*. net.

A Textbook of General Physiology

By Dr. Hugh Davson. Second Edition. Pp. xvi+846+32 plates. (London: J. and A. Churchill, Ltd., 1959.) 84*s*. net.

IN 1916 appeared the first edition of "Bayliss" and in 1951 that of Davson. Claude Bernard had defined general physiology as "the study of phenomena common to plants and animals". William Bayliss, in the first edition of his "Principles", had adopted Burdon-Sanderson's definition "the study of the endowments of living materials". Dr. Davson indicated that in practice Bayliss restricted this study to those aspects of living material which showed some immediate prospect of being described in terms of the known laws of physics and chemistry.

He referred to the fact that Dr. Leonard E. Bayliss, son of Sir William Bayliss, was preparing a fifth edition of his father's "Principles". Despite the years since it was first written (1916) and since its last edition in 1924, it still led the field. This fifth edition shows changes in format, in ambit and approach, so marked that even the publishers seem uncertain as to the author. On page iii (the title-page) it is described as by L. E. Bayliss; on page iv as the "Fifth Edition of W. M. Bayliss's Principles by L. E. Bayliss". What does it matter? The genetic interrelationship is so close that the initials are almost of no importance. Dr. Leonard Bayliss has had a bigger task, which he has accomplished by scrapping entirely the old book and writing two volumes, one largely on physical chemistry in its own right and a second (entitled "General Physiology") on the applications in living material. In this, he has been singularly successful, for the internal classification within these volumes is a physiological classification based on function and not on morphological systems. This he has illustrated by studying phenomena at all levels in botany, zoology and microbiology. He has some beautiful discussions on the applications of modern physics in even more modern biology, particularly in the chapter on servo-mechanisms.

Dr. Davson's book has three new chapters, on "Sensory Response", on "Excitability of Cardiac Muscle" and on "Electrical Activity in Smooth Muscle". He stresses functional energy in metazoa and particularly in the integrated vertebrate. He is therefore most informing when discussing the underlying biophysics of mammalian physiology. He has also been able to focus on the last decade aspects of cell structure, particularly the work of Watson and Crick in regard to inclusion bodies, nucleo-protein, the cell membrane, protein synthesis and viruses.

General physiology is splitting into biophysics and biochemistry, and biomathematics. The recent finding of polarization in light coming from Mars, suggesting absorption bands reminiscent of carbon–hydrogen chains and of cellulose, points to a bio-astronomy. The physicist is making serious endeavours to utilize models as an aid to interpretation of the nervous system. Sir Cyril Hinshelwood, in his presidential address to the Royal Society last year, suggested the time is ripe to apply modern scientific disciplines to the study of the paranormal phenomena of extra-sensory perception. The all-in-all book embracing the whole of general physiology is going to be more and more difficult to write and maintain.

These two branches, from the root stem Sir William Bayliss, are most impressive; each author has had a somewhat different task, each has worked differently and each produced a book that is invaluable. What is both interesting and important is that, while different, they integrate and reciprocate with each other and the possession of one is no reason for not possessing the other.

A. ST. G. HUGGETT

ANALYTICAL CHEMISTRY OF POLYMERS

Analytical Chemistry of Polymers

Edited by Gordon M. Kline. Part 1: Analysis of Monomers and Polymeric Materials: Plastics—Resins—Rubbers—Fibres. (High Polymers: a series of Monographs on the Chemistry, Physics and Technology of High Polymeric Substances, Vol. 12, Part 1.) Pp. xviii+666. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 125*s*.

INDUSTRIALLY, the term high-polymers covers vinyl plastics, condensation polymers—important in the synthesis of fibres, resins and drying oils—natural and synthetic rubbers, proteins, ion-exchange resins and many other special classes. In each of these fields special procedures for physical and chemical analysis have been developed and their description is widely scattered throughout the literature, in industrial specifications and in research reports.

This book, which is the collective work of twenty-six authors who are all members of the staff of American industrial concerns, brings together in one volume methods of analysis which have been used successfully in the determination and testing of commercial monomers and polymers. The methods for the determination of physical properties and chemical composition of each of the major industrial polymers, namely, acrylic plastics, alkyls, amino-resins, cellulose derivatives, epoxy resins, ethylene and fluoroethylene polymers, furan resins, natural resins, phenolic resins, polyamides, polyesters, proteins, rubbers (natural and synthetic), silicones, styrene monomers and polymers, vinyl polymers and co-polymers, and synthetic and natural fibres, are summarized in a separate chapter.

In each case methods are described for the assay and determination of pertinent impurities in the monomers; this is followed by a discussion of analytical problems of identification and characterization of the chemical composition and physical properties of the polymers. Special chapters are devoted to plasticizers, ion-exchange resins and drying oils. In general, the main features of the analytical method and apparatus used are described and the reader is referred to the original publication for detailed directions. In cases where the methods have not been previously published, full details of the procedure are given.

The book provides the best survey and compilation I have seen, and it should be of great use to the practising polymer chemist and analyst. The editor has been successful in bringing together a very valuable collection of information on polymers, and in the second volume, which is in preparation, it is intended to cover the subjects of molecular structure determination, chemical group analysis and identification procedures for polymers.

C. E. H. Bawn

THE ORGANIC CHEMISTRY OF SULPHUR

Aspects of the Organic Chemistry of Sulphur

By Prof. Frederick Challenger. (Organic Chemistry Monographs.) Pp. vii+253. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1959.) 40*s.*; 7.50 dollars.

A CONSIDERABLE portion of Prof. F. Challenger's researches have been concerned with organic derivatives of sulphur, and a book on this subject written by him is greatly welcome. He has chosen six topics to discuss, each as a separate chapter, and naturally occurring organic derivatives occupy a prominent position. Many of the subjects discussed are those which he has studied intensively in the course of his own work, and upon which he can therefore write with particular authority.

The first two chapters, on "Simple Organic Compounds of Sulphur. Properties, Preparation and Biological Significance" and "Natural Sulphonium Compounds, Sulphides, Sulphoxides, Mercaptans and Sulphido-amino Acids" respectively, cover appropriately the widest fields, but even in discussing these comparatively simple classes of compounds the author has a fund of very interesting information on various points which will probably be novel to many organic chemists.

The chapter on "Sulphur Compounds of Petroleum" affords an excellent account of this subject, and the discussion of the desulphurization of organic compounds by Raney nickel, its mechanism, stereochemistry, and various applications is of great value.

Each of the remaining three chapters forms a complete monograph in itself. "The Natural Mustard Oil Glucosides and the Related *Iso*thiocyanates and Nitriles" starts with a very interesting historical review of the early work on oil of mustard, and then covers the modern chemistry of a surprisingly wide variety of compounds in its 146 pages. Prof. Challenger has worked on biological methylation since 1931, and his chapter "Biological Methylation with Particular Reference to Compounds of Sulphur" gives, as one would expect, an authoritative and thoroughly comprehensive account of this subject. Among the many subjects discussed are the mechanism of biological methylation, the transmethylation from methionine and choline, and the formation of 'active methionine' in enzyme systems and its synthesis in the laboratory: the chapter finishes with a discussion of the metabolism of ethanethiol, and the possible mechanism of its anti-tubercular effect. The last chapter is devoted to "Co-enzyme A, its S-acetyl Derivative and Related Compounds."

One quality of this book which greatly impressed me is that it is refreshingly readable. This arises partly from the author's clear natural style, and partly from his gift of presenting and discussing a considerable amount of material in a deceptively unhurried manner, so that, although no words are wasted, the reader never feels that he is being 'crowded'.

This high standard of writing, combined with the author's wide knowledge, makes one wish that he would now, with greater leisure, write a volume which would be the sulphur analogue of Sidgwick's "Nitrogen", that is, a volume in which the preparation and properties of the various classes of organic sulphur compounds would be systematically discussed, and many features of their chemistry critically assessed, without any attempt to achieve a comprehensive account. Several chemists have started on this task, and have fallen by the wayside *en route*: Prof. Challenger's vigour and enthusiasm would take him safely—and still in eminently readable style—to the end of the task.

F. G. Mann

LIGHT-INITIATED ORGANIC SYNTHESIS

Präparative Organische Photochemie

Von Prof. Alexander Schonberg. (Organische Chemie in Einzeldarstellungen, Band 6.) Pp. xii+274. (Berlin: Springer-Verlag, 1958.) 58 D.M.

PHOTOCHEMISTRY is perhaps still considered to be essentially the province of the physical chemist, yet during the past twenty-five years a vast amount of information has accumulated on the use of light to initiate reactions leading to the formation of relatively simple organic molecules (as distinct from polymers of high molecular weight). Prof. A. Schonberg directs attention through his book to the scope and utility of what is rapidly developing into an important section of organic chemistry.

The topics covered by Prof. Schönberg include photo-isomerism; photo-dimerization; photochemical oxidation reactions; addition reactions with olefins and acetylenes; photochemical reactions involving ketones, acids, acyl halides, anthracene derivatives, organic halides, etc.; cyclization reactions; photohalogenation; and photochemical reactions of nitric oxide, nitro-compounds, diazo-, diazonium-, and azo-compounds, sulphur, arsenic, and mercury compounds. Reactions leading to the formation of high polymers are excluded as being outside the scope of the book. Prof. G. O. Schenk's chapter on equipment available on the Continent is of less interest to British chemists than other chapters, but will nevertheless provide useful ideas for the design of photochemical reactors and other apparatus. The book was completed in mid-1957, and literature up to the end of 1957 is included as an appendix.

Experimental details are given for numerous syntheses, and the high yields often obtained will encourage many organic chemists; however, it will often be necessary to read the original literature to ensure that the correct technique is being used.

Many of the reactions described involve free radicals as intermediates, and although a brief summary of the mechanism or the probable course of the reaction is often given, the author wisely restrains himself from over-emphasizing this aspect, and concentrates on the preparative use of photochemistry. For full appreciation of the very many reactions discussed it will thus be necessary for a newcomer to the field to read a standard text on free-radical chemistry.

This book is a useful addition to chemical literature, even though the approach is essentially—and sometimes disappointingly—non-critical. The printing and general lay-out are excellent, making the book easy to read and to use for reference. Some will doubtless wish for an English translation; most would prefer a price lower than £5 2*s*. 0*d*. (4½d. a page).

R. N. HASZELDINE

CHEMICAL NOMENCLATURE

An Introduction to Chemical Nomenclature

By Dr. R. S. Cahn. Pp. viii+96. (London: Butterworths Scientific Publications, 1959.) 10*s*. 6*d*.

THE ever-increasing tempo of scientific research the world over creates *pari passu* new problems of communications between scientists. New phenomena providing evidence of a multiplicity of yet smaller and more perplexing sub-atomic particles—the traditional domain of the physicist; new matter at molecular level formed by the almost infinite range of permutations and combinations of the near hundred atoms of the periodic table—the chemist's field; each demands the utmost care in selecting terms with which to describe them if a scientific Babel is to be avoided. In the field of chemistry the International Union of Pure and Applied Chemistry has, through its various nomenclature committees, sponsored much excellent and fruitful study to which Dr. Cahn from Great Britain has contributed in no small measure. The present booklet is timely, especially in view of recent new developments in inorganic chemistry and the concomitant nomenclature changes. While there are no major changes of principle in organic nomenclature, it is in the inorganic field that older chemists will have to accustom themselves to some radical departures from old familiar names for common substances if they are to be systematic. But the Union is realistic when it refers to a system as "in use but not recommended" and Dr. Cahn is not remote from everyday chemical life when he says, "Probably it will die hard, for ferrous chloride comes more glibly off the older tongue than iron (II) chloride or ferrum (II) chloride or even iron dichloride; but it will probably die in time". So did Charles II.

Throughout, Dr. Cahn treats the intractable problem of reconciling usage with system in a friendly sympathetic style and pedantry rarely obtrudes. The principles are clearly stated and it should be possible for the chemist arriving at the substance $NaH(PHO_2F_2)$ to describe it correctly in his paper to the Chemical Society as sodium hydrogenhydrido-dioxodifluorophosphate, and equally for another chemist searching the indexes in the years to come to find and identify the entry. But much remains to be done, especially with the inorganic heterocycles involving P, N, B, Si, S and the rest, and Dr. Cahn and his colleagues would no doubt prefer that chemists did not spawn exotic new compounds unless they could be given a proper systematic name before a trivial (and possibly misleading) name gained currency in the literature. There is a challenge for the nomenclature or theoretical research chemist to outstrip his experimental colleague and prepare the name ready for the substance.

The organic section lucidly states current principles but contains one or two disconcerting errors. Thiocresol $C_6H_4Me.SH$ could surely never have the systematic name toluene-ω-thiol nor has glycollic acid ever been $HO.CH_2.CH_2.COOH$. Dr. Cahn rarely nods and he should correct these errors. To perplex chemists there is a Mitford-like disapproval of 'mesyl' while 'tosyl' appears to be 'U' in some places. Half a guinea for such a small booklet is the price for quality, not bulk.

H. J. BARBER

ELECTRONIC STRUCTURE OF MOLECULES

Die Methoden der Molekülphysik und ihre Anwendungsbereiche

Von H. Preuss. (Fortschritte der Physik, 1 Sonderband.) Pp. vii+167. (Berlin: Akademie-Verlag, 1959.) 22 D.M.

FIRST of all, the title is wrong. For despite its label this is not an account of the methods of molecular physics. If it were, it would contain some discussion of statistical mechanics, perturbation theory, properties of angular momentum and of spin, influence of electric and magnetic fields on molecules, etc. In fact it is solely concerned with the electronic structure of molecules, the techniques used and the type of result obtained.

Dr. Preuss is already well known to workers in the field of the wave mechanics of molecules as the author of a series of three books containing the numerical values of the various Coulomb and exchange integrals which play such a large part in it. The present book could be regarded as a compendium of the fundamental methods which are involved when using these integrals.

There is an introductory chapter on what is described as "Semi-empirical Theories", followed by the two main chapters of the book, on theoretical, and semi-theoretical, calculations. This particular classification is not one that has hitherto been used to divide up the field. But it has a good deal to commend it. Previously it has been more customary to have separate chapters on the molecular-orbital method and the valence-bond method: and each chapter has covered both the *ab initio* calculations and the semi-theoretical ones. To-day, however, no one wants to flog the old horse by arguing which is the better, since we know that for an attempted accurate calculation neither is satisfactory unless it is modified to such an extent that it merges with the other. The separation chosen by Preuss corresponds much more closely with the way that present-day work is being organized. On one hand there are those who want as exact an estimate of the energy and the wave function, as can be obtained. Ideally these people will use no empirical data whatever. On the other hand there are those who want to understand the reasons why molecules behave as they do—why, for example, their colour shifts to the red on methylation, or why carbon-hydrogen bond lengths are nearly, but not quite, constant.

Of the two main chapters the 'non-empirical' one is the better and includes several theories such as the density matrix, and the method of configuration interaction, not usually covered in text-books: and also Löwdin's natural spin orbitals. But it suffers from an undue emphasis on the two-electron atom. The chapter entitled 'semi-empirical theories' seems to be rather out of balance, with several huge lists of not very important numerical results, and scarcely any serious attempt to provide a critique for the approximation being discussed. But it does give a useful survey of Moffitt's method of atoms-in-molecules: and of the free-electron gas model.

C. A. Coulson

CHEMICAL THERMODYNAMICS

An Introduction to the Study of Chemical Thermodynamics

By Prof. D. H. Everett. Pp. xx+240. (London: Longmans, Green and Co., Ltd., 1959.) 28*s*. net.

Bases Fondamentales et Applications de la Thermodynamique Chimique

Par Prof. Maurice Dodé. Tome 1: Les Principes, Les Systèmes Ideaux Gazeux, et avec Phases Condensées Pures. Pp. iv+516. (Paris: Société d'Edition d'Enseignment Supérieur, 1959.) 4,000 francs.

The authors of these books are enthusiasts about thermodynamics, but with rather different outcomes to their enthusiasm. Prof. Everett shares the view of P. Duhem (1903) that the range of scientific studies to which thermodynamics is applicable is extremely broad. There are aspects of this universal discipline of interest to philosophers, mathematicians, physicists and chemists—we would now add biophysicists and biochemists to Duhem's list—but different treatises are needed for each of these groups of savants. This makes it particularly important to prepare for such advanced treatises by introductory work carefully designed to lead in the appropriate direction. Everett's book leads to chemical thermodynamics. He is well aware of the confusion and boredom induced in future chemists by many introductory treatments of thermodynamics which stress the physical, philosophical or pseudo-engineering aspects, or which over-emphasize its mathematical elegance and rigorousness. To avoid these educational mishaps, Everett's text starts by getting readers interested in the use of thermodynamic equations, and familiarized with accurate and quite complex symbolism before they are led to examine the fundamental laws of thermodynamics with any degree of profundity. The book is designed to serve the needs of university students up to pass degree level in chemistry, or as a subsidiary to main biological subjects. It leads on to more advanced treatises in a very effective way. The chapter on "Conditions of Chemical Equilibrium" seems particularly noteworthy in an elementary book of this kind; there are many other useful sections. Not every reader will find mechanical analogies of thermodynamics in the text easier to follow than their thermodynamic counterparts, but there is no doubt that the book as a whole is a very valuable contribution to the teaching of 'chemical' thermodynamics in the all-important elementary stages. The book should promote confidence and accuracy in students, though the examples for working given in the appendix should probably be amplified and diversified for use in a teaching course.

Like Prof. Everett's book, the text by Prof. Dodé is intended to serve the needs of students of chemical thermodynamics, in this instance chiefly industrial chemists and chemical engineers. British readers will find it a much more untidy and probably a much less useful work. It is less carefully contrived to induce a strong and accurate grasp of chemical thermodynamics by elementary students. Dodé's book quite rightly stresses the usefulness and power of De Donder's affinity function and refers rather charmingly to "L'affinité chimique, cette vieille notion restée si longtemps d'ordre sentimental". But the text contains much extraneous matter of mainly physical, semi-historical or philosophical nature. Calculations of chemical equilibria are described in very considerable detail. Some of the material quoted seems rather out of date. More powerful and convenient procedures could be found, particularly in some of the American text-books quoted by Everett for further reading.

A. R. Ubbelohde

A STRUCTURAL TOOL FOR THE CHEMIST

Nuclear Magnetic Resonance

Applications to Organic Chemistry. By Prof. J. D. Roberts. (McGraw-Hill Series in Advanced Chemistry). Pp. viii+118. (London: McGraw-Hill Publishing Company, Ltd., 1959.) 46*s*. 6*d*.

The nuclear magnetic resonance spectrum of an organic liquid, observed under high-resolution, provides the organic chemist with a pattern of lines characteristic of the molecule. The position and intensity of the lines and their multiplet splitting can in favourable examples tell him what groups are present in the molecule, and how they are joined together. He thus has yet another tool to help him to identify a product, confirm or reject a structure, distinguish between isomers, detect and measure chemical exchange, and determine the kinetics of a reaction. The timely development by Varian Associates of the necessary commercial instrument led to rapid and widespread exploitation of the method by organic chemists, particularly in North America.

Although there are a number of learned works which dwell on the physical theory and practice of the phenomenon there was no book which provided a simple introduction to the less mathematically minded chemist. Prof. Roberts's very readable monograph fills this want. Apart from an appendix there are only six equations in the book. The essentials are introduced in a few well-chosen words, illustrated clearly, and doubtless expensively, by diagrams in three colours. It is assumed that the reader will be using the crossed-coil detection system, an assumption which was generally correct for this type of work in the past, but which is becoming less justified now that single-coil spectrometers are finding their way on to the market. The organic chemist is given an attractive presentation with well-chosen examples of what this new tool will do. The physicist is no less fascinated by the account of the chemical applications by a practising chemist. The book closes with an intriguing set of problems with which the reader is invited to beguile the time by identifying twenty pure compounds from their proton resonance spectra given only their molecular formulæ.

E. R. ANDREW

THEORY AND PRACTICE OF SEDIMENTATION

Ultracentrifugation in Biochemistry

By Howard K. Schachman. Pp. xii+272. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 8·80 dollars.

THIS monograph is very welcome. The bibliography lists more than two hundred papers dealing with technical innovations, new applications of sedimentation techniques and modifications and extensions of sedimentation theory which have appeared since the publication of Svedberg and Pedersen's original book on the ultracentrifuge. It is a great asset to have this mass of work organized and critically discussed.

Dr. Schachman has restricted himself primarily to the description of the principles underlying the use of the analytical ultracentrifuge (preparative centrifugation is not mentioned) and to a survey of the many applications which are of interest to biochemists. Throughout the monograph, though, the emphasis is on problem and technique rather than on the biochemical value of the results. Indeed the index contains only one entry relating to a specific solute, human serum, and this reference deals with a remarkable boundary anomaly which shows how difficult it can be to assess relative concentrations in a multicomponent system. The absence of data on specific macromolecules is perhaps inevitable, since there are very few results in the literature which meet the stringent requirements of an error of only a few tenths of a per cent which the author demonstrates is now technically possible, and very few published photographs of schlieren boundaries will bear comparison with the beautiful examples to be found in this book.

A comparatively short section on experimental aspects includes a description of the merits and uses of the different types of cell now available and a general discussion of the principles and practical limitations of the schlieren, absorption, interferometric and Lamm scale optics. Useful practical advice is also to be found in the later chapters. The interpretation of sedimentation data is dealt with succinctly, the reader being referred to the several excellent reviews available for more detailed discussion. The greater part of the monograph is devoted to an exposition of theory and practice in sedimentation velocity and sedimentation equilibrium experiments and the increasingly important method of determining molecular weights by the method of Archibald. In the section on sedimentation velocity experiments a clear differentiation is made between those aspects of analysis which are based soundly on theory and those, for example the extrapolation of results to infinite dilution, which are still essentially empirical. There are surprisingly large fields which have as yet received little or no theoretical investigation. The complexity of the computations required to derive all the information possible from any one set of experiments is well brought out and makes one echo the author's hope that some of the labour will be reduced by the development of automatic scanning and registration techniques to replace the photographic methods now in use.

It is evident from the steady stream of papers now appearing that the dramatic developments in the application of sedimentation techniques to biochemical problems which has occurred during the last decade has by no means ended. Dr. Schachman's monograph provides an admirable basis for the appreciation and assessment of future work.

K. V. SHOOTER

CHEMICAL ANALYSES OF ROCKS

Petrochemische Berechnungsmethoden auf Äquivalenter Grundlage

Von Prof. Conrad Burri. (Methoden von Paul Niggli.) (Lehrbucher und Monographien aus dem Gebiete der Exakten Wissenschaften. Mineralogisch-Geotechnische Reihe, Band 7.) Pp. 334. (Basel und Stuttgart: Birkhäuser Verlag, 1959.) 38 Swiss francs; 38 D.M.

THIS well-produced volume deals with methods of recalculating chemical analyses of rocks (chiefly igneous and metamorphic rocks) on a comparative basis, and the methods discussed are mainly those devised by the late Prof. Paul Niggli, of Zurich, though some reference is also made to the calculations of T. F. W. Barth and P. Eskola on the basis of anion percentages and standard cells.

The book is the most complete treatment of the methods of calculating the so-called Niggli values (*si*, *al*, *fm*, *alk* and so on) and of their use which has so far appeared, a use which has had a considerable vogue among European petrographers, but only a limited appeal to workers in Great Britain and in the United States. There is also a very full account of the Niggli norm, devised to supersede the Clark-Iddings-Pirsson-Washington norm, the disadvantage of which is that the standard minerals used as a basis of calculation rarely correspond completely with the actual mineral composition, or mode, of the rock. The Niggli equivalent-norm has the advantage that phases such as the amphiboles and the micas can be represented in the calculations when they are present, but it would be a mistake to expect, even using this method, any really exact correspondence between norm and mode. Indeed, the description of this book as a "Monograph in the Field of Exact Science" is, in the reviewer's opinion, scarcely justifiable when the persistent inaccuracy of the method, and of even the best of chemical analyses of rocks, revealed by the international investigations of the past ten years, is recalled. Many petrographers now doubt whether it is proper to base elaborate calculations or classifications on such a shaky foundation. However, for those who still enjoy this exercise, here is a work after their own hearts. The new tables of molecular percentages included as an appendix are probably the best so far produced, and there is a wealth of illustration of graphical representation of the results of the calculations, for example, in triangular plots.

The author rightly claims priority for 'petrochemical' as a term to cover the chemistry of rocks and looks askance at the increasing use of the term to describe chemicals derived from petroleum. It might be suggested that the latter usage is now so widespread that it would be advisable to abandon petrochemical as a term of geology, and leave it to the chemical engineer. K. C. DUNHAM

GEOLOGICAL WAYS AND BY-WAYS

Principles of Geology

By James Gilluly, A. C. Waters and A. O. Woodford. Second edition. (Series of Geological Texts.) Pp. viii+534. (San Francisco: W. H. Freeman and Company; London: Bailey Bros. and Swinfen, Ltd., 1959.) 7.50 dollars; 64s.

"PRINCIPLES OF GEOLOGY" appeared in 1952 when it was welcomed as an original and stimulating book. Clear style, remarkably little jargon and arresting illustrations were obvious virtues. Now, after seven years, when the first edition has proved useful to teachers and taught alike, the second edition has appeared, printed on a larger page, setting off figures and plates advantageously. The sequence of the chapters has been logically rearranged with a modicum of rewriting to incorporate some recent work and to expand the reviews provided on certain topics. The authors have retained their approach of furnishing short sketches of the people, like Nicholas Demarest, for example, involved in making geological discoveries, or in the controversies arising from them. The principle of uniformitarianism is sustained throughout, although some of the extraordinary incidents described as occurring in storms and floods supply live ammunition for the neo-catastrophists.

The selection of examples of geological phenomena fulfils the condition that "all the world's a stage", the Old World and the New, continents and oceans alike. Thus an earthquake, landslide and turbidity current intimately related to one another are demonstrated from the Grand Banks in 1929; the quiet sinking of a large region shown by a swamped river system in Indonesia, while building-stones in Glasgow's houses are used as evidence that deserts like those in present-day Nevada once existed where now flows the Clyde.

To me the locating of Funafati as "not far from Tarawa of World War II fame" is a case of the cart before the horse. In the new grouping sedimentary rocks and the environments of deposition get a chapter to themselves, but we "go out through that same door where in we went" in that the origin of dolomite is still mysterious. A later chapter commences with an account of the Lisbon earthquake of 1755, leads downwards through sial and sima to the Mohorovicic discontinuity into the mantle until it comes to the core of the earth, stuffed, as formerly, with question marks.

The discussion of mountains is excellently done and covers some familiar ground, but this is so vividly described that it leaves no doubt what the writers mean or where they stand in the realm of Alpine theories. Two points are of special interest. The first is the brief revised account of the "Basin Ranges" in the south-western United States. The individual ranges often have diverse and complicated structures not clearly related to any discernible geosyncline. Each one stands apart from its neighbours and is bounded by normal faults. The second is the comparison of the river-carried deposits of the Bramaputra and Irrawaddy respectively, thus presenting the idea also advocated by Kuenen[1] that substantial filling of a geosyncline may be accomplished along its trend and need not necessarily originate from its flanks.

It is a surprise to find a book of this character with so little to say about rift valleys and the recently described intriguing long straight fracture zones in the eastern Pacific, but perhaps something has to be held in reserve against a third edition. Recalling the scope of an ancient text-book like G. A. J. Cole's "Aids in Practical Geology", it is odd that the two geological handmaids, mineralogy and petrology, have each an appendix devoted to them but palæontology is omitted. Nevertheless, here is a book which all geologists will read with profit and enjoyment, and there will be few whom it does not caress or jolt into having to think. J. V. HARRISON

---

[1] Kuenen, Ph. H., *Kon. Ned. Geol. Mijnb. Gen., Geol. Ser.*, 18, 189 (1957).

GLOSSARY OF GEOLOGICAL TERMS

Geological Nomenclature (English–Dutch–French–German)

Edited by A.A.G. Schieferdecker. (Royal Geological and Mining Society of the Netherlands.) Pp. xvi+523. (Gorinchem: J. Noorduijn en Zoon, N.V., 1959.) 45 guilders.

IT is now thirty years since the Royal Geological and Mining Society of the Netherlands published a glossary of geological terms in the Dutch language, with English, French and German equivalents. The work noticed here is an entirely new production sponsored by this Society, and prepared by a team of collaborators of several nationalities. It has become necessary as a consequence of the progress of geological and closely allied sciences in the interval; which has led to the introduction of new concepts, new terms and new methods of carrying out geological investigations. Furthermore, and this is of particular interest to English-speaking geologists, because, in the opinion of the sponsors, the English language has become increasingly dominant in geological literature, the new edition has been prepared in English. Thus, the introductory matter and table of contents are in this language, and the terms and phrases are given first and defined in English. These are followed by their Dutch, French and German equivalents.

The glossary contains 5,489 entries, and is arranged by subjects, there being eleven main divisions. Each of these is again divided, sometimes into as many as ten or eleven subdivisions, and the latter are again divided into smaller subject groups. Such an arrangement was no doubt essential in preparing the glossary, since the various subdivisions have been compiled by a large number of specialist collaborators but it does not make for ease of reference. This difficulty has been overcome by numbering consecutively all the entries, and their inclusion in a single four-language alphabetical index in which the reference to any particular term is by number, whichever language is used in consulting the index. Cross-reference from index to text can thus be made rapidly.

The principal divisions cover general and physical geology; geomorphology; sedimentation; stratigraphy; tectonics; geophysics; orogeny; vulcanology; petrology of igneous and sedimentary rocks; and mineral deposits. Crystallographic terms and the names of minerals, rocks and stratigraphical formations have been omitted from this edition; and palæontological terms are not included. It is a little surprising that among the list of collaborators there are few who may be supposed to have English as their mother tongue; but this omission is seldom apparent in the text and, where noticeable, without serious results. In choosing terms for inclusion in the glossary the editor has cast his net widely, and both glossary and index appear to have been compiled with much care. There is no doubt the book will form a valuable addition to geological, geographical and engineering libraries. Welcome as this new glossary is, in view of the very large amount of geological literature now appearing in the Russian language, often without adequate summaries in western European languages, the preparation of a supplement of Russian geological terms, in which the same index figures could be used, would be an extremely useful compilation. V. A. Eyles

LOW-ENERGY NUCLEAR PHYSICS

Proceedings of the International Conference on Nuclear Physics

Low-Energy Nuclear Interactions and Nuclear Structure, Paris, 7–12th July, 1958. Presented by Mme. P. Gugenberger. Pp. v+950. (London: Crosby Lockwood and Son, Ltd., 1959.) 140*s*. net.

The international meeting of nuclear physicists held in Paris during July 1958 yielded the conference report under review, dealing essentially with low-energy nuclear physics. The conference and the preparation of the report (carried out by Mme. P. Gugenberger) were made possible financially by the United Nations Educational, Scientific and Cultural Organization and the International Union of Pure and Applied Physics, augmented by various other public and private sources. The volume of 1,600 pages reflects in its structure the new style of conference: specialist rapporteurs present the relevant contributions offered by members of the conference as survey papers, thus producing a well-knit whole out of a number of components. This survey is printed verbatim as are the discussion remarks following the rapporteurs presentations (325 pages). The rest of the volume contains the text of the communications, with an author index (612 pages).

My personal reaction to this volume is one of delight. The text gives the reader the impression of being present at the meeting, and the discussion produces a lively atmosphere through argument and counter-argument; as a result one can learn much about the subject with considerably less effort of will than from the original papers. Naturally, the rapporteur has already spent some effort in digesting the contents of a bunch of scientific papers. It seems clear that this type of conference and its reporting methods are here to stay. It is more stimulating and more informative than the string of 10-minute talks with which one is familiar from Physical Society meetings.

The conference was opened by Prof. F. Joliot on July 7, 1958 (five weeks before his death) and closed with an illuminating summary by Prof. L. Rosenfeld. The various sections deal with the following topics: (*a*) Elastic Scattering of Neutrons (H. H. Barschall); Charged Particles (A. E. Glassgold). (*b*) Scattering and Nuclear Forces: Scattering by Electrons (R. Hofstadter); Analysis of *p–p* Scattering below 40 MeV. (M. H. McGregor). (*c*) Direct Interaction: Theory (C. T. De Dominicis); Deuteron Stripping (G. R. Satchler); Experimental (B. L. Cohen). (*d*) Heavy Ions (A. Zucker). (*e*) Photonuclear Reactions (J. S. Levinger). (*f*) The Independent Particle Model and its Connexion with the Collective Model (A. M. Lane, S. A. Moszkowski). (*g*) The Collective Model (A. Bohr); Coulomb Excitation (F. K. McGowan). (*h*) Structure of Nuclear Matter (C. Bloch). (*i*) Weak Interactions: Theory and Experimental Results (R. Nataf).

It is regretted that the text of the Russian contributions was not received in time for incorporation in the report.

Mme. P. Gugenberger and the publishers are to be congratulated on producing this fine conference volume; they both deserve the gratitude of the nuclear physicists. E. Bretscher

ROCKET PROPELLANTS

Rocket Propellants

By Francis A. Warren. Pp. ix+218. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 52*s*. net.

This book is designed to provide both the technical reader and the newcomer with basic information on the propellants used in modern rockets. The author has been directly associated with the development of propellants and rockets since 1942 and is well qualified to write a book on this topic. There are chapters dealing with the different types of propellants (both solid and liquid), propellant ingredients, the manufacture of solid propellants, performance and burning characteristics, the more important design features in both solid and liquid motors, safety, quality control and the future of rocket propellants. For a book of its size all these subjects are dealt with very adequately; the matter is clearly presented and supported by a useful selection of photographs, line drawings and graphs. There is surprisingly good coverage of the possible combinations of fuels and oxidants, and in the early chapters one frequently encounters novel items of information and 'know-how' not previously seen in publications of this kind.

The bibliography quoted is extensive but, perhaps inevitably, predominantly American. During the Second World War, and particularly in its early stages, the Americans were supplied with a great deal of information from Great Britain about the design and manufacture of small solid-propellant rocket motors. It is always a little disappointing that British workers who have played a conspicuous part in these developments are not as well known as they deserve to be, mainly because they have been associated with material which only slowly finds its way into the 'open' literature.

While the book is very readable and informative, there are some omissions. For example, in the section dealing with composite propellants there is no mention of 'plastic propellant', a wholly British concept which started during the War. This propellant has a good performance and possesses exceptional chemical stability. Its main ingredients are ammonium perchlorate (the oxidant) and a hydrocarbon binder (the fuel); these are mixed together to form a stiff 'putty' which can then be pressed into the desired shape in a rocket tube. Plastic propellant is used in a range of fairly large motors, notably in the *Skylark* rocket, which has been employed in the upper atmosphere research firings in Australia.

In the discussion on "Ballistic Agents", minor ingredients used to modify the burning characteristics of propellants, it is mentioned that potassium sulphate was originally used to reduce the flash and smoke in guns. This latter point, that is to say, smoke reduction, is incorrect, since any inorganic additive must aggravate the smoke problem. However, the book is well edited and no slips of real significance have been noted.

The final chapter deals with "The Future of Propellants". This outlines very clearly the possibility of developing propulsion systems of greatly enhanced performance by various applications of nuclear power.

The author is to be commended on producing a very readable book which contains a useful blend of basic information and technology. It can be recommended to those seeking a good introduction to all aspects of rocket propellants. W. B. LITTLER

AN EASY GUIDE TO RADIO ASTRONOMY

Radio Studies of the Universe

By Dr. R. D. Davies and Dr. H. P. Palmer. Pp. viii+200+14 plates. (London: Routledge and Kegan Paul, Ltd., 1959.) 25*s.* net.

AS the joint authors of this book are two experienced radio astronomers working at the Jodrell Bank Experimental Station, the authoritative nature of the material is assured. The book is intended for the non-specialist, and does not assume any appreciable previous knowledge of either radio or astronomy. It can be recommended as a useful and informative outline of the results achieved in all aspects of this progressive new branch of scientific activity.

The book begins with a brief outline of optical astronomy; then a description of radio methods is followed by an account of the various sources of radio emission beyond and within the Galaxy including the Sun and solar system. Subsequent chapters deal with the application of radar to the study of meteors, auroræ, the Moon and planets, and the contribution of radio-astronomical methods to the study of the Earth's upper atmosphere. There are a useful glossary and a selected list of references. The book is printed in large type and illustrated with plates and diagrams.

The writing of books of this class, often described as 'semi-popular', presents the problem of conveying a correct meaning without encumbering the reader with the detailed concepts of rigorous treatment. In this elementary survey of radio astronomy, the authors have for the most part succeeded well in this respect. In some places a slight amplification would have been helpful. It would have been worth attempting to show, possibly in a further appendix, how the expressions for the beam-width of a radio telescope and for the lobes of an interferometer pattern are derived, as these involve only elementary ideas of wave motion. The significance of band-width in radio noise reception could also have been more adequately covered.

Only in a few instances could one feel more particularly critical of the authors' approach. For example, a statement that the amount of radiation received by an aerial is proportional to its area is followed by a discussion of linear aerials, and it is not made clear what 'areas' they possess. Later, radar echoing properties of objects are again loosely identified with their 'areas'. A different type of misleading impression arising from inadequate explanation occurs, for example, in the description of visual solar activity, where a statement ". . . when the outer edge of the Sun is viewed through a telescope . . ." neither suggests the necessary precautions nor the special technique involved in making optical solar observations. It would not, however, do justice to the book to dwell unduly on a few defects of detail. The book as a whole provides a simple and comprehensive guide to radio astronomy. J. S. HEY

PROBLEMS OF SPACE FLIGHT

Vistas in Astronautics

Vol. 2. Edited by Morton Alperin and Hollingsworth F. Gregory. Second Annual Astronautics Symposium sponsored by Air Force Office of Scientific Research, and Institute of Aeronautical Sciences. (International Series of Monographs on Aeronautical Sciences and Space Flight. Division 7: Astronautics, Vol. 2.) Pp. x+318. (London and New York: Pergamon Press, 1959.) 105*s.* net.

THE second Astronautics Symposium organized by the U.S. Air Force Office of Scientific Research was held at Denver, Colorado, in April 1958, and this volume records the proceedings. The papers can conveniently be divided into four groups. The first group is concerned mainly with scientific experiments in space, and includes a concise survey by S. F. Singer of the outstanding scientific problems in the region out to the Moon's distance. The second and largest group deals with the propulsion, orbits, control and guidance of space vehicles. There is a significant paper by A. Ferri and others, who conclude that the use of turbo-jet and ram-jet engines in the launching missiles for space vehicles, up to speeds of say Mach 4, might considerably reduce the weight at launch and the rocket thrust required. Another notable contribution comes from J. H. Laning, jun., and others, who describe a design study for a vehicle to go near Mars, to photograph it, and to return.

The third group of papers records a discussion panel on the question "What use is man in space?" The answer given by almost all the speakers was: "not much use at all". But the U.S. Air Force chairman stoutly resisted this undermining of the Symposium's *raison d'être* by saying that man will, nevertheless, go into space.

The fourth and most controversial group of papers is concerned with the Moon. First, T. Gold argues persuasively that the Moon's surface is deeply covered in dust: "the top few feet may well be extremely loose and more treacherous than quicksand". Then F. L. Whipple, just as persuasive, contends that the dust must cement "into a weak, porous matrix" under the bombardment of meteorites, corpuscular radiation, etc. Finally comes G. P. Kuiper, whose paper is the most striking in the book, since it contains twenty-three magnificent photographs of the Moon, mostly full-page: after surveying the lunar topography in detail, Dr. Kuiper finds "overwhelming evidence that the traditional view that the mare floors are *lava fields* is correct"—a rebuff for the dust-men.

These technical papers, which take up most of the book, form a valuable record; but the same cannot be said for the introductory material, which often sounds too nationalistic a note. Nor is the editing perfect: for example, a three-line footnote on p. 139 has somehow escaped the deletion it obviously deserves, and the grouping of the contributions is not entirely logical, since the solitary paper on "Space Navigation" appears in the section entitled "Control and Propulsion . . .", and not in the section on "Departure, Space Navigation and Re-entry", which would seem to be its proper home.

D. G. King-Hele

PLANETARY DYNAMICS

Celestial Mechanics

By E. Finlay-Freundlich. Pp. viii+150. (London and New York: Pergamon Press, 1958.) 50*s*. net.

Stability in Celestial Mechanics

By Prof. Yusuke Hagihara. (Jubilee Publication in Commemoration of the Sixtieth Birthday of Prof. Yusuke Hagihara, by his Friends and Pupils.) Pp. x+106. (Tokyo: Kasai Publishing and Printing Co., 1957.) n.p.

TEN years ago it was commonly thought by many astronomers, most mathematicians and almost all physicists that celestial mechanics was a dead subject of historical interest, that it had been worked out, and that it was unlikely in the future to yield new results of fundamental importance. The advent of artificial satellites has led to a re-awakened interest in many of the problems of celestial mechanics. It is therefore quite appropriate that new text-books should be written not only to cater for the new demand but also so that those unfamiliar with the subject may become acquainted with the vast body of knowledge which exists and of which they might otherwise remain ignorant.

The two books under review are of quite different kinds. Prof. Freundlich's book is a self-contained introduction to the subject. After a brief introductory chapter, the *n*-body problem is discussed, including Lagrange's solutions to the three-body problem, the singularities of the three-body problem and periodic solutions in the neighbourhood of the points of libration. This is followed by an outline of the application of the Hamilton-Jacobi theory, a discussion of the principles underlying perturbation theory, and several discussions on the problems of periodic motions. The book ends with chapters on the two-body problem for extended deformable bodies and on the motion of the apsidal line in relativistic mechanics.

The most surprising feature of the book is the discussion in a relatively elementary way of so many advanced topics, and this is to be commended. It is unfortunate, however, that space was not found for a rather more detailed discussion of some of the basic problems. For example, many university mathematical courses in dynamics end at Lagrange's equations, and proofs of Hamilton's equations and the Hamilton-Jacobi Theorem (without the use of contact transformations) would have added to the value of the book. Also a course on celestial mechanics can scarcely be considered complete if it does not include the equations for the variation of the elements of an orbit. This is, after all, the feature of celestial mechanics of most interest for artificial satellites. Those who, like myself, are frequently charged with the duty of giving formal lecture courses in celestial mechanics, will be grateful to Prof. Freundlich for providing in this text a useful survey of the subject, but they will of necessity supplement this survey with selections from more advanced books to fill the more obvious lacunæ.

Prof. Hagihara's book was published by his friends and pupils to celebrate his sixtieth birthday. He has attempted to summarize the present situation in the efforts towards solving the very difficult problem of the stability of the solar system. His book ranges widely over many difficult aspects of celestial mechanics, and, by omitting or outlining proofs, he succeeds in giving in a short space an exhaustive survey. He discusses the results of the most advanced research work more completely than any existing text-book or review, and gives comprehensive bibliographies. His book is a land-mark in celestial mechanics.

Neither of the books under review contains any discussion of the numerical problems of celestial mechanics, and it is to be hoped that someone will be stimulated into filling this gap in the literature.

R. H. Garstang

STEVIN'S MATHEMATICAL WORKS

The Principal Works of Simon Stevin

Edited by Prof. D. J. Struik. Vol. 2A: Mathematics. Pp. v+1–456. Vol. 2B: Mathematics. Pp. iii+457–976. (Amsterdam: Swets and Zeitlinger, 1958.) n.p.

THESE two volumes comprise Stevin's principal mathematical works. The first begins with an account of his little known "Tables of Interest" (1582). In a period of rapid commercial expansion, when even the ordinary arithmetical operations still presented difficulty, the computation of interest called for no little skill, and so the appearance of Stevin's "Tables" must have proved a boon to the great banking houses, such as those of Lyons and Antwerp. Many readers will be interested to trace, with the help which Prof. D. J. Struik has abundantly provided, the origins and the growth of such tables; they will be grateful for the translation and the copious references provided.

The "Problemata Geometrica" deals with the division of polygons into parts having a given ratio. The *regula falsi*, a favourite device of the mathematicians of the Middle Ages, is freely used. Then follows a study of the regular and semi-regular polyhedra and the construction of polyhedra similar to a given polyhedron. Stevin follows closely in the footsteps of Euclid and Archimedes without removing many of their obscurities. The ample footnotes provided have at least succeeded in making a difficult subject attractive.

Probably the most interesting section of Stevin's work is his exposition of the principles underlying the use of decimal fractions. Prof. Struik's judgment: "It is safe to assume that Stevin's work contributed to the growing popularity without ascribing the success exclusively to him" (p. 377), is very fair, and it is supported by an exhaustive list of references to pioneers in the development of this branch of arithmetic. The facsimile reproduction of "La Disme", and its side-by-side translation, cannot but be accorded a warm welcome from those who have not access to Stevin's original tract. Nevertheless, it is extremely doubtful if the decimal system of writing fractions would have achieved such a wide popularity had it remained in the clumsy notation which Stevin adopted. A number of writers of the period who employed decimal fractions, either with or without Stevin's notation, follow the exposition. The omission of the names of Oughtred and Wallis is a little surprising. The former, in his "Clavis Mathematicæ", adopted a much more convenient notation. "Decimal parts are written in the same line with integers . . . They take their denomination from the place of their last figure, as 0/5 are five-tenths, 0/56 are fifty-six hundredths". Wallis, in his "Mathesis Universalis" (1657) followed Oughtred's notation, but in his "Algebra", written nearly thirty years later he sometimes uses the full stop, as 3.14159, and sometimes the comma, as 12,756.

The main merit of Stevin's "L'Arithmétique" is the systematic way in which he discusses operations with rational, irrational, and algebraic numbers, and the theory of equations of the second, third and fourth degrees. Here the editor shows an intimate knowledge of the steps which led to the solution of algebraic equations during the fifteenth and sixteenth centuries, and he has placed the reader very much in his debt by his exhaustive bibliography. He rightly criticises Stevin's interpretation of powers higher than the cube as "a clumsy procedure". Not everyone, however will agree with his view that "the way out towards spaces of higher dimensions only appeared in the nineteenth century". For did not Descartes ("La Géométrie", 1637) point the way when he threw aside the dimensional restrictions of earlier writers (for example, Vieta) and divorced such expressions as a^2, b^3, and higher powers from reference to physical quantity? These are nothing more than the terms of a continued progression, the first term being unity. They should not, therefore, have caused any embarrassment in explaining powers higher than the cube. In this section of the work no little skill is shown in the selection for reproduction of those passages which best illustrate the sixteenth century approach to the solution of equations.

Readers will welcome the section dealing with Stevin's contribution to trigonometry, which is preceded by a brief account of the development of the subject from Ptolemy. The chief feature of this, in Prof. Struik's judgment, is the clarity of its exposition. This view will be readily accepted. But there was rather more in it than this. It was only a few years prior to the appearance of this work that trigonometry had emerged as an independent science. Stevin's contribution gave a great impulse to a movement which was already rapidly gathering strength.

Stevin's work on perspective is probably among the most original of all his work. It was written in the vernacular, and this may well be a reason why it has not become widely known outside the Low Countries. Prof. Struik's translation does much towards removing this limitation.

The appearance of these two volumes goes a long way towards filling a gap in our acquaintance with Stevin's mathematical work. They illustrate the vast range of his contributions to the subject. His gifts, outstanding as they were, have been overshadowed by those of his great contemporaries and successors. For Stevin lived in an age of intellectual giants—Vieta (1540–1603), Galileo (1564–1642), Kepler (1571–1630), and he was followed by men no less distinguished—Wallis (1616–1703), Fermat (1601–1665), Pascal (1623–65), Descartes (1596–1650)—to name but few. This, together with the fact that much of it was written in Flemish, may be a reason why his work has hitherto not received at the hands of the historian of science the recognition which is its due. Prof. Struik has gone a long way to remedy this situation, and the appearance of later volumes will be awaited with considerable interest.

The only feature open to serious criticism is the index, which, for a work of nearly a thousand pages, is condensed into a few columns. Would it be too much to hope that, in subsequent volumes, Prof. Struik will devote as much care to the compilation of a really helpful index as he has done to the rest of the work?

J. F. Scott

GÖDEL'S THEOREM

Gödel's Proof

By Ernest Nagel and James R. Newman. Pp. ix+118. (London: Routledge and Kegan Paul, Ltd., 1959.) 12*s*. 6*d*. net.

FROM time to time a little masterpiece of exegesis appears in the field of mathematics and physics: this little manual is certainly such a one. It deserves a place with Sylvanus Thompson's "Calculus Made Easy", and Biggs's "Wave Mechanics". But in a sense it is better than either of them, in that it manages to convey the spirit of the genius of Kurt Godel, and to show his achievement of 1931 (at which time he was twenty-five years old) as at least comparable with Euclid's, when he selected the particular form which he did to enunciate the parallel postulate, realizing at the same time that proof was needed, but impossible to supply. It is curious that, as in Godel's theorem, it is in these declarations of impotence that mathematicians sometimes reach their zenith. In demonstrating, and accepting, the impossible, mankind (paradoxically) breasts its summit.

Throughout history, the axiomatic method has gained favour, and advanced from strength to strength. Seen in full vigour in Euclid's geometry, it appears again for mechanics in the hands of Archimedes. Centuries later, something akin ran in the mind of Descartes, and in our own century (1908) we find it in the *Axiomatik* of Carathéodory's thermodynamics. What more fitting for it to support the great structure of arithmetic, and the aesthetic satisfaction of David Hilbert's systematic foundations ? Yet that is just what it has failed to do, and what Gödel showed it fundamentally incapable of doing. It is nothing less than that which constituted the core of his original paper, with the forbidding title "On Formally Undecidable Propositions of Principia Mathematica and Related Systems". All this germinated in the mind of the young member of the Vienna Circle. When events shattered that distinguished group, Princeton came to the rescue, and Harvard acclaimed Kurt Godel at his true stature.

The authors of the present book begin by discussing the problem and absolute proofs of consistency, giving an example wherein such a proof is successful. This entails, *en route*, the systematic codification of formal logic. A reader with some little competence in the sentential and existential calculus will have no particular difficulty in following the train of thought thus far. Then comes the idea of mapping, and its use in mathematics. It is exactly here that the power of Godel is so remarkable. We are familiar with the processes of projective geometry, or those involving the theorem of Pappus, wherein an abstract structure of relations in a domain (A) can be mirrored as holding in another domain (B). (In this particular case the transform is between points and lines.) What Gödel did was to map statements 'about' arithmetic as expressions 'in' arithmetic. In other words, he managed to project the meta-mathematics of arithmetic upon arithmetic itself. This method amounts in effect to making meaningful statements about a formalized mathematical system; it says something about mathematics, but plainly not belonging to it. Meta-language and meta-science sometimes present difficulties to the British way of thinking. Perhaps a very crude analogy would be the distinction between history and historiography, which is well accepted among scholars.

The end-result of Gödel's achievement is that arithmetic is incomplete. The way in which this remarkable conclusion is reached is by proving that there is at least one mathematical truth which cannot be said to follow from the axioms, and yet can be established meta-mathematically from outside.

We are thus faced with severe limitations in the whole axiomatic method itself, and everything built upon it. One cannot specify once for all a fixed set of axioms to shore up and bear the whole load.

There is, as the authors point out in a significant footnote (pp. 99–100), a throw-back to a type of Platonic realism. Gödel would seem to accept the existence of classes and concepts as real objects whether in fact we have 'realized' them or not. This may have wide repercussions, for it may prove to be in line with Heisenberg's primordial matter (after the manner of Anaximander), which he considers may be needed to extricate the quantum theory from its present philosophical confusion. Supposedly, such an entity would exist independently of our thoughts about it.

For what is little more than an essay on a vast subject, the writers have done astonishingly well. The proof-reading must have been as near faultless as human frailty can accomplish, since a minor misprint in such a strange land would lead many a careful inquirer to despair. To make Gödel's theorem more accessible is something supremely worth while, and this book is the way to do it.

F. I. G. Rawlins

ORGANIZATION AND METHODS

Organization and Methods

A Service to Management. Edited by G. E. Milward. Pp. xxxii+408+4 plates. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1959.) 63*s*. net.

THIS is essentially a practical book and gives the essence of the experience in organization and methods work of nine large commercial companies. Mr. Milward has done an excellent job in producing such a readable volume and one which does not show evidence of its rather mixed parentage. As one completely untrained in office management, yet who has had to accept responsibility for the many 'administrative' aspects of a large scientific institution, I can testify to the value of organization and methods procedures as described in this book in simplifying and often in reducing the ever-increasing paper work.

The book is concerned essentially with the practice of "Organization and Methods", the types of people required to carry out its procedures, their training and methods of working. It does not ignore the human factors which form such an important part in the operation of any organization. Its range is from the setting-up of an organization and methods department to information about types of office machines and their efficient use, and even to some matters of detail such as the optimum size for an office desk. In these days, when there is such a plethora of office machines and office systems on offer, it is extremely valuable to have, in convenient form, the product of the experience of leading companies.

A feature of the book which is claimed to be unique is a chart on the field of office machinery. This sets out diagrammatically the seven basic clerical operations and the machines which carry out or assist them, while the pros and cons of mechanization are discussed in the text. There is much in this book of interest and value not only to the managers of large commercial offices but also to those who have to incorporate in their organizations or institutions some efficient system of collection of data, record-keeping, ordering, etc. The index does not do justice to the book—especially one on this subject. For example, 'Pros and cons of mechanization' is indexed under '*P*', with no reference under '*M*'; 'Glossary of arithmetical terms' is under '*G*', with no reference under '*A*', and so on.

E. S. Hiscocks

SHORT REVIEWS

Alan M. Turing

By Sara Turing. Pp. xiv + 157 + 7 plates. (Cambridge: W. Heffer and Son, Ltd., 1959.) 21*s*. net.

FRIENDS and acquaintances of the late Dr. A. M. Turing, as also a much wider circle who only knew him through his published work, will welcome this succinct and timely biography by his mother, Mrs. Sara Turing. Alan M. Turing, who died in tragic circumstances in 1954, in his forty-second year, had already gained wide recognition for his work in mathematics, computing theory and machine design, and for a novel physico-chemical theory of morphogenesis; and, on the evidence, he was still on the flood-tide of even more remarkable achievements. Unfortunately, this was not to be.

Now, in this readable volume, presented with admirable detachment and singularly unmarred by the excess of sympathy which might well have crept in, we have an outline sketch of a very remarkable, and original, if sometimes wayward personality, direct, friendly, whimsical, and generous to a degree. Talent may be said to be the mainstay of academic life; but his contemporaries recognized that Turing had that very much rarer quality—genius. How much genius it is not possible to assess at this stage. Hence the value of this biographical memoir; for as Lyn Irvine (Mrs. M. H. A. Newman) has indicated in a percipient foreword, this is a source-book for future biographers, especially those who are concerned with the nature and manifestation of genius.

A Source Book in Greek Science

By Prof. Morris R. Cohen and Dr. I. E. Drabkin. Second printing, with corrections. (Source Books in the History of the Sciences.) Pp. xxi + 581. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1958.) 60*s*. net.

IT is interesting to see that this well-known work, which first appeared in 1948 from the McGraw-Hill Book Co., has been taken over by the Harvard University Press and is distributed in Britain by the Oxford University Press; and it is to be hoped that the other volumes in this excellent series are to be made similarly available in the near future. The great value of the book has always lain in its making immediately available, to students of the history of science and to other interested readers, English versions of Greek scientific literature that they would otherwise have to seek through many volumes in a library of considerable size; and it has another importance as a corrective of the partial and narrow view that scientific thought began in the seventeenth century. These six hundred pages of extracts on mathematics, astronomy, geography, physics, chemistry, technology, geology, meteorology, biology, medicine, physiology and psychology, with easy reference through a detailed table of contents, place at the reader's disposal a wealth of scientific literature and information that ranges through ten centuries. The comments connecting the extracts and the notes on the extracts have been well prepared, and the illustrations are suitably chosen.

Two impressions of Greek science that the reader gets from a critical survey of these extracts are very clear, namely, the preponderance of mathematics and the lack of understanding of experimental science. One could say with confidence not so long ago that in these joint respects Greek science differed much from that of our own time, but to-day one may be allowed to wonder whether there are not some scientific activities that have recently resumed these ancient characteristics.

Robert Boyle

Father of Chemistry. By Dr. Roger Pilkington. Pp. 179. (London: John Murray (Publishers), Ltd., 1959.) 18*s*. net.

ALL scientists know Boyle's Law, and many are aware of Boyle's work on combustion and respiration and his critical approach to chemical theory. But how many know that the author of "The Sceptical Chymist" wrote a religious romance and financed the translation of the Bible into the language of the North American Indians?

Dr. Roger Pilkington gives a balanced account of all aspects of this remarkable man's life and character. Boyle's chemical heritage is well described, and his scientific work is described as fully as possible in a short book, but more might have been said about the work and opinions of his contemporaries and the consequences of his discoveries and theories. This would have been particularly useful to readers unfamiliar with the history of science. If such a chapter can be added to a future edition it will enhance the value of a well-written book that can be read with profit by all who are interested in the men behind the scientific laws and theories.

W. A. SMEATON

Structure and Function of Genetic Elements

Report of Symposium held June 1–3, 1959. (Brookhaven Symposia in Biology, No. 12.) Pp. v + 187. (Upton, New York: Brookhaven National Laboratory, 1959. Available from Office of Technical Services, Department of Commerce, Washington, 25.) 2 dollars.

THE Brookhaven symposia on biology are sponsored by the Department of Biology of the Brookhaven National Laboratory. The twelfth symposium was held during June 1–3, 1959, and was devoted to the topic of the structure and function of genetic elements. The object of the symposium was to bring together the several points of view of the physical chemist, the biochemist, the geneticist, the cytologist, and the cytochemist. There are fourteen papers in all, covering these disciplines. All are valuable and important, and almost as valuable as the papers are the full reports of discussions and comments by the participants.

The subjects dealt with are: (1) Structural aspects of nucleic acids; (2) Biochemical activities of nucleic acids; (3) Genes; (4) Genetic transfers by viruses; (5) Structure and duplication of chromosomes; and (6) Nuclear-cytoplasmic relationships.

The results presented at this symposium may be compared with those of eight years ago at the fourth Brookhaven symposium, on a similar theme, the chemistry and physiology of the nucleus. It is clear that considerable advances have been made in our knowledge of the structure and function of the genetic elements. This is in some part due to improved techniques in the various areas of study. Autoradiography is, for example, extensively employed to help solve the problem of how chromosomes duplicate themselves.

Among the most valuable contributions are those of a general nature, for example, those concerning the present position of the coding problem (Crick), the present status of the adaptor hypothesis (Hoagland) and a comparative view of the chromosome (Steffenson).

Light touches are provided by Crick—"Hinshelwood once suggested a code dependent on the sugar but I never understood what he meant", and Zamenhof—"Could it be that all these things are not gene determined ? Or could it be that there is some information also in the sugar, God forbid ?"

S. C. HARLAND

Blindness in West Africa

By Prof. F. C. Rodger. Pp. xiv+262+1 plate+6 maps and 96 text figures. (London: H. K. Lewis and Co., Ltd., 1959. Published for the Royal Commonwealth Society for the Blind.) 70*s*. net.

IN Great Britain there are about two certified blind persons in every 1,000 of the population. A report from thirty-nine Commonwealth and Colonial territories has given a figure of about eight blind per 1,000, with far the largest numbers in West Africa.

This book records the findings of a survey in Nigeria, North Ghana and the Cameroons, and Prof. Rodger, allowing for factors like visual standards, assesses the overall figure of blindness as about 1 per cent of the population with the figure much higher than this in North Ghana, where onchocerciasis, a generalized infestation by a fly-borne filarial worm, is very severe. The countries, the people and their eye diseases are all reported upon, and, while much is technical, Prof. Rodger has presented his material so that a lay person will find interest in it. Eye disease among children was especially investigated and considerable attention paid to nutritional standards. The report is objective and parts make gloomy reading, for much of the blindness arising from infection (purulent smallpox, syphilis, etc.) and malnutrition is preventable. Trachoma, the cause of the greatest number of blind, is now amenable to treatment, and may perhaps be eradicated before too long ; but the elimination of filarial worm disease remains a problem to be solved.

The production of the book is good, though the illustrations vary a lot in quality.

R. C. DAVENPORT

The Hand of Life

The Story of the Weizmann Institute. By Ritchie Calder. Pp. 78+65 plates. (London: Weidenfeld and Nicolson, 1959.) 30*s*. net.

IN 1934 the Daniel Sieff Institute was established in the desert at Rehovoth, Israel, as a memorial to the son of Mr. and Mrs. Israel Sieff and the nephew of Sir Simon Marks. The memorial had been suggested by Dr. Chaim Weizmann, the distinguished chemist who became the first president of Israel. Ten years ago the Weizmann Institute was also founded at Rehovoth and, to mark both occasions, Ritchie Calder has produced a tribute worthy of the magnificent buildings and gardens which now flourish in a place where twenty-five years ago there stood nothing but sand. This handsome book describes some of the outstanding investigations which have been made at both Institutes and also contains a series of photographs which give a clear impression of what life is like for those who live and work at Rehovoth ; their scientific investigations are a worthy memorial to Sieff and Weizmann.

Paths Across the Earth

By Lorus and Margery Milne. Pp. xi+216. (London: Cassell and Co., Ltd., 1959.) 16*s*. net.

IT is unfortunate that the wrapper should tell us that the authors, two American zoologists, have "travelled together from the Arctic to the Equator to try to solve such problems", because they say little at first hand and nothing new. The book is in fact a popular account of the migratory movements of animals, presented in chapters devoted to general aspects or questions ; New World examples naturally predominate. It should be interesting to readers coming fresh to the subject and willing to accept a degree of arbitrary simplification. There are, however, surprising omissions ; for example, Kramer is not mentioned among seven authorities named in respect of bird navigation ; there is no reference to the regular annual movements of some African antelopes—indeed almost an implication that such do not occur ; and a section on echo-location contains, in that regard, only a vague statement about mice and none of the precise information available for bats, cetaceans and certain birds. There are also definite errors ; for example, it is the reverse of true to say that ringing has shown that the majority of British native starlings do not remain throughout the year but migrate towards the Mediterranean ; and it is not the case that the cattle egret has shown no recent range expansion in the Old World comparable with its spread to and in the Americas.

LANDSBOROUGH THOMSON

Handbook of Toxicology

Vol. 5: Fungicides. Analysis and Compilation by Everett F. Davis, Barbara L. Tuma and Lucy C. Lee. Edited by Dorothy S. Dittmer. Prepared under the direction of the Committee on the Handbook of Biological Data, Division of Biology and Agriculture, National Academy of Sciences—National Research Council. Pp. ix+242. (Philadelphia and London: W. B. Saunders Company, 1959.) 38*s*. 6*d*. net.

THIS volume lists 196 substances known to destroy fungi or to inhibit their growth and reproduction. For each the structural formula, physical and chemical properties, tests (*in vitro*, *in vivo* or both), toxicity to man and animals, and use are given. Authorities for this information are included in the bibliography of 326 titles, and patent numbers (United States and others) for 112 of the 196 substances are listed in Appendix i. Appendix ii lists 500 other substances, refers to references to them in the general bibliography, but gives no other information. This should be a useful reference work for those advising on the use of fungicides in industry and agriculture.

Agricultural Insects of East Africa

Compiled by R. H. Le Pelley. Pp. x+307. (Nairobi: East Africa High Commission, 1959.) 42*s*.

ENTOMOLOGISTS and agriculturalists in many tropical countries, particularly in Africa, have been greatly handicapped because they have not been able to refer to authoritative lists giving the names of insects recorded there. A great deal of the information required has been collected by Government entomologists, and has been buried in departmental files. Dr. Le Pelley has performed a useful service in bringing together in this book so many records of insects and mites associated with plants in Kenya, Uganda, Tanganyika and Zanzibar; workers here, in adjacent territories and even in other parts of tropical and sub-tropical Africa, will find the lists invaluable. Parasites, predators and stored products insects are included, with the original reference to the publication first giving their occurrence. A list like this cannot but be incomplete, as its author would be the first to point out; but he is to be sincerely congratulated on his success in including so many records others would not have unearthed.

The title, "Agricultural Insects of East Africa", may mislead. This book contains only a list of names of insects and plants. It does not give any descriptions of the animals, or of their importance in agriculture. It is a very valuable work as it stands, and it is perhaps unfortunate that the title does not make its nature more obvious.

Kenneth Mellanby

A Laboratory and Field Manual of Ornithology

By Olin Sewall Pettingill, Jr. Third edition, second printing. Pp. viii+279. (Minneapolis: Burgess Publishing Company; London: Mayflower Publishing Co., Ltd., 1958.) 40*s*.

IN recent years ornithology has become increasingly respectable among contemporary sciences without losing its place as a source of casual interest and amusement. This status has been achieved to a large extent by improvements in standards of teaching as reflected in such books as this laboratory and field manual. In Britain it seems difficult to isolate ornithology as a special subject in the curricula of secondary schools and universities, and teaching is confined mainly to extra-mural environments. But in the United States, apparently, this difficulty is not felt to the same extent, for Prof. Pettingill's manual is based on notes for lectures at high schools and colleges. The text consists of explanatory material and directions for study, including lines of research for advanced students. Although retaining the form and structure of lecturer's notes (it is a photo-offset reproduction of typescript) it is a valuable source of useful information on most aspects of bird biology.

J. D. Macdonald

The Buzzard

Text and Photographs by Frank Wenzel. Translated from the Danish by Reginald Spink. Pp. 86. (London: George Allen and Unwin, Ltd., 1959.) 35*s*. net.

THIS book from Denmark, written and illustrated by Frank Wenzel, is a fine example of bird photography. Its illustrations from photographs in colour and in black-and-white include many superb pictures, some of remarkable dramatic quality, for example the colour plate facing p. 80. This shows a buzzard balancing itself with extended wings held aloft on a swaying branch. The bird is silhouetted against a stormy sky with a dazzling sun gleaming from between the clouds. Another pleasing picture is the portrait of a buzzard facing p. 73. It shows a remarkably light-coloured bird in a green woodland setting and it reminds us how this species varies in colour and markings. A little farther on is a photograph of a very dark male, with plumage of deep sooty brown, indeed almost black.

The letterpress is comparatively slight; but it is based on first-hand observations, telling of the author's experiences among the buzzards of his native Denmark. He gives us many exciting descriptions of its woods, heaths and marshes. He tells how he built a hide in a tree from which he could see into a buzzard's nest in a neighbouring tree; he adds he thought it desirable to ensconce himself in it under cover of darkness, though to do so he had to walk through the night-time woods. "Moonlight makes everything change character," he says. "Things well known in daylight now appear quite unfamiliar. Tree trunks look like dark figures throwing long mysterious shadows in the undergrowth; harmless stumps are transformed into witches and ogres. The silence was broken over by the bog. There was a strange purring and whirring noise . . . it was the phantom nightjar filling the night with magic and mystery."

This volume would make a fine present for any young person with aspirations to use his camera in the portrayal of birds.

Frances Pitt

Diseases of Farm Crops

By A. Beaumont. Pp. 128+48 photographs. (London: W. H. and L. Collingridge, Ltd., 1959.) 25*s*. net.

THE farmers and agricultural students for whom the author intends this companion volume to his "Diseases of Garden Plants" will be glad that it is written so clearly, with so few scientific terms and generously illustrated by photographs nearly all of which show what is intended. Readers better versed in plant pathology will recognize that most of the recent work is mentioned in summaries of the major diseases. The author is realistic about the importance of diseases, and the control measures necessary or practical; he emphasizes the effects of crop rotation and has added many cautionary notes born of his long experience as an advisory plant pathologist.

Because much of it is good, the weaker parts of the book stand out starkly. The arrangement of diseases under crops and the organs attacked makes reference easy, but leads to much repetition which could be avoided by tabulation or some grouping of closely related hosts. The too-simple section on naming and recognition of diseases, the many notes on rare fungi and, for example, the 15 references under marrow stem kale which contain little more than notes of frequency and cross-references, all make one wish the author had used this space to expand the sections on principles and major diseases.

J. M. Hirst

A Handbook of West African Flowers

By Harold N. Saunders. Pp. 124. (London: Oxford University Press, 1958.) 5*s*.

IT is not an easy task to select the commonest plants in an area, and the larger the area the more difficult it becomes. When the area is West Africa from Gambia to Nigeria, with a flora of several thousand species, no selection within reasonable limits can hope to satisfy everybody everywhere. Nevertheless this attractive little book has courageously attempted the task, and the result is both creditable and useful. Within the limits of no more than 124 pages, 364 species are briefly described, and small, simple, clear illustrations of 120 of them are fitted in, four to a page. In addition there are a glossary and an ingenious numerical key, which the user after some practice should find helpful. A word of warning to the user to read *all* the choices in each column on pages 108 and 109, before deciding which one fits his plant best, is, I think, desirable. Hitherto there has been no pocket-book of West African flowers for the beginner. Now, for as little as five shillings, there is, and I hope that this book will start to perform its most valuable function of arousing interest and intelligent observation of what is growing round them among those people previously daunted by the learned and weighty scientific works, from which alone hitherto the name of the commonest West African roadside weed might be laboriously extracted. J. P. M. Brenan

Miocene Floras of the Columbia Plateau

Part 1: Composition and Interpretation. By Ralph W. Chaney. Part 2: Systematic Considerations. By Ralph W. Chaney and Daniel I. Axelrod. Pp. viii+237+44 plates. (Publication No. 617.) (Washington, D.C.: Carnegie Institution of Washington, 1959.) 4.25 dollars; Cloth bound 4.75 dollars.

This excellent and comprehensive review of the Middle to Late Tertiary floras of the Western United States is for the most part a revision and synthesis of the research work carried out in the University of California by Emeritus Prof. Ralph Chaney and Dr. D. I. Axelrod, who have contributed many papers on this subject covering a period of more than forty years. The results of their research and that of earlier workers on the composition of the floras is brought together and from the result of this synthesis deductions are made as to the ecological and climatic features under which the floras existed. As an example, they find evidence that as a result of the increasing altitude of the Cascade Range during the Pliocene the conditions became drier and hotter and many constituent types of plant disappeared; whereas on the eastern sides of Asia and North America where the climates have remained moister these types still persist as constituents of the floras.

The second part of the review consists of what is in essence a catalogue raisonné of the fossils. These are well illustrated in the plates and there are also photographs of present-day vegetation in the United States for comparison with that of the Tertiary.

J. Walton

Memoirs of the Geological Survey of Great Britain

Palæontology, Vol. 4, Part 2: Fossil Plants of the Carboniferous Rocks of Great Britain. By Dr. Robert Crookall. Second edition. Pp. iv+85–216+plates 25–58. (London: H.M. Stationery Office, 1959.) 110*s*. net.

The Geological Survey of Great Britain is publishing a complete account of the Coal-measure plants of Great Britain. This work represents the second part of the series on palæontology of which the first (pages 1–84) appeared in 1955. Like its predecessors it gives references exhaustively; descriptions are full and amply illustrated by photographs. The photographs indeed repay study with a fairly strong hand lens; structures 0·1 mm. apart can just be resolved. It is very like the memoirs being produced elsewhere on the same subject; as far as I can judge, the work is of equal completeness and quality, though the paper and margins may be less sumptuous. Like them, it seems written mainly for the geologist who has to correlate a rock by means of its fossil plants, and what is more, does it by the well-tried hand-lens methods. In the course of being complete, the present volume mentions microscopic work done by others, but does not add to it. If the botanically minded fossil botanist wants such information, he can determine his plant here, but then do all his own work. The treatment is conservative; the several subgenera used by some are rejected and though new species are made, their numbers are moderate. The only really adverse criticism to be made is at the very slow production. Kidston's Volume 1 of the series is dated 1923–25.

T. M. Harris

Strahlenbiologie

Grundlagen und Ergebnisse. Von Prof. Dr. Hedi Fritz-Niggli. Pp. xvi+379. (Stuttgart: Georg Thieme Verlag, 1959.) 65 D.M.

Prof. Fritz-Niggli deserves congratulation for a masterly review, with 28 pages of references, of a subject that is difficult to make into a logically coherent whole. Though the reader is left feeling that the core of the subject, the cause of radiobiological damage, is as mysterious as ever, that is not the fault of the author. A further feeling, surprising and depressing, results from the author's painstaking historical research; this is that many of the facts that became familiar during the post-bomb wave of radiobiological research were just as familiar during the post-X-ray-radium wave at the beginning of the century. Good examples are the effects on blood cells and embryos, which were studied in amazing detail between 1903 and 1908.

A commendable feature of the book is that each branch of the subject is introduced with a short sketch of the basic knowledge needed to follow it; but the reader's education is rather peculiar. He is told that the atoms in a gram of hydrogen if placed end-to-end would stretch 76 times round the Earth's solar orbit, that proteins have large molecular weights and that nucleic acids are biologically important; but it is assumed that he knows how to distinguish a gynogenetic from an androgenetic haploid habrobracon. Fortunately his knowledge of histology is assumed to be imperfect; he is shown normal pictures for comparison with the abnormal. The book is attractively written and printed, with good illustrations and plenty of tables and ingenious but rather brain-twisting diagrams.

Die Aktivierte Essigsäure

Das Coenzym A und seine Acylderivate im Stoffwechsel der Zelle. Von Dr. Karl Decker. (Sammlung Chemischer und Chemisch-technischer Beiträge, Neue Folge, Nr. 57.) Pp. viii+300. (Stuttgart: Ferdinand Enke Verlag, 1959.) Ganzleinen 74.80 D.M.

The index of this monograph might almost be that of a general text-book of biochemistry: so wide-spread are the functions of coenzyme *A*. It is difficult to realize that this coenzyme was discovered only about ten years ago and that the mass of fundamental knowledge described in this book was mostly gained within that short time. Coenzyme *A* is a catalyst which is built up in the body from pantothenic acid, one of the vitamins of the B complex. It acts as a carrier of acid groups, particularly acetate; the acid, when combined as a thiol ester with the coenzyme, can take part in reactions which do not occur with the free acid. The acetyl derivative of coenzyme *A* ('activated acetic acid') is a key intermediate substance in the body, for it is on the direct pathway for the metabolism of carbohydrate and fat. It is involved in many other important biochemical processes such as the synthesis of cholesterol, the acetylation of drugs like the sulphonamides and the formation of acetylcholine, one of the chemical transmitters of nerve activity.

All these, and many other functions of the coenzyme, are described and fully documented. The early chapters deal with the events leading to its discovery, and with its preparation, properties and estimation. The information is well set out, much of it in tabular form, and the literature is covered up to and including 1958. It may be worth mentioning that the high cost of materials for present-day biochemical research is not only due to the need for expensive isotopes, for the cost of a gram of commercial coenzyme *A* runs into hundreds of pounds. Beside this, the cost of the book may not seem so high. It is very useful to have all this information collected together and the book should be in every biochemical library. D. C. HARRISON

Tables of Physical and Chemical Constants and some Mathematical Functions

By Dr. G. W. C. Kaye and Dr. T. H. Laby. Prepared under the direction of an Editorial Committee. Twelfth edition. Pp. viii+231. (London: Longmans, Green and Co., Ltd., 1959.) 25*s*. net.

THE latest edition of this admirable book is, like its predecessors, an outstanding work of reference of which its editorial board and contributors can be justly proud. So many complimentary things have been said in the past about previous editions that it is difficult to add anything more. Suffice it to say that the present edition more than maintains its great tradition for accuracy and clearness in the presentation of the abundant data, and that it remains an indispensable book for all students of physics and chemistry and their teachers.

The tables have been thoroughly revised and brought up to date, and certain sections, like radioactive and stable isotopes, have been extended to bring them into line with modern times, while the general atomic constants have been entirely recalculated.

Extensive changes have also been made in the chemistry section, in particular with chemical thermodynamics and electro-chemistry, while in the physics section the main revisions have been under the headings time, elasticity, full radiation and atomic physics. But in spite of the inevitable changes and modifications, this edition has the same essential features as before. It is still "Kaye and Laby", the friend and guide of countless numbers of students of successive generations, for it continues to be a completely reliable source of an amazing amount of essential material expressed so clearly, concisely and accurately. T. M. YARWOOD

Atomic Terminology

A Dictionary of Nuclear Science, Engineering and Technology in Four Languages (English–German–French–Italian). Compiled by Lore Lettenmeyer. (Die Fremdsprachen in der Praxis, Reihe B, Band 1.) Pp. 298. (München: Isar Verlag; London: Temple Press, Ltd., 1958.) 42*s*. net.

WITHIN the limits of its scope, "Atomic Terminology" is a model of what a multilingual dictionary should be. In the main part of the work, where the order is English alphabetical, each of the 1814 entries is given a number; this number is repeated before the German, French and Italian equivalents, and is also used in the indexes in each of these three languages. English synonyms are listed together, but each appears also in its alphabetical place with a cross-reference. The fact that the number of synonyms is, on occasion, as many as thirteen indicates the thoroughness with which the compilation has been carried out.

The keeping of the dictionary to pocket size has naturally imposed limitations: there are no definitions, and no information about sources, so that the user cannot tell *a priori* which forms are in common use and which, if any, have been coined by the compiler. Nevertheless, the general impression is one of careful and reliable lexicography, and this is confirmed by the extreme paucity of obvious errors: half a dozen misspellings such as 'Cockroft', and as many terminological inexactitudes such as 'restricted theory of relativity', in almost 300 pages. Dr. Lettenmeyer's valuable work is to be warmly recommended to all who have occasion to seek quick reference to correct equivalents of terms in the field of nuclear energy. J. B. SYKES

Electromagnetic Phenomena in Cosmical Physics

Edited by B. Lehnert. (International Astronomical Union Symposium No. 6, held in Stockholm, August 1956.) Pp. xiii+545. (Cambridge: At the University Press, 1958.) 50*s*. net.

THIS volume testifies to the increasing interest in electromagnetic phenomena which has characterized research in cosmical physics during the past decade. It is a subject in which simultaneous development and combination of theoretical, experimental and observational work are necessary, and this is reflected in the topics discussed at the symposium. Part 1 is devoted to magneto-hydrodynamics, and both theory and laboratory work are discussed. The paper by W. H. Bostick on the experimental study of plasmoids is of especial interest.

Part 2 is devoted to solar electrodynamics, Part 3 to stellar magnetism and Part 4 to solar and interplanetary magnetic fields. The papers in these three parts give a good indication of the importance of electrodynamic phenomena in astrophysics. It is not surprising that in this very live field few of the papers reach final conclusions, and they serve to emphasize how little we really know about the phenomena.

Part 5 is mainly concerned with cosmic rays, Part 6 with high current discharges and Part 7 contains a number of additional contributions on various subjects. From the vigorous discussions after the papers it is clear that the symposium was a success and of much benefit to the experts. The casual reader will not find this collection of papers suitable for general reading, and must await the production of a more systematic treatment of the subject.

R. H. GARSTANG

Nuclear Reactor Physics

By Prof. Raymond L. Murray. Pp. xi+317. (London: Macmillan and Co., Ltd., 1959.) 30*s*. net.

THIS is a reprint of the 1957 American edition and therefore contains no references to developments since 1956. It presents a clear and concise introduction to the basic equations and physical concepts, and its reappearance at a price which is now within reach of the student is to be welcomed. The author covers the basic areas of reactor physics, starting with those problems for which simple mathematical models provide an adequate approximation, and develops the power of the mathematical techniques as the book proceeds and as they are needed to cover the later, more complex, problems.

A feature of the text is the illustration of each development of the theory by applying it to a specific physical problem; a list of problems is also provided at the end of each chapter. These provide a very effective technique for showing the student what can be done with the theory.

The reader should, however, note that although this book is an excellent elementary text, the use of modern high-speed computing machines has meant that the calculation procedures currently in use for the solution of reactor problems differ appreciably from those described in Prof. Murray's book.

J. Fell

Physics and Mathematics

Vol. 3. Edited by Donald J. Hughes, J. E. Sanders and J. Horowitz. (Progress in Nuclear Energy, Series 1.) Pp. viii+403+xii. (London and New York: Pergamon Press, 1959.) 105*s*. net.

THE second (1958) Geneva Conference on the Peaceful Uses of Atomic Energy differed from the first in that the declassification of much of the early work was complete, and so attention was concentrated more on critical appraisal and interpretation, rather than on the mere presentation of data.

This third volume in the series "Physics and Mathematics" contains a selection of some twenty-one papers considered by the editors to be the most significant contributions to the dozen or so sessions on the physics of atomic energy. There can be no doubt that several of the papers, which cover the fields of neutron cross-section measurement, the physics of fission, neutron thermalization theory, and other aspects of reactor physics, are of great significance. For example, Leachman's paper on "The Fission Process" fills a very definite need for a readable review of recent data and theories on this controversial subject.

It can inevitably be argued that certain papers have been included the fields of which are too narrow, and that other, possibly better, papers have been excluded. It is the opinion of this reviewer, however, that the volume contains a selection of papers which will form a most useful reference work for any physicist interested in the more fundamental aspects of reactor physics.

E. R. Rae

A Student's Introduction to Physics

By Franklin Miller, Jr. Pp. xv+608. (London: Routledge and Kegan Paul, Ltd., 1959.) 50*s*. net.

THE author of this copiously illustrated text-book believes that all students can, and should, be familiar with the basic principles of physics, and accordingly he covers the whole field from its nature to the structure of the atom and nuclear energy.

The student requires no mathematics beyond simple algebra, and principles are emphasized rather than technological applications, though several of these are dealt with.

For a text in elementary physics there are several departures from the orthodox presentation. For example, the structure of the atom is introduced very early and students become acquainted with protons, electrons, neutrons and isotopes almost at the start. For a book of this scope I agree this is the correct approach, since there is no doubt much interest is taken nowadays by the ordinary student in anything pertaining to what is termed 'modern physics', and the early introduction must act as a stimulus to learn more about the principles of classical physics.

Another sensible innovation is the elimination of all reference to conventional positive current; the text deals only with direction as indicated by the electron flow.

Metric and f.p.s. units are used in mechanics, but only M.K.S. units are used in the section on electricity and atomic physics, thus keeping in line with modern practice.

Many worked examples, questions and problems are included in the book; the text, supported with many diagrams and illustrations, is well written and thoroughly done and it should certainly fulfil the aim of its author.

T. M. Yarwood

Analyse de Variance et Plans d'Expérience

Par Prof. Daniel Dugué et Prof. Maurice Girault. (Probabilités Statistique—Recherche Opérationnelle. Section B: Statistique Mathématique.) Pp. xiii+68. (Paris: Dunod, 1959.) 800 francs.

THIS short book gives a compact account of the elements of analysis of variance and experimental design. By English standards, its compounding of very elementary ideas on standard distributions and models with methods for design construction based upon Galois fields and vector spaces reads strangely; however, this book appears to be a successful execution of this intention. Necessarily the limitation of length prevents adequate critical discussion of the ways in which the designs should be used. Ascription of the distribution of the ratio of two independent χ^2 variates to 'Behrens–Fisher' is surprising.

D. J. Finney

Between Earth and Space

By Dr. Clyde Orr, Jr. Pp. ix+253+8 plates. (New York: The Macmillan Company, 1959.) 34*s*. 6*d*.

THE future of mankind has always been a concern of thinkers, the deleterious effects of Man's own activities having prompted many pamphlets. The substance of such a tractate might well be drawn from the last two chapters of this book. One of these deals with atmospheric pollution, and here, as might be expected from a chemist, Dr. Orr is at his best, the subject-matter being of higher quality than is suggested by such a poetic title as "A Ravaged Realm".

The twelve earlier chapters give a non-technical account of man's environment and its evolution. The presentation is more that of a popular lecture than that of a text-book and flows easily. As seems inherent in this type of treatment, there are statements as of fact which the specialist would accept only as possible hypotheses. The initiate is, however, not seriously misled, being shown a balanced picture with a spice of the more spectacular phenomena.

A selected reading list is given of some two hundred references from a wide variety of sources largely of a popular or semi-popular nature. This list is not classified, there is no reference to it in the text, nor is there any indication of which part of each reference is thought to be apposite. To pursue every reference would take even the most assiduous reader quite some time, an unduly heavy task to develop from an easily read book which itself supplies good light relaxation.

B. R. LEATON

Man's Conquest of the Stars

By Pierre Rousseau. Pp. 356. (London: Jarrolds, Publishers (London), Ltd., 1959.) 25*s*. net.

IN this book the author has attempted to show how the development of astronomical science has influenced, and been influenced by, human methods of thought. When primitive man first turned to agriculture he needed the stars to forecast the changes of the seasons. The sophisticated thinkers of the Greeks attempted to encase astronomy in their different philosophies—whether the perfect circles of Plato or the divine harmony of Pythagoras. When Europe was submerged by the Dark Ages, the Arabs maintained the study of astronomy, chiefly to ensure that the Moslem hours of prayer were accurately fixed. When the Renaissance dawned, the new discoveries of astronomy helped to break the chains that fettered human thought. In succeeding centuries the great explorations stimulated the study of navigation, and the industrial revolution made possible the construction of instruments of greater power and accuracy.

This history is fully developed in M. Rousseau's book; but the most powerful part is his discussion of the contribution of the seventeenth-century scientist-philosophers Descartes, Newton, and their contemporaries. They invented methods which led directly to the 'scientific method' as we understand it to-day. The author assesses the stature of each new school of astronomy by the closeness with which it adheres to this method.

It should not be thought from the above remarks that this is a closely reasoned philosophical treatment—the style is racy and frequently enlivened by anecdotes. However, this style is virtually irreconcilable with spherical astronomy, which is made unnecessarily obscure in comparison with the rest of the book.

D. H. P. JONES

Astronomy

A Textbook for University and College Students. By Dr. Robert H. Baker. Seventh edition. Pp. viii + 547. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1959.) 52*s*. 6*d*.

THIS work is an excellent descriptive handbook of modern astronomy and astrophysics. It is the seventh edition of a book originally published in 1930, but has been completely rewritten and embraces all new developments up to 1958. However, it is not encyclopædic in approach; the author has been at pains to describe the context as well as the content of each section so that the subject appears as an organic whole. Thus radio-astronomy appears not as a self-contained unit but as the means for demonstrating the spiral nature of our galaxy, the size of which is known from optical means. The photo-electric measurement of the apparent brightnesses of stars is shown to lend a greater precision to the cosmic distance scale. Earth satellites had not made much direct contribution to astronomy at the time of publication, and they receive a correspondingly small mention.

All this information is conveyed in a lively and lucid style and there are plenty of really good photographs. Line diagrams are often used to illustrate more obscure points. In the preface the author states that no special knowledge of mathematics or physics is required; this rather vitiates its value as a university text-book. However, it would make a good reference to the descriptive part of a general course in astronomy as well as being an intelligible introduction for the layman.

D. H. P. JONES

The Sun and Its Influence

An Introduction to the Study of Solar-Terrestrial Relations. By Prof. M. A. Ellison. Second edition (revised). Pp. xiv + 237 + 9 plates. (London: Routledge and Kegan Paul, Ltd., 1959.) 25*s*. net.

THE second edition of Prof. Ellison's book is the same as the first except for a few corrections and an added description of the solar cosmic ray event of February 23, 1956. The book is an authoritative factual description of solar activity and its terrestrial effects. It is written for the general reader, but provides a stimulating narrative for students or workers interested in any of the phenomena operating between the Sun and the Earth. The solar problems studied are the solar atmosphere, solar radiation, radio emission and various aspects of the solar cycle. Special attention is given to solar flares. The main terrestrial effects are to be found in the ionosphere, the Earth's magnetism, and auroræ.

C. W. ALLEN

A Concrete Approach to Abstract Algebra

By Prof. W. W. Sawyer. Pp. v + 233. (San Francisco: W. H. Freeman and Co.; London: Bailey Bros. and Swinfen, Ltd., 1959.) 1.25 dollars; 10*s*. 6*d*. (paperbound).

IN abstract algebra, the novice is sometimes perplexed by the contrast between the almost ludicrous simplicity of the techniques and the profundity of the concepts, and may accept the logic of a modern text without acquiring any real grasp of the subject. To help him, Prof. Sawyer begins with a simple concrete model: a child with no arithmetic and no English, placed in an English schoolroom, might soon learn to associate the responses "four" and "six" with the teacher's demands, "Two and two make . . .", "Two times three is . . . ", and thus arrive at formal addition and multiplication tables without having any knowledge of the specific character of the elements to which these tables apply. By insistence on such concrete models, the author is able to emphasize the structure of an algebra, to deal with such topics as finite arithmetics, extensions of fields, and vector spaces, without inducing a feeling of unreality. A final good chapter shows how these notions can be applied to the familiar old problem of the trisection of an angle. Prof. Sawyer writes clearly and entertainingly: there are many non-mathematicians who want to know what modern mathematics is doing, and they will find this book helpful, though some references for further reading might well have been supplied.

Differential Geometry

By Prof. Erwin Kreyszig. (Mathematical Expositions, No. 11.) Pp. xiv + 352. (Toronto: University of Toronto Press; London: Oxford University Press, 1959.) 48s. net.

THE calm backwater of classical differential geometry was stirred up by the general theory of relativity and is now once more in the main stream: Prof. Kreyszig keeps within familiar euclidean space, but has in mind extensions to Riemannian geometry. He first deals with the curvature and torsion of a curve, defined rather artificially as normalizing factors for certain vectors associated with the curve, but quickly related to the more concrete notion of the components of the angular velocity of the fundamental orthogonal triad. Then he discusses the first and second ground forms for a surface and geodesic curvature, using tensor methods which are introduced and elaborated as they are needed. This part of the book gives the minimum which every mathematician must know, and Prof. Kreyszig has taken pains to make the argument both detailed and rigorous. For the rest of the book he selects certain more advanced topics of importance. There is a very good chapter on mapping, in which the unifying power of this concept is illustrated. Another chapter deals with Levi-Cività's parallel displacement as an introduction to the general theory. The final chapter covers a variety of special topics, such as minimal surfaces and surfaces of constant Gaussian curvature. Exercises for the student are interesting and not oppressively numerous. The teacher should find this book helpful because of the care with which topics have been chosen from a very wide field, and because of the skill with which analytical rigour and geometrical intuition have been mated.

Britain's National Parks

Edited by Harold M. Abrahams. Pp. 151 + 40 photographs. (London: Country Life, Ltd., 1959.) 25s. net.

WHEN the first British national park was designated ten years ago it was hoped, in Lord Birkett's words, that "the fairest places in these islands will be secure from all assault arising from accident or design". With ten parks created this has proved to be far from the truth, and those who administer the parks need all the support they can get to resist the encroacher, both private and public.

This beautiful book, made up of a series of articles by men and women who know their parks lovingly and intimately, supported by photographs of the quality one expects from the publisher, should encourage all readers to join the ranks of those who see to it that encroachments are not made without due cause.

British Industries and Their Organization

By Prof. G. C. Allen. Fourth edition. Pp. xi + 332. (London: Longmans, Green and Co., Ltd., 1959.) 25s. net.

IN this edition Prof. Allen has largely re-written his book, which was first published in 1933 and substantially revised in 1951. The first chapter, which is substantially unaltered, traces the chief features of British industrial growth up to 1914, and the second chapter, much enlarged, outlines the economic history of the period from 1914 to 1959, so far as is relevant to the main theme of the book. The remaining ten chapters are concerned with particular industries; but, as in previous editions, the chemical and electrical industries are not included, and the book suffers a little in consequence. The select bibliography has also been completely revised.

R. BRIGHTMAN

Biographical Memoirs of the National Academy of Sciences of the United States of America

Vol. 33. Pp. vi + 484 + 16 plates. (New York: Columbia University Press; London: Oxford University Press, 1959.) 40s. net.

THE "Biographical Memoirs" of the U.S. National Academy of Sciences are the counterpart of the Obituary Notices of the Royal Society, and Vol. 33 worthily maintains the high standard. The memoirs it contains are noteworthy for the completeness of the bibliographies appended to each memoir, but the time-span is exceptional, ranging from Josiah Boyce (September 14, 1916) and M. C. Wood, jun. (January 3, 1920) to P. D. Merica (October 20, 1957), though apart from Dunham Jackson (1946) and T. H. Morgan (1945) the subjects of the remaining memoirs died between 1950 and 1957. Among the memoirs likely to be of the widest interest to British readers are those of Isaiah Bruman, R. A. Millikan and L. F. Small.

The Wealth of India

A Dictionary of Indian Raw Materials and Industrial Products. Raw Materials, Vol. 5: H–K. Pp. xxv + 332 + xii + 16 plates. (New Delhi: Council of Scientific and Industrial Research, 1959.) Rs. 30.

THE appearance of the fifth volume of this work will be welcomed, the first volume having appeared twelve years ago. According to the chief editor's introduction it is considered that half the total work has now been printed. With the machinery for the preparation of this gigantic task now apparently well organized and tried, it may be that the remaining five volumes will be completed in a shorter time. It would seem that the task may well take twenty years to complete. This is not unduly long, however, when one considers how long other similar large tasks, involving several authors, take to complete. For example, some of the large tropical floras now in preparation are unlikely to be completed in less than twenty or even thirty years.

This volume follows a similar pattern to the previous four volumes and contains a great deal of useful information presented in a form readily intelligible to the ordinary reader. It is well illustrated with line drawings, photographs and a few coloured plates. The coloured frontispiece is the sunflower (*Helianthus annuus*), which is, of course, of American origin. A typically Indian economic plant would perhaps have been more appropriate.

The volume deals with the raw materials falling under the letters H–K. It contains 380 entries—370 on plants, 7 on animals and 3 on minerals. The preponderance of plant raw materials, compared with animal and mineral, is no cause for surprise to those familiar with the amazing richness in economic plants which Nature has so generously bestowed upon the Indian sub-continent. Important products in this volume include—*Hevea* (rubber), *Hibiscus* (with several different economic plants), *Hordeum* (barley), *Hydnocarpus* (chaulmoogra oil), *Indigofera* (dyes), *Ipomoea* (sweet potato), jade, *Jasminum* (perfumes) and *Juglans* (walnut).

F. N. HOWES

(*Continued from p.* 34)

applied intermittently to the fine grains subjected to the 'grinding' actions in each of these types of apparatus.

That a real pressure component is operative in the action of the mortar assembly was shown by increasing or reducing the weight of the pestle-head assembly by means of a suitable weight or counterpoise to twice or one-sixth the normal weight. Thus, although about 20 per cent conversion of calcite to aragonite was achieved by only 13 hr. of grinding under normal weight, and about 5 per cent in the same time under half the normal weight, more than 100 hr. under the one-sixth weight failed to produce detectable amounts of aragonite. Presumably the greatly reduced weight of pestle is not sufficient to generate pressures greater than 3,000 bars on the calcite, leaving it still in its equilibrium field. Another example is the litharge–massicot transition of lead oxide in which litharge is the low-pressure (and also low-temperature) form. The action of the light-weight pestle (under nitrogen) will drive massicot readily to the stable litharge (this being merely the effect on kinetics due to bond breakage), but if litharge is the starting material no change to massicot is observed. To accomplish the latter the heavier pestle is necessary, presumably since only then is enough pressure available to reach the massicot field. On the other hand, the heavy pestle will produce some litharge when acting on massicot, because all values of pressure up to the maximum must be encountered, since the apparatus of necessity produces a whole 'spectrum' of pressures. A similar example was found on grinding a mixture of the senarmontite and valentinite forms of Sb_2O_3.

Thus it is clear that the stresses causing fracture generally operate to accelerate reactions, although the effect is larger in some pairs of structures than in others. Superimposed on this kinetic effect is a hydrostatic pressure effect. Detailed verification of the separability of the 'stress' and pressure effects has been effected[5] in an uniaxial high-pressure device[6] so modified that a slow continuous oscillating displacing shear action by the movement of one piston through 2° of arc is applied to samples (of the above compounds) simultaneously subjected to high pressures and temperatures. It is sufficient to mention here that it has been established that stresses in the form of displacing shear do not alter equilibrium pressures of transitions (within the experimental limits), although they do contribute enormously to the rates of such reactions.

Burns and Bredig[2] have already pointed out that the possibility of phase transformations taking place on grinding must be taken into account in explaining discrepancies in the behaviour of calcium carbonate. Our results show that: (1) 'grinding' or mixing, in both 'automatic mortars' and 'Wig-L-Bug'-type shakers not only can introduce appreciable amounts of surface and strain energy but also can quite generally cause the formation of high-pressure phases; (2) the effective maximum in the 'spectrum' of hydrostatic pressures obtained in such instruments is not less than about 15,000 bars; (3) in addition to the quasi-hydrostatic pressures exerted, the shearing stresses causing the breakage of bonds and/or the storage of strain energy result in a very marked acceleration on the kinetics of such transformations.

This work was done as part of the high-pressure studies under contract with the Office of Naval Research, Metallurgy Branch, *NONR*-656(20). We are also indebted to S. Merrin and D. Corrigan, who carried out some of the experiments reported.

FRANK DACHILLE
RUSTUM ROY

Department of Geophysics and Geochemistry,
Pennsylvania State University,
University Park, Pa. Feb. 10.

---

[1] Zaslavsky, A. I., Kondrashov, Y. A., and Tolkachev, S. S., *Doklady Akad. Nauk.*, 75, 559 (1950). Bode, H., and Voss, E., *Z. Elektrochem.*, 60, 1053 (1956).

[2] Burns, J. H., and Bredig, M. A., *J. Chem. Phys.*, 25, 1281 (1956). At the time of oral presentation (see ref. 5) of this work, Prof. J. Goldsmith directed our attention to his work with J. C. Jamieson on the grinding of magnesian calcites, etc., reported orally at the American Crystallographic Association, Milwaukee meeting, 1958.

[3] MacDonald, G. J. F., *Amer. Min.*, 41, 744 (1956). Jamieson, J. C., *J. Chem. Phys.*, 21, 1385 (1953). Clark, S. P., *Amer. Min.*, 42, 564 (1957).

[4] Dachille, F., and Roy, R., *J. Amer. Ceram. Soc.*, 41, 78 (1959).

[5] Dachille, F., and Roy, R., oral presentation, Geol. Soc. Amer., Pittsburgh meeting, November 3 (1959).

[6] Dachille, F., and Roy, R., *Z. Krist.* (in the press).

Strontium-90 in the 'Mixed Layer' of the Atlantic Ocean

OCEANOGRAPHY and marine geochemistry have only relatively recently been able to take advantage of isotopic tracer techniques; unfortunately, the conceptual framework devised for isotope studies in biochemistry and physiology is not readily applicable to systems of very large spatial extension.

In considering the significance of the ocean reservoirs in the geochemistry of carbon dioxide, and in using the distribution of carbon-14 to derive rates of ocean mixing in both vertical and horizontal planes, it has been conventional[1] to divide the oceans into shallow surface reservoirs assumed to be well mixed, and deep reservoirs assumed to be only slowly renewed from the surface. Since, in some applications, the quantitative expression of this picture is extremely sensitive to the assumed depth of the surface reservoir, and to its rate of renewal from below, it seems important to point out that these parameters are measurable by using relatively short-lived radioisotopes, which are added to the system at the surface. In the case of the Atlantic Ocean, North and South, this condition is well met by radioactive strontium-90 from bomb test fall-out. To the Atlantic, strontium-90 has been added, measurably; only as fall-out to the ocean surface. In this form the isotope is wholly soluble in water[2]; and in sea water, the dilution of the radioisotope by both stable strontium and stable calcium in solution is so great that neither biological nor chemical processes produce significant changes in strontium-90 concentration. Thus, its vertical transport depends wholly on vertical movement of the water in which it is dissolved.

As a part of an extended study of the marine geochemistry of long-lived radioisotopes from fall-out, we are obtaining a number of series of measurements of the change in strontium-90 concentration with depth in the ocean. Some of these measurements, together with descriptions of the methods employed, have been published[3]. We now present (Table 1) seven series of strontium-90 analyses, all but one previously unreported. These series agree in showing very significant concentrations of radiostrontium at depth in the open ocean, both north and south of the equator. The number of analyses is still too few to justify very precise integration of the curves of strontium-90 versus depth, but an average concen-

Table 1. STRONTIUM-90 IN ATLANTIC WATER COLUMNS

Station position	15° 49′ S. 35° 50′ W.	8° 26′ S. 7° 45′ E.	16° 15′ N. 43° 37·5′ W.	36° 23′ N. 70° 33′ W.	31° 15′ N. 68° 10′ W.	34° 30′ N. 65° 42′ W.	34° 39′ N. 67° 24′ W.
Date collected	1/2.4.57	1.3.57	22.11.57	13.7.57	8.12.57	11/12.7.58	15/16.7.58
^{90}Sr disinteg./min. per 100 litres at depth							
0 m.	4·1 ± 0·5	5·0 ± 1·0	6·3 ± 0·6	10·5 ± 0·6	10·9 ± 0·6	7·6 ± 0·6	9·1 ± 0·6
100			5·4 ± 0·5		7·7 ± 0·6	13·0 ± 0·7	8·2 ± 0·6
300		2·4 ± 1·0				11·8 ± 0·9	5·5 ± 0·5
400			2·2 ± 0·3		3·9 ± 0·6		
500				4·1 ± 0·6		7·3 ± 0·4	6·4 ± 0·5
700		< 0·3			2·3 ± 0·4	3·7 ± 0·5	3·4 ± 0·5
1,000	1·5 ± 0·6			< 1·0		< 0·9	1·7 ± 0·3
1,200			1·6 ± 0·3				

Note.—Deviations reported are those expected from counting statistics only.

tration, from 300 to 700 m., of about half the surface value, is indicated. The upper 100 m. appears likely to be well mixed, as generally assumed, with a sharp gradient from 100 to 300–400 m. Appreciable concentrations at 1,000–1,200 m. are frequent, although we have never found measurable radiostrontium in samples from 3,000–5,000 m.

We wish to emphasize here only two features of these distributions: the indicated mass transport, and the time-scale. The water columns so far sampled appear to have from three to four times as much total strontium-90 below 100 m. as remains above that depth; and it is reasonable to assume that this radioisotope has all been added since mid-1954[4]. The possibility of vertical transport by sinking along sigma-*T* surfaces appears to be strictly ruled out by the short times available, and the enormous horizontal distances which would have to be traversed. A more or less direct vertical movement by wind-driven mixing is indicated. The facts of the close agreement of samples from 400–500 m. from the two 1957 Sargasso Sea stations, and the significantly higher figures for the July 1958 stations, support the postulate of vertical transport during the winter period of surface-water cooling and high wind velocities.

It is unfortunate that present uncertainty about the mechanism and rate of stratospheric fall-out should preclude conversion of our figures for total vertical transport of strontium-90 into annual rates of down-mixing (and hence of up-mixing) of ocean surface-water in mid-latitudes. For this, more observations over a longer time span will be needed, and this will be profitably supplemented by the collections of precipitation which have begun on weather ships. It does now seem reasonable to point out that the same mechanism which has produced in three years at depths of 300–700 m. an approximately 1 : 1 mixture of surface-layer strontium-90, and pre-1954 sub-surface strontium-90, would have produced the same sort of dilution of surface sea-water carbon-14. Broecker's weighted average[5] of carbon-14 in North Atlantic water at 200–400 m. very closely approximates this same 1 : 1 ratio. Clearly, to assign the reduction in carbon-14 activity to radioactive decay, and conclude a 'crude age' of 290 years, become untenable, in the light of our demonstration that surface-added radioactivity reaches this same concentration ratio in three years. An attempt must be made to interpret these reductions in specific activity, and that in the surface layer as well, as standing concentrations maintained by mixing processes. Unlike the situation in biochemistry, here the gradient area across the boundary between two reservoirs contains a major fraction of the tracer in the system. A very much larger flux of carbon-14 across the sea surface must then be postulated to maintain the very much greater reservoir indicated. Our strontium-90 measurements, as well as the first of the weather ship fall-out measurements[6], indicate that much more fall-out may have been delivered per unit area to the sea surface than has been reported for the land. It is of course possible simply that the sea surface is a more efficient collector of fall-out than any which have been devised for shore-based study, and that retention in the water column is more reliable than on soil. Without a theory of the processes responsible for this difference, if real, we cannot tell whether this may also help to clarify the problem of the transfer of carbon-14.

A more detailed report of this work is being prepared for early publication elsewhere. Various aspects of the programme have been supported by the United States Atomic Energy Commission (contracts *AT* (30–1)—1918, *AT* (30–1)—2174), the United States Office of Naval Research (contract *NONR*-2196) and the United States National Science Foundation. Most of the stations mentioned have been collected as part of the U.S. International Geophysical Year programme.

VAUGHAN T. BOWEN

Woods Hole Oceanographic Institution,
Woods Hole, Massachusetts.

THOMAS T. SUGIHARA

Department of Chemistry,
Clark University,
Worcester, Massachusetts.

[1] Arnold, J. R., and Anderson, G. C., *Tellus*, 9, 28 (1957). Craig, H., *ibid.*, 9, 1 (1957). Eriksson, E., Int. Oceanographic Congress, New York (1959).

[2] Martell, E. A., U.S.A.E.C. Bulletin *AECU*-3262, p. 59 (1956).

[3] Bowen V. T., and Sugihara, T. T., *Proc. U.S. Nat. Acad. Sci.*, 43, 576 (1957); Proc. Second U.N. Int. Conf. Peaceful Uses Atom. Energy, Geneva, 1958, Paper *UN*-403 (1958). Sugihara, T. T., *et al.*, *Anal. Chem.*, 31, 44 (1959).

[4] Dunham, C. L., in "Fallout from Nuclear Weapons Tests", 1, 23 (U.S. Gov. Printing Office, 1959).

[5] Broecker, W. S., *et al.*, Int. Oceanographic Congress, New York (1959).

[6] U.S.A.E.C. report *HASL*-77, p. 25 (1960).

CHEMISTRY

Gas Content of Graphites

ARTIFICIAL graphite for use in graphite-moderated nuclear reactors, as anodes for mercury vapour rectifiers, and crucibles for vacuum fusion work should contain little gas. Otherwise, when the graphite is heated to operating temperatures, the gas is desorbed, resulting in adverse effects. For example, in the graphite-moderated nuclear reactor, hydrogen and carbon monoxide released from the graphite can interact with the fuel-cladding material (usually zirconium or stainless steel), resulting in hardening and embrittlement of the metal. Released carbon monoxide can disproportionate on cooler metal heat-exchanger surfaces depositing carbon, resulting in an adverse effect on the heat-transfer and flow properties of the system.

The present communication summarizes briefly results on the gas released from typical nuclear graphites (and an electrode graphite, for comparison) when degassed at an upper temperature between 1,500 and 2,000° C. *in vacuo*. For the degassing studies, a pumping system consisting of a liquid-nitrogen cold trap and a two-stage Van-Hespen mercury diffusion pump was used. Power to heat the graphite samples (1 in. long by ½ in. diam.) was supplied by a 5-kW. high-frequency induction generator.

Table 1 presents results for the gas released from a sample of nuclear (*A*) and a sample of electrode graphite. Both graphites were graphitized in an Acheson-type furnace, as described by Abbott[1]. For the nuclear graphite, the graphitizing was done in a chlorine (gas purified) atmosphere[2]; and the cooling was done in helium. For the electrode graphite, the atmosphere during heating and cooling consisted primarily of carbon monoxide and nitrogen which diffused in through the coke packing material. There were also significant pressures of carbon dioxide and oxygen at lower graphitizer temperatures, where the packing material did not completely convert oxygen to carbon monoxide.

Table 1. GAS RELEASED FROM GRAPHITES WHEN HEATED TO ELEVATED TEMPERATURES*

Property	Nuclear (*A*)†	Electrode‡
Total gas evolved (c.c./gm. at S.T.P.)	0 12	0 74
Analysis of gas evolved (vol. per cent)		
Hydrogen	59·4	30·8
Carbon monoxide	23·8	53·2
Carbon dioxide	12·7	16 0
Water	2·7	*N.D.*§
Hydrocarbons	1·4	*N.D.*

* Nuclear graphite degassed to 1,900° C.; electrode graphite degassed to 1,500° C.

† Surface area, 0·3 m.²/gm.; porosity, 25·2 per cent; ash, <0·004 per cent.

‡ Surface area, 0·4 m.²/gm.; porosity, 31·3 per cent; ash, 0 11 per cent.

§ Not determined.

For the results given in Table 1, runs were made on three different pieces of each graphite, with the results between each piece agreeing within 10 per cent. As expected[3], a considerably smaller quantity of gas is released from the nuclear than from the electrode graphite. This cannot be accounted for by a difference in Brunauer–Emmett–Teller surface area of the two materials. It is also noted that the percentage of carbon oxides in the evolved gas from the electrode graphite is considerably higher than from the nuclear graphite. Undoubtedly, this is a result of chemisorption by the electrode graphite of carbon monoxide, carbon dioxide and oxygen in the graphitizer and enhanced chemisorption of oxygen (because of the higher impurity content of the electrode graphite) at ambient temperatures following unpacking of the graphitizer. From other studies[4], it is concluded that the hydrogen released from a nuclear graphite is chemisorbed primarily on carbon atoms at crystallite edges.

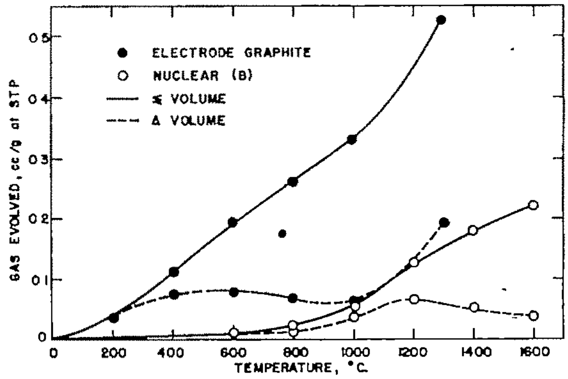


Fig. 1. Comparison of the integral and differential degassing curves for an electrode and a nuclear graphite

Gas-release from a thermally purified nuclear graphite (*B*), as a function of outgassing temperature, is compared with that from the electrode graphite (previously discussed) in Fig. 1 and Table 2. Because of the large amounts of carbon dioxide desorbed from the electrode graphite at low temperatures, a maximum in the differential degassing curve occurs at approximately 500° C. Another maximum (and higher) in the differential degassing curve of electrode graphite will occur above 1,300° C. On the other hand, for the thermally purified nuclear graphite (*B*), gas release below 800° C. is small; and only one maximum in the differential degassing curve is indicated at about 1,200° C. Interesting points to note from the results in Table 2 are:

(1) For the nuclear graphite (*B*), significant amounts of hydrocarbons are found in the gas up to 1,200° C. These gases consist mainly of C_2H_4, C_2H_2, C_2H_6, CH_4, and *iso*-C_4H_8, with C_2H_4 predominant at the lower temperatures and C_2H_2 predominant at the higher temperatures. It is uncertain what fraction of the hydrocarbons recovered is a result of reaction of carbon with desorbed hydrogen (ionized in the high-frequency induction coil)[4]. Carter and Greening[3] also reported hydrocarbons during the degassing of nuclear graphite.

(2) Considerably more water is recovered upon the low-temperature outgassing of electrode graphite than nuclear graphite (*B*). Since water adsorption on carbon occurs primarily at sites containing oxygen[5], this result is consistent with the fact that the electrode graphite originally contains more oxygen

Table 2. ANALYSES OF GAS EVOLVED FROM GRAPHITES OVER DIFFERENT TEMPERATURE INCREMENTS

Temperature increments (° C.)	Volume percentage of: H_2	CO	CO_2	H_2O	Hydrocarbons
Nuclear (*B*)*					
20–600	34·4	20·8	16·9	7·7	20·2
600–800	43·9	10·8	10·0	4·6	30·7
800–1,000	54·6	7·2	3·1	2·9	32·2
1,000–1,200	63·9	7·3	1·4	nil	27·4
1,200–1,400	85·8	11·1	1·8	nil	1·8
1,400–1,600	70 8	24 4	2 5	nil	2 4
Electrode					
20–200	8·7	14 1	22·8	43·5	10·9
200–400	4·8	21·4	59·5	11·9	2·4
400–600	45·0	36·2	3·8	2·5	12·5
600–800	51·9	38·3	nil	nil	9·8
800–1,000	36 4	63·6	nil	nil	nil
1,000–1,300	24·5	75·0	nil	nil	nil

* Surface area, 0 4 m.²/gm.; porosity, 25·2 per cent; ash content, <0·07 per cent.

Table 3. Effect of Graphitization Temperature and Atmosphere on Subsequent Gas Release upon Degassing at 2,000° C.

Property	Graphite* I	II	III
Ash content (per cent)	0 87	0·044	0·0006
Total gas evolved (c.c./gm. at S.T.P.)	0·98	0 36	0·20
Analysis of gas evolved (vol. per cent):			
Hydrogen	12 5	27·5	32 0
Carbon monoxide	52 0	53 5	48·5
Carbon dioxide	19·5	15 0	11·5
Water	13·5	3·0	7 0
Hydrocarbons	2·5	1 0	1·0
Sample weight loss (per cent)	0·19	0·13	0 05

* The maximum graphitization temperatures for I, II and III are 2,600, 3,000 and 2,700° C., respectively.

(ultimately desorbed as carbon dioxide and carbon monoxide).

(3) An increase in the carbon monoxide : hydrogen ratio of the desorbed gas at outgassing temperatures above 1,000° C. for the nuclear graphite (*B*) and above 600° C. for the electrode graphite indicates that an important fraction of the carbon–oxygen complex leading to carbon monoxide has a higher thermal stability than has the chemisorbed hydrogen.

Table 3 presents results for the gas released from three samples of graphite following heat treatment under different conditions. All samples were outgassed at a maximum temperature of 2,000° C. Graphites I and II were heated and cooled under an atmosphere similar to that used for the electrode graphite. Graphite III was treated in a halogen atmosphere and cooled (flushed) in an inert gas atmosphere to about 1,500° C. It is seen again that the use of a halogen atmosphere during graphitization (and perhaps cooling, in part, in an inert atmosphere) is particularly effective in reducing the subsequent amount of gas released from the graphite. As previously discussed[4], this is related probably to enhanced removal of metallic impurities. These impurities can be oxidized and/or catalyse the chemisorption of gases on carbon. In the former case, the reduction of these metal oxides by carbon at high degassing temperatures leads to gaseous carbon oxides.

The sample weight losses, given in Table 3, are a result of both gas desorption and metal volatilization. For example, for graphite I, each process accounts for about 50 per cent of the loss of weight. Considerable material was collected on the cool walls of the desorption chamber during the degassing of sample I. An emission spectroscopic analysis indicated that the main constituents of the deposit were silicon, iron and magnesium.

The kinetics of the adsorption and desorption of hydrogen on nuclear graphite will be reported on in more detail elsewhere.

We thank the Atomic Energy Commission, Contract No. *AT* (30–1)–1710, for support of the above work.

J. P. Redmond
P. L. Walker, jun.

Fuel Technology Department,
Pennsylvania State University,
University Park, Pennsylvania.

[1] Abbott, H. W., "Encyclopedia of Chemical Technology", 3, 1 (Interscience Encyclopedia, Inc., New York, 1949).

[2] Cronan, C. S., *Chem. Eng.*, 66, No. 4, 114 (1959).

[3] Carter, R. L., and Greening, W. J., "Evolution of Gas from Graphite Moderator Material", Preprint 319, Nuclear Engineering and Science Congress, Cleveland, Ohio (1955).

[4] Redmond, J. P., Ph.D. thesis, Pennsylvania State University (1959).

[5] Healey, F. H., Yu, Yung-Fang, and Chessick, J. J., *J. Phys. Chem.*, 59, 399 (1955).

Optical Properties of the αω-Dimethanesulphonoxyalkanes

The well-known alternation of the melting points with chain-length of a homologous series of compounds (for example, the normal paraffins, mono- and di-basic fatty acids, *n*-acetyl L-amino-acids) has been observed in the series of αω-dimethanesulphonoxyalkanes $CH_3SO_2O(CH_2)_nOSO_2CH_3$ [1]. The melting points of this series are shown plotted in Fig. 1, from which it is observed that the butane derivative ($n = 4$) exhibits a melting point which is very much larger than the rest of the series. A discontinuity of this kind is unusual, and it is of interest to examine it further.

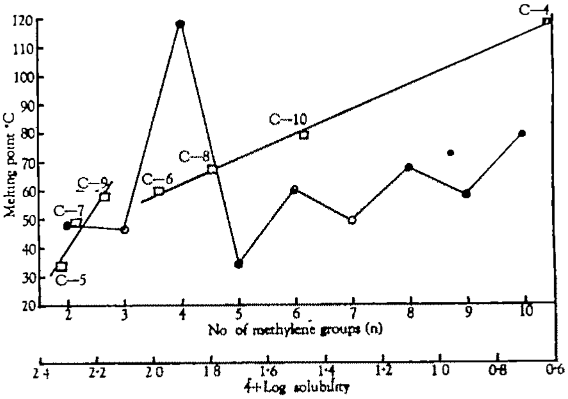


Fig. 1. Physical properties of the αω-dimethanesulphonoxyalkanes. ○, Variation in melting point with number of methylene groups; ⊡, relationship between melting point and logarithm of solubility in ether (C–4, butane derivative, etc.)

The alternation in properties of the odd and even members of the αω-dimethanesulphonoxyalkanes is reflected in their solubilities in an organic solvent, ether. Thus, as shown in Fig. 1, the odd and even series respectively show a linear relationship between their melting points, T_m, and the logarithm of their solubilities, S, that is, $\log S_{\infty} - T_m$. In terms of the Clausius equation, for ideal solution:

$$\ln S = -\frac{L_f}{R}\left\{\frac{1}{T} - \frac{1}{T_m}\right\} = -\frac{L_f}{T_m}\left\{\frac{T_m - T}{RT}\right\}$$

for constant-pressure conditions, where L_f is the latent heat of fusion of the solute and T is the temperature at which the solubility (as the mole fraction) is measured. The rectilinearity between $\log S$ and T_m suggests that, over the limited range considered, L_f increases approximately proportionately to T_m. Then $\log S = -\frac{\alpha(T_m - T)}{RT}$. The slopes of the lines for the two series differ by a factor of about 4, suggesting that the change in L_f with chain-length in the even series is greater than that for the odd series. Similar effects have been observed with other series, for example, the fatty acids[2]. It will be noted that the butane derivative ($n = 4$) exhibits the solubility properties characteristic of the even series in this respect.

The crystal form and optical constants of the compounds have been determined to examine whether the difference in the butane compound is easily interpreted in terms of the crystal structure. The values obtained are given in Table 1.

Table 1. THE OPTICAL PROPERTIES OF THE αω-DIMETHANESULPHONOXYALKANES

No. of methylene groups (n)	Crystal system	Habit	Refractive indices			Birefringence $n_\gamma - n_\alpha$	Optical data		
							Sign	Optic axial angle	
			n_α	n_β	n_γ			Range of values	Most common value
3	Orthorhombic	needles	1·489	1 504	1·513	0 024	–	66–71°	69°
4	Monoclinic	plates	1 510	1 520	1·566	0·056	+	48–55°	54°
6	Monoclinic	needles	1·477	1 504	1·523	0·046	–	68–86°	74°
7	Monoclinic	plates	1 490	1·499	1 554	0 064	+	38–45°	42°
8	Triclinic	plates	1·497	1 512	1·575	0·078	+	49–60°	55°
9	Monoclinic	plates	1·495	1 502	1 564	0·069	+	38–41°	40°
10	Triclinic	plates	1 500	1·517	1·580	0·080	+	43–56°	51°

The compounds are white crystalline solids, although some difficulty is sometimes met in crystallizing the n-pentane member of the series: this compound was not used in this study. The three principal refractive indices were determined with a three-axis universal stage by the immersion method using monochromatic sodium light and the values given have a reproducibility of + 0·002. The optic axial angle (2 V) was determined orthoscopically.

The crystal habit of the compounds and the orientation of the elements of optical symmetry have been used to assign them to a crystal system. No goniometric measurements have been made, and more detailed work by X-rays is needed to determine the fundamental crystallographic constants.

Optically, the compounds fall into two main groups: (a) those with n = 7–10; (b) those with n = 3–6. The optical constants of the compounds containing 7–10 methylene units show good agreement with the results obtained from melting point and solubility determinations. Two sub-series can be recognized: those in which n is an odd number and those in which n is even. Crystallography, optic axial angles, refractive indices and birefringence all accord within each sub-series, but can be used to distinguish between them.

The compounds for which n = 6 or less show no such simple relationship. The butane derivative (n = 4), which is abnormal in the melting point sequence, shows good agreement optically with the series n = 8–10, indicating that its abnormality is not due to fundamentally different crystal structure. The compounds in which n = 3 and n = 6 show rather unexpected similarities. Both are acicular in habit, although the hexamethylene compound (n = 6) is monoclinic whereas the trimethylene compound (n = 3) is orthorhombic. They are the only members of the series investigated which are optically negative and which have large optic axial angles (about 70°); the other compounds have optic axial angles of about 40–50°.

The investigation indicates that there is a strict correlation between chemical and optical properties in the compounds containing seven or more methylene groups. The crystallography and optical properties appear to be controlled by the number of methylene groups in the structure; compounds in which n is even are triclinic, whereas when n is odd the crystals exhibit monoclinic symmetry. The crystallography of compounds in which n = 6 or less may, on the other hand, be controlled by the methanesulphonoxy end groups which are large in relation to the remainder of the structure. The abnormally high melting point of the butane derivative (n = 4) reflects a high lattice energy which, although it is not revealed crystallographically, may be due to the relative positions of the large end groups in the space lattice.

The optical properties of a great number of such compounds have been listed by Winchell[3].

We wish to thank Dr. R. F. Hudson for helpful discussions.

A. C. BISHOP
R. D. MARSHALL*

Departments of Geology and Chemistry,
Queen Mary College,,
London, E.1.

---

* Present address: Department of Chemical Pathology, St. Mary's Hospital Medical School, London, W.2.

[1] Hudson, R. F., Timmis, G. M., and Marshall, R. D., *Biochem. Pharmacol.*, 1, 48 (1958).

[2] Garner, W. E., and Randall, F. C., *J. Chem. Soc.*, 125, 881 (1924).

[3] Winchell, A. N., "Optical Properties of Organic Compounds" (Univ. of Wisconsin Press, 1943).

Requirements for Stereospecificity in Hydrolysis by Chymotrypsin: Diethyl β-Acetamidoglutarate

As part of our study of the relation of structure of substrate to stereospecificity in enzyme reactions[1], we wish to report asymmetric hydrolysis of diethyl β-acetamidoglutarate by α-chymotrypsin. This compound was prepared by acetylation of diethyl β-aminoglutarate[2], b.p. 142–144°/2 mm.; anal. calc. for $C_{11}H_{19}NO_5$: C, 53·88; H, 7·81; N, 5·71. Found: C, 54·33; H, 7·84; N, 5·50. (Chymotrypsin was from Worthington, salt free.) A solution of 0·544 gm. of the ester and 0·524 gm. of the enzyme in 52·4 ml. of 0·02 M phosphate buffer was allowed to react at 27° in a pH-stat at pH 7·8, one ester group being 80–85 per cent hydrolysed in 5 hr. The reaction showed reproducible first-order kinetics, $k_1 = 0{\cdot}0057$ min.$^{-1}$, indicating extremely weak catalytic activity. However, the reaction was stereospecific. Neutralization of the alkali which had been added, evaporation to dryness and extraction with acetone led to optically active monoethyl-β-acetamidoglutarate, 0·318 gm., 78 per cent yield, m.p. 93–94 per cent. $[\alpha]_D^{21^\circ}$ + 5·9° (5 per cent acetone)[3]. Anal. calc. for $C_9H_{15}NO_5$: C, 49·73; H, 6·96; N, 6·45. Found: C, 49·80; H, 6·92; N, 6·51. The half-ester was prepared in the racemic form by hydrolysis of the di-ester to the di-acid, β-acetamidoglutaric acid, m.p. 185–186° dec., anal. calc. for $C_7H_{11}NO_5$: N, 7·41; found: N, 7·38; conversion of the di-acid to β-acetamidoglutaric anhydride, m.p. 140–141°; anal. calc. for $C_7H_9NO_4$: C, 49·11; H, 5·30; N, 8·18; found: C, 49·05; H, 5·26; N, 8·16; and conversion of the anhydride to racemic monoethyl β-acetamidoglutarate, m.p. 77–78°. Anal. found: C, 49·71; H, 6·92; N, 6·42. The racemic and (+) monoesters had identical infra-red spectra in chloroform.

Asymmetry is shown despite the lack of the two structural features which are characteristic of specific substrates for chymotrypsin[4], the beta-aryl and alpha-acylamido groups, which do lead to high reactivity if the stereochemistry is correct. These two groups, combined with that undergoing hydrolysis, have been thought to provide the three-point contact which has been considered necessary for asymmetry in this type of reaction[5], and for stereospecificity[6], and in particular for stereospecificity in hydrolysis by chymotrypsin[7]. However, the beta-aryl group is neither necessary nor sufficient[8] to lead to stereospecificity, while the acetamido group in either the alpha or the beta position does lead to stereospecificity in the hydrolysis of the malonate[1] and glutarate esters respectively, in which the presumed three-point contact cannot be occurring. Classical diastereomeric interactions may in principle account for asymmetric reactions of molecules of type *Cabdd* with enzymes and with other optically active reagents[9]. Scale models show that as the functional group of an asymmetric molecule attacks one group *d* of *Cabdd*, other groups of the reagent interact differently with the groups *a* and *b* at the developing centre of asymmetry *C*, depending upon which of the groups *d* is attacked. Such diastereomeric interactions of the acetamido group with rather rigidly organized asymmetric chymotrypsin may suffice to lead to reaction via preferred orientations and to stereospecificity.

We are pleased to acknowledge generous support by the Division of Research Grants, National Institutes of Health (*RG* 4584).

SAUL G. COHEN
EZRA KHEDOURI

Department of Chemistry,
Brandeis University,
Waltham 54, Massachusetts.

[1] Cohen, S. G., and Altschul, L., *Nature*, 183, 1678 (1959).
[2] Feuer, H., and Swarts, W. A., *J. Amer. Chem. Soc.*, 77, 5427 (1955).
[3] The specific rotation has essentially the same value as that of monomethyl β-acetoxyglutarate, Serck-Hanssen, K., *Arkiv Kemi*, 10, 185 (1956).
[4] Neurath, H., and Schwert, G., *Chem. Rev.*, 46, 69 (1950).
[5] Ogston, A. G., *Nature*, 162, 963 (1948).
[6] Laidler, K., "The Chemical Kinetics of Enzyme Action", 172 (Oxford, 1958).
[7] Tinico, L., *Arch. Biochem. Biophys.*, 76, 148 (1958).
[8] Snoke, J. E., and Neurath, H., *Arch. Biochem.*, 21, 351 (1949).
[9] Altschul, R., Bernstein, P., and Cohen, S. G., *J. Amer. Chem. Soc.*, 78, 5091 (1956).

Structure of the Viscous Phase of Liquid Sulphur

TRANSITIONS in the liquid phase have been reported for few substances. However, sulphur has been extensively studied and the variation of most of its properties through the transition region determined[1].

At present the mobile phase Sλ, obtained on melting, is thought to consist principally of S_8 rings which open at the transition temperature of 159° and polymerize to chains of 10^4–10^6 atoms to form the S_μ phase. Evidence for the chain structure is based mainly on an interpretation of the viscosity results of Bacon and Fanelli[2], which attain a maximum of 930 poises at 166°. Powell and Eyring[3] suggested that, as the addition of as little as 0·02 per cent of iodine is capable of suppressing the viscosity maximum from 930 to 57 poises, iodine tends to add terminally to the free valencies formed when the S_8 rings open at the transition temperature, so preventing excessive chain growth.

It is possible, however, to check this hypothesis by allowing sulphur alone in the viscometer to attain its maximum viscosity at 166°, when the long chains, if present, should be fully formed, and then making the iodine addition. If the long-chain hypothesis is correct, the addition of iodine *in situ*, at this temperature, should only have a minor effect on the viscosity maximum as it will add terminally at the free valence ends of the chain. If this is done, however, it is found that the viscosity maximum is still suppressed.

This suggests that unless the iodine is able to split a sulphur chain as readily as add terminally, which is unlikely, long chains of the order estimated by Gee[4] of 10^6 and Powell and Eyring of 10^4 are not present in the viscous phase.

On the basis of the thermal conductivity, viscosity, self-diffusion and surface tension data a different model of the structure of S_μ sulphur has been proposed[5] which does not necessitate the postulated existence of long chains. In this model the sulphur units in the viscous phase have only an average molecular complexity of 20–30 atoms. However, when the S_8 rings of the Sλ phase open at the transition temperature and polymerize slightly, the new units formed at this temperature are well below their normal freezing point. In such a supercooled state the viscosity naturally attains very large values.

E. MCLAUGHLIN

Department of Chemical Engineering,
Imperial College of Science and Technology,
London, S.W.7.

[1] Schenk, *Physica*, 23, 325 (1957).
[2] Bacon and Fanelli, *J. Amer. Chem. Soc.*, 65, 589 (1943).
[3] Powell and Eyring, *J. Amer. Chem. Soc.*, 65, 648 (1943).
[4] Gee, *Trans. Farad. Soc.*, 48, 515 (1952).
[5] McLaughlin and Turnbull (unpublished work).

BIOCHEMISTRY

Bradykinin Activity of some Synthetic Peptides with only Slight Structural Resemblance to Natural Bradykinin

RECENT findings[1] have indicated an unexpected kind of structural specificity among biologically active peptides. Although minor changes in chemical structure may reduce or even abolish a particular biological activity, large and sweeping changes sometimes do not destroy potency. Thus, in such peptides as strepogenin, oxytocin, lycomarasmin and gramicidin *S*, neither the sequence of amino-acid residues in the peptide nor the actual amino-acid composition of the naturally occurring peptide is essential for biological activity. We have therefore sought to examine this situation further, and to determine whether it applies to other kinds of biologically active peptides. We have found that it does apply to bradykinin.

Pure bradykinin has only very recently been isolated[2] and shown to be an octapeptide composed of arginine, proline, phenylalanine, glycine and serine. At the time this result was announced, we had isolated from enzymic digests of insulin the disulphide of leucylvalylcysteinylglycylglutamylarginine (a peptide with strepogenin activity), and had synthesized it[3]. As by-products of the synthesis, several related peptides were also available. Because these compounds were of nearly the same size as bradykinin, and, like it, contained arginine, assays of their

Table 1. AMOUNTS OF COMPOUNDS NECESSARY TO CAUSE MAXIMAL CONTRACTION

Compound	Ileum (mgm./ml.)	Uterus (mgm./ml.)
Bradykinin*	5×10^{-6}	5×10^{-7}
A	inactive at 10	—
GlA	inactive at 12	—
$(LVCGGlA)_2$	inactive at 2	inactive at 0·1
$(LVCGGlA \text{ diamide})_2$	1·4	0·14
$(LVCG\textit{iso}GlA)_2$	0·2	0·1
Histamine	5×10^{-4}	—
Serotonin	—	1×10^{-5}

A = arginine, Gl = glutamyl, G = glycyl, C = cysteinyl, L = leucyl, V = valyl and *iso*Gl = a glutamic acid residue joined by the γ-carboxyl group to the amino-group of the next amino-acid.

* Values given are for pure bradykinin and were taken from a personal communication from Dr. D. F. Elliott.

ability to function as bradykinin were carried out. It was felt that if the situation outlined at the start of this communication had general validity, some of the synthetic peptides should show bradykinin activity. Thus, the only amino-acids in common among the synthetic peptides and natural bradykinin would be arginine and glycine.

Assays were performed as described by Roche e Silva[4]. Both the isolated guinea pig ileum and the isolated rat uterus were used. The former was standardized with histamine, and the latter with serotonin. The peptides available were glutamylarginine and the disulphide dimers of leucylvalylcysteinylglycylglutamylarginine, its diamide, and leucylvalylcysteinylglycyl*iso*glutamylarginine. These were dissolved in the salt solution appropriate for each type of assay, and the *p*H of the solutions was adjusted to that of the test system. Each active peptide gave the typical slow contraction of the muscles shown by natural bradykinin, and the effects were not overcome by an antihistamine (benadryl).

The results are summarized in Table 1. There it can be seen that some only of the peptides exhibited activity. Consequently, a mere peptide of arginine, or of arginine and glycine, was not enough. Free arginine likewise was inactive. Note that although leucylvalylcysteinylglycylglutamylarginine was inactive up to 2 mgm., its diamide was potent. This might suggest that overall charge on the molecule was important for activity, especially since natural bradykinin contains no dibasic amino-acid residue. However, the corresponding *iso*glutamyl peptide, which has approximately the same charge as its isomeric inactive relative, was active. One might say that so long as the gamma carboxyl group of glutamic acid in the peptide was substituted (either by ammonia or by arginine), activity resulted, whereas if it was free the peptide was inactive.

The synthetic peptides studied were not nearly so potent as bradykinin, even though they did show activity. This may have been because of their striking difference in chemical structure from the natural compound, but may also have been related to the fact that the synthetics were larger than bradykinin. The synthetic peptides were disulphides, and the active ones were thus composed of 12 amino-acid residues, whereas bradykinin contains 8. One striking feature of active peptides related to strepogenin and to the melanophore-stimulating hormone has been that in each case an optimal size seems to be important for highest potency[1,5]. Whatever the merits of this question about size, the present results show clearly that for bradykinin, just as for strepogenin, oxytocin, etc., the exact chemical constitution of the naturally occurring peptide is not essential for biological activity, even though it may influence the potency quantitatively.

This investigation was supported in part by a grant from the United States Public Health Service.

G. L. TRITSCH
D. W. WOOLLEY

The Rockefeller Institute,
New York.
Feb. 15.

[1] Woolley, D. W., and Merrifield, R. B., *Science*, 128, 238 (1958).

[2] Elliott, D. F., Lewis, G. P., and Horton, E. W., *Biochem. J.*, 74, 15*P* (1960).

[3] Tritsch, G. L., and Woolley, D. W., *J. Amer. Chem. Soc.*, 80, 1490 (1958); and *ibid.* (in the press).

[4] Roche e Silva, M., *Acta Physiol. Latinoamer.*, 2, 238 (1952). Hamberg, U., *Biochim. Biophys. Acta*, 34, 135 (1959).

[5] Merrifield, R. B., and Woolley, D. W., *J. Amer. Chem. Soc.*, 80, 6635 (1958). Hofmann, K., Woolner, M. E., Yajima, H., Spühler, G., Thompson, T. A., and Schwartz, E. T., *J. Amer. Chem. Soc.*, 80, 6458 (1958).

Synthesis of Contractile Proteins in the X-Irradiated Embryo

IN skeletal muscle the formation of actin precedes that of myosin in the early developmental stages of the chick[1,2] as well as *Triturus pyrrhogaster*[3], and in regenerating limb tissues of the latter[3]. The following questions therefore arose[4]: Does the formation of actin induce that of myosin and does it directly cause myosin formation? To obtain an answer to this question, the synthesis of contractile proteins in X-irradiated embryos of *Triturus pyrrhogaster* was examined by means of a serological technique[3].

G-Actin and myosin were prepared from large specimens of *Triturus pyrrhogaster* by the method of Straub and Szent-Györgyi[5]. Both proteins were injected intravenously (four times with 3-day intervals, 100 mgm. in total) into rabbits. The immunized rabbit sera were raised to their serological specificity by resorption test with saline extracts of liver, spleen and skin tissue of *Triturus pyrrhogaster*. Titration with homologous antigen was then carried out. The titre of both sera was adjusted to 1 : 512 before carrying out the precipitin reaction with saline extracts of X-irradiated embryos. Constant volumes of sera and progressively decreasing amounts of antigen were used in order to avoid an excess of antigen. The irradiation of embryos was carried out 108 hr. after fertilization under the conditions of Table 1.

Table 1. IRRADIATION CONDITIONS

Dose of X-rays (r.)	kVp.	m.amp.	Filter	Target-object distance (cm.)	Intensity (per min.)
500	180	25·0	Cu (1·0 mm.) + Al (0·5 mm.)	28	167·6
200	,,	10·0	,,	,,	66·6
50	,,	2·5	,,	,,	16·7

In normal embryos, actin and myosin first became detectable 132 and 176 hr., respectively, after fertilization[3]. In the case of irradiation with 50 r., both actin and myosin were detected 156 hr. after fertilization. The time of actin and myosin formation after fertilization was changed to 180 and 144 hr., respectively, with 200 r., and to 204 and 132 hr., respectively, with 500 r., as shown in Fig. 1.

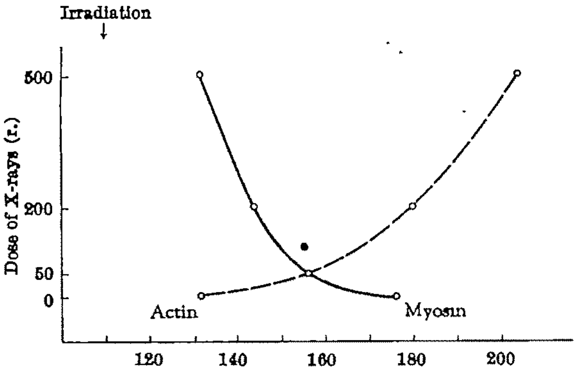


Fig. 1. Synthesis of contractile proteins in early development of the embryo of *Triturus pyrrhogaster* irradiated by X-rays 108 hr. after fertilization

X-irradiation 108 hr. after fertilization, therefore, markedly suppresses the synthesis of actin and promotes that of myosin in early developmental stages. The order of actin and myosin formation in the irradiated embryos at doses of 200 r. and 500 r. was opposite to that found in the non-irradiated control.

It was thus proved that during skeletal muscle differentiation in the early embryo of *Triturus pyrrhogaster*, the formation of actin does not induce that of myosin and the processes of synthesis of those proteins are independent of each other.

YOSHITO OGAWA

National Institute of Genetics,
Misima, Shizuoka-ken,
Japan.

[1] Ogawa, Y., and Kawahara, T., *Kagaku*, 27, 258 (1957) (in Japanese).
[2] Ogawa, Y., Kawahara, T., and Miura, J., Ann. Rep. Nat. Inst. Genet. Japan, 8, 29 (1958).
[3] Ogawa, Y., *Nature*, 182, 1312 (1958).
[4] Ebert, J. D., *Proc. U.S. Nat. Acad. Sci.*, 39, 333 (1953).
[5] Szent-Györgyi, A. G., "Chemistry of Muscular Contraction" (Academic Press, New York, 1951).

Production of Shikimic Acid by *Penicillium griseofulvum* Dierckx

SEVERAL phenolic substances have been isolated from the cultures of *Penicillium griseofulvum* Dierckx: 2-hydroxy-6-methylbenzoic acid[1], 2,5-dihydroxybenzoic acid[2], *o*-, *m*- and *p*-hydroxybenzoic acid[3], 2,4-dihydroxybenzoic acid, 3,4-dihydroxybenzoic acid and 3,5-dihydroxybenzoic acid[4]. Those compounds, together with amino-benzoic acids[5], fulvic acid[6], griseofulvine[7] and patuline[8], were identified in metabolic solutions of cultures ten days of age or older. In order to detect substances which could be involved in the production of benzoic derivatives it seemed advisable to investigate the metabolic solution in the earliest stages of the culture. This has led to the identification of shikimic acid, which is interesting because of its possible conversion to phenolic substances such as has been shown for *Escherichia coli*[9]. Besides shikimic acid, sedoheptulose, *d*-erythrose and pyruvic acid have also been found. This communication describes the isolation and identification of shikimic acid and related substances.

Batches of 500 Erlenmeyer flasks of 500 ml. capacity each containing 100 ml. Czapek–Dox medium were aseptically inoculated with a suspension of *P. griseofulvum* (our strain *P* 34) and incubated at 25°. After 30 hr. the cultures were filtered through Chardin filter paper. The metabolic solution, having a *p*H of 5·8, was passed successively through a column of 'Dowex 50' (chloride) and then through a column of 'Dowex 2' (acetate). This last column was then washed with distilled water until sugar could no longer be detected, and after this washing it was eluted with a mixture of 50 per cent *N*/10 sodium acetate and 50 per cent *N*/10 acetic acid. The eluate was acidified to *p*H 3 by addition of *N*/10 hydrochloric acid and concentrated *in vacuo*.

The paper chromatography of this solution was carried out with Whatman paper No. 4 using four different solvents giving the following R_F:

	Shikimic acid	5-Dehydro-shikimic acid	5-Phospho-shikimic acid
n-Butanol–formic acid–water (50:2·5:10, v/v) (ref. 10)	0·43	0 46	0 09
n-Butanol–acetic acid–water (50:3:12·5) (ref. 10)	0·42	0 22	0·05
Phenol–water (3:1 w/v) (ref. 11)	0·44	0·48	0·11
tert.Butanol– benzyl. alc.–*iso*propanol–water (1 3 1:1, v/v) (ref. 11)	0·42	0 50	0·01

The reagents used were: (1) bromocresol green, (2) ammoniacal silver nitrate and (3) a succession of metaperiodate, nitroprussiate and piperazine. The chromatogram was then warmed to 105° C.[12].

These three reagents gave yellow spots for shikimic acid, 5-dehydroshikimic acid and for 5-phosphoshikimic acid. The identification of shikimic acid was also confirmed by co-chromatography with an authentic sample.

In order to obtain some information concerning the biosynthesis of shikimic acid the following experiments were carried out.

The mould was grown for 10 days at 25° in 500-ml. Erlenmeyer flasks containing 100 ml. Czapek–Dox medium. After having eliminated the culture solution, the mycelium felts were aseptically washed three times, each time with 100 ml. sterile distilled water. Then the preformed mycelium was left to act for 28 hr. at 25° on 100 ml. of one of the four following solutions: (1) *d*-erythrose 10^{-3} *M*, pyruvic acid 10^{-3} *M* and adenosine triphosphate 10^{-4} *M*; (2) *d*-erythrose, 10^{-3} *M*; (3) pyruvic acid, 10^{-3} *M*; (4) *d*-erythrose, 10^{-3} *M* and pyruvic acid 10^{-3} *M*.

After incubation the solutions were filtered and chromatographically analysed as described above. The results were that in solution (1) 5-dehydroshikimic acid and 5-phosphoshikimic acid were present while in solution (4) only traces of those substances could be detected and neither of them could be found in solutions (2) and (3).

Another series of experiments was made where *d*-erythrose was replaced by sedoheptulose. After 28 hr. incubation solution (1) contained only traces of 5-dehydroshikimic acid and of 5-phosphoshikimic acid and solution (4) contained none of either. But after 48 hr. incubation solution (1) contained more 5-dehydroshikimic acid and 5-phosphoshikimic acid, while in solution (4) traces of those two acids were detected.

Two other series of experiments were carried out with the same solutions but with shaken cultures. The results were exactly the same as those obtained with the ordinary cultures.

This is the first time that shikimic acid has been reported in mould metabolism. This substance seems particularly interesting owing to its probable place in the biosynthesis of the benzene ring which is present in many mould metabolites.

On the other hand, neither quinic acid nor dehydroquinic acid could be detected in the metabolic solution of *P. griseofulvum*, although those acids have been proved to play an important part in the synthesis of shikimic acid by *Escherichia coli*[13].

It is also worthy of note that shikimic acid is formed more readily by *P. griseofulvum* from *d*-erythrose + pyruvic acid + adenosine triphosphate than from sedoheptulose + pyruvic acid + adenosine triphosphate. This seems to suggest that in this case the biosynthesis of shikimic acid proceeds more easily via $C_4 + C_3$, while it has been shown for *Escherichia coli* that this biosynthesis takes place via sedoheptulose[14].

Finally, the comparison between the results obtained with solution (1) and with solution (4) points to the hypothesis that these phosphoric esters are directly involved in the synthesis, namely, *d*-erythrose-4-phosphate and phospho-enol pyruvic acid.

PAUL SIMONART
ANSELME WIAUX*

Department of Microbiology,
University of Louvain, Belgium.

---

* Aspirant du Fonds National de la Recherche Scientifique.

[1] Anslow, W. K., and Raistrick, H., *Biochem. J.*, 25, 39 (1931).
[2] Raistrick, H., and Simonart, P., *Biochem. J.*, 27, 628 (1933).
[3] Simonart, P., and Wiaux, A., *Bull. Soc. Chim. Biol.*, 41, 537 (1959).
[4] Simonart, P., Wiaux, A., and Verachtert, H., *Bull. Soc. Chim. Biol.*, 41, 541 (1959).
[5] Simonart, P., and Wiaux, A., *Zent. f. Bakt.*, II Abt., 12, 708 (1959).
[6] Oxford, A. E., Raistrick, H., and Simonart, P., *Biochem. J.*, 29, 1102 (1935).
[7] Oxford, A. E., Raistrick, H., and Simonart, P., *Biochem. J.*, 33, 240 (1939).
[8] Simonart, P., and de Lathouwer, R., *Zent. f. Bakt.*, II Abt., 111, 339 (1957).
[9] Srinivasan, P. R., Shigeura, H. T., Sprecher, M., Sprinson, D. B., and Davis, B. D., *J. Biol. Chem.*, 220, 475 (1956).
[10] Weiss, U., and Davis, B. D., *J. Amer. Chem. Soc.*, 75, 5572 (1953).
[11] Stak, J. B., Goodban, A. E., and Owens, H. S., *Analyt. Chem.*, 23, 413 (1951).
[12] Cartwright, R. A., and Roberts, E. A. H., *Chem. and Indust.*, 230 (1955).
[13] Davis, B. D., and Weiss, U., *Naunyn-Schmiedebergs Arch. Exp. Pathol. Pharmakol.*, 220, 1 (1953).
[14] Srinivasan, P. R., Sprinson, D. B., Kalan, E. B., and Davis, B. D., *J. Biol. Chem.*, 233, 913 (1956).

Measurement of Transaminases in Serum

WITH the growing emphasis on the study of glutamic oxaloacetic and glutamic pyruvic transaminases of the serum, both in the diagnosis and the prognosis of a large number of pathological conditions, particularly in cardiovascular and hepatic diseases, a need for a simple and accurate method for the measurement of these transaminases is apparent.

A sensitive method has been devised which serves for the accurate and concurrent determination of the transaminases. This method can be used to assess the accuracy of earlier methods[1,3-5], and because of its simplicity it can be used easily as a routine method in clinical investigations.

The method involves the transamination by the serum of *dl*-alanine and α-ketoglutarate to glutamate and pyruvate (in the case of glutamic pyruvic transaminase) and of *dl*-aspartate and α-ketoglutarate to glutamate and oxaloacetate (in the case of glutamic oxaloacetic transaminase), in the following reaction:

$$R.\mathrm{CH.NH_2.COOH} + R'\mathrm{CO.COOH} \overset{(T)}{\rightleftharpoons} R.\mathrm{CO.COOH} + R'\mathrm{CH.NH_2\ COOH}$$

The measurement is based in the determination of the end-product of the transamination (pyruvate and oxaloacetate, respectively).

The substrates used are as follow:

(1) Glutamic pyruvic transaminase, 0·2 *M* *dl*-alanine and 0·002 *M* α-ketoglutaric acid: *dl*-alanine, 1·78 gm.; α-ketoglutaric acid, 0·03 gm.; dipotassium hydrogen phosphate, 2·00 gm.; distilled water to make up 100·00 ml.

(2) Glutamic oxaloacetic transaminase, 0·2 *M* *dl*-aspartic acid and 0·002 *M* α-ketoglutaric acid: *dl*-aspartic acid, 2·66 gm.; α-ketoglutaric acid, 0·03 gm.; dipotassium hydrogen phosphate, 2·00 gm.; distilled water to make up 100·00 ml. The reagents at the beginning are diluted to 80·00 ml. with water, adjusted to *p*H 7·4 with sodium hydroxide and made up to 100·00 ml. To each is added 1 per cent clear chloroform as a preservative. They can be kept in the refrigerator for many weeks, but should be discarded if they become cloudy or mouldy.

Other reagents used are: (*a*) aniline citrate: citric acid, 5·0 gm.; distilled water, 5·0 ml.; aniline, 5·0 ml.: the reagent is diluted before use 1 : 5 with distilled water; (*b*) dinitrophenylhydrazine 0·002 *M*: 2,4-dinitrophenylhydrazine, 0·04 gm.; conc. hydrochloric acid, 5·00 ml.; distilled water, 95·00 ml.; the reagent is diluted in the hydrochloric acid with 15–20 ml. water with vigorous shaking and made up to 100·00 ml.; (*c*) aqueous solution of 0·75 *M* sodium hydroxide; (*d*) pyruvic acid stock solution: pyruvic acid, 1·00 gm.; distilled water, made up to 1,000·00 ml.; it should be stored in the refrigerator.

To 0·8 ml. of serum saline in a test-tube add 0·2 ml. of serum with a pipette and mix the contents. 0·5 ml. of substrate for glutamic pyruvic or glutamic oxaloacetic transaminase is added and the tube is placed in a water-bath for 60 min. at 37° C. The tube is then held at room temperature and 0·5 ml. of the diluted citrate aniline is pipetted into it; this stops the enzymatic reaction. Immediately 0·5 ml. dinitrophenylhydrazine is added and the contents are vigorously mixed. Exactly 5 min. after the addition of the latter reagent (the time necessary to form pyruvate–dinitrophenylhydrazone but excluding the formation of α-ketoglutarate–dinitrophenylhydrazone), 3·0 ml. of sodium hydroxide are added, the contents are mixed by inversion of the tube and the colour produced is measured after 30 min. (the colour remains stable for 1 hr.), in a spectrophotometer at 500 mμ with a cuvette of 1 cm. diameter, against the blank set at zero optical density. The blank is a mixture of the reagents prepared in the same way as that of the sample, except that the serum is replaced with serum saline.

From the graph prepared with the use of known solutions of pyruvic acid (20, 40, 60 . . . 500 μgm./ml.) in the place of the serum and in the same quantity (0·2 ml.), after treatment of the tube as described, the pyruvic acid formed by the serum sample is determined directly in micrograms per ml. at 37° C., and for a period of 60 min. 1 unit is the amount of activity in 1·0 ml. of serum that results in the formation of 1 μgm. of pyruvate as defined by Cabaud *et al.*[1].

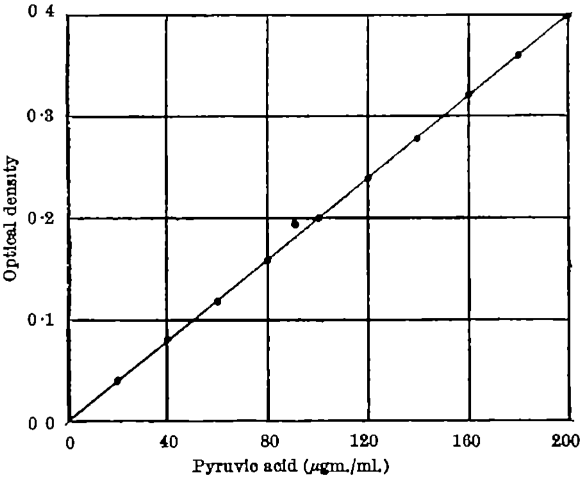


Fig. 1. Graph prepared with the use of known solutions of pyruvic acid, treated in the same way as the serum for glutamic pyruvic and glutamic oxaloacetic transaminase under the conditions described in the text. It is evident that linear relations exist between solutions of pyruvic acid from 0–200 μgm./ml. and the optical density produced and exhibited by them. The colorimetric measurement is made in a 'Unicam 600' spectrophotometer at 500 mμ with a cuvette of 1 cm. diameter

Fig. 1 indicates that the colorimetric reaction under the conditions of this technique follows closely Beer's law, up to the concentration of 200 μgm./ml. In the case in which the activity of the serum is very high, the determination is repeated with a sample of the serum diluted 1/5 or 1/10 with serum saline and the final result obtained is multiplied by 5 or 10.

An investigation of certain colorimetric methods for the estimation of transaminases in serum demonstrated the difficulties and inconveniences of some of the techniques. The methods described by Cabaud, Leeper and Wroblewski[1,2] and by Umbreit, Kingsley, Schaffert and Siplet[3] are characterized by the same principles as those of Tonhazy, White and Umbreit[4]. These methods are cumbrous. The deproteinization of the serum, the extraction by toluene and centrifugation require many manipulations. The separation of the toluene fraction is often difficult, and in many cases it forms a gelatinous mass and is obtained only after breaking it up and repeated centrifugations. On the other hand, the alkalinization of toluene requires the use of recently prepared solutions of alcoholic potassium hydroxide, which causes cloudiness of the mixture after the lapse of a few minutes.

In comparison with the previous methods, the method of Reitman and Frankel[5] is exceptionally easy and simple. Experience shows, however, that the method is unsatisfactory, because of its particular characteristics ; for the colorimetric determinations of the end product (pyruvate and oxalate) formed are made by the use of a graph of mixed solutions of the pyruvic and α-ketoglutaric acids, in an empirical way.

It is evident that the method described is considerably simpler, requiring the use of a test-tube only for the transamination reaction and for the determination of the pyruvate produced. In addition it is accurate, because the end products, pyruvate in the case of the glutamic pyruvic transaminase, and the resulting pyruvate by decarboxylation of oxaloacetate by the use of citrated aniline in the case of glutamic oxaloacetic transaminase, are both calculated directly by the use of a prepared graph on the basis of known solutions of pyruvic acid. The method is also very sensitive. The greatest error found among the replicates of a considerable number of normal and pathological sera was approximately 2·5 per cent.

In 50 presumably healthy individuals of ages ranging from 20 to 40 years the range of values for glutamic pyruvic and glutamic oxaloacetic transaminase was found to be 15–98 and 26–92 units per ml. of serum determined at a temperature of 37° C., and for a period of 60 min. Thus readings above 100 units per ml. indicate pathological conditions.

H. Yatzidis

Hippocratean University Hospital,
University of Athens School of Medicine,
Athens.

[1] Cabaud, P., Leeper, R., and Wroblewski, F., *Amer. J. Clin. Path.*, **26**, 1101 (1956).
[2] Wroblewski, F., and Cabaud, P., *Amer. J. Clin. Path.*, **27**, 235 (1957).
[3] Umbreit, W. W., *et al.*, *J. Lab. Clin. Med.*, **49**, 454 (1957).
[4] Tonhazy, N. E., White, N. G., and Umbreit, N. W., *Arch. Biochem.*, **28**, 36 (1950).
[5] Reitman, S., and Frankel, S., *Amer. J. Clin. Path.*, **28**, 56 (1957).

Conjugation of 3 : 4-Benzpyrenols in Mouse Skin

The liver is undoubtedly the major site of glucuronide synthesis in the mammal[1,2], but varying degrees of glucuronide synthesizing activity have also been reported for other tissues. These include the kidney[1,2], intestine[3], cartilage[4] and granulation tissue[5], although the findings of different workers have not always been in agreement. The only specific investigation of this nature which we have been able to find applied to such activity in skin is that of Zini[6], who reported that isolated rat skin possesses 'some' glucuronide synthesizing activity with *o*-aminophenol as substrate. No quantitative details are given, but the assumption is that the level of activity falls far below that of other tissues in which significant activity was observed. Evidence from another field, however, would suggest that the glucuronide synthesizing ability of skin may be by no means insignificant and indeed may play an important part in the detoxification of foreign substances at that site. Thus it is now well confirmed that the carcinogenic hydrocarbon, 3 : 4-benzpyrene, is metabolized in mouse skin both *in vivo*[7-9] and *in vitro*[10] to yield a water-soluble polar derivative designated as BPX_2 (ref. 7). Subsequent work by one of us (K. H. H.) has shown this metabolic fraction to consist of a mixture of glucuronide conjugated benzpyrenols[11]. The analogous sulphate conjugated fraction[11], on the other hand, has not so far been detected within the skin, and this has led one of us (G. C.) to suggest that the formation of this complex (BPX_1) is divorced from the carcinogenic response elicited by 3 : 4-benzpyrene at this site[9]. It was of importance, therefore, to re-examine the conjugating ability of mouse skin in the light of this evidence.

Mice, in batches of about twenty, were closely clipped or plucked and in parallel experiments a solution of either 3 : 4-benzpyrene or the phenol, 8-benzpyrenol, in acetone was applied to the denuded areas of skin. After varying intervals of time the animals were killed and the treated areas of skin removed, minced and homogenized. Extraction and separation into glucuronide and sulphate conjugated fractions were then carried out using a modified form of the original method of Weigert and Mottram[7]. Details of this have been published elsewhere[11].

The experiments with 3 : 4-benzpyrene confirmed the findings of other workers with regard to the formation of benzpyrenyl glucuronides within the skin although the concentration at any time was found to be low. Identical behaviour was observed in the parallel experiment with the phenolic derivative 8-benzpyrenol, for, although the glucuronic acid ester was readily detected in the extracts, the total amount present at any time was of the same order as that yielded by the parent hydrocarbon. This suggests that the initial hydroxylation of benzpyrene is not a limiting factor in determining the concentration of conjugated metabolites within the skin.

Throughout these experiments evidence was also sought of conjugation with sulphuric acid. Trace amounts of a metabolite possessing the physical properties of a benzpyrenyl sulphate were isolated after treatment with both 3 : 4-benzpyrene and 8-benzpyrenol, but the small amount obtained prevented an unequivocal identification. *In vitro* studies with microsome-free supernatant fraction of skin homogenate fortified with adenosine triphosphate, as described by De Meio, Wizerkaniuk and Fabiani[12], yielded inconclusive results.

The conclusion arrived at from this work, therefore, is that mouse skin does possess the ability to conjugate foreign phenolic compounds with glucuronic acid and possibly sulphuric acid. To what extent this occurs, however, is as yet unknown, for these experiments do not preclude the possibility that the conjugates are either rapidly removed from the skin via the blood stream or perhaps bound firmly to cellular constituents. The additional point also arises that hydroxylation of aromatic hydrocarbons can occur within the skin although no evidence exists as yet as to the mechanisms involved.

K. H. HARPER
G. CALCUTT

Department of Cancer Research,
Mount Vernon Hospital,
Northwood, Middlesex.

[1] Lipschitz, W. L., and Beuding, E., *J. Biol. Chem.*, **129**, 333 (1939).
[2] Karunairatnam, M. C., Kerr, L. M. H., and Levvy, G. A., *Biochem. J.*, **45**, 496 (1949).
[3] Hartiala, K. J. V., *Ann. Med. Exp. Fenn.*, **33**, 239 (1955).
[4] Castellani, A. A., De Bernard, B., and Zambotti, V., *Nature*, **180**, 859 (1957).
[5] Bollet, A. J., Goodwin, J. F., and Brown, A. K., *J. Clin. Invest.*, **38**, 451 (1959).
[6] Zini, F., *Sperimentale*, **102**, 40 (1952).
[7] Weigert, F., and Mottram, J. C., *Cancer Res.*, **6**, 97 (1946).
[8] Calcutt, G., *Brit. J. Cancer*, **11**, 605 (1957).
[9] Norden, G., *Acta Path. Microbiol. Scand.*, Supp. 96, 1 (1953).
[10] Weigert, F., Calcutt, G., and Powell, A. K., *Brit. J. Cancer*, **1**, 405 (1947).
[11] Harper, K. H., *Brit. J. Cancer*, **12**, 645 (1958).
[12] De Meio, R. H., Wizerkaniuk, M., and Fabiani, E., *J. Biol. Chem.*, **203**, 257 (1953).

Heterogeneity of Tumour Ribonucleic Acid and the Effect of 'Degranol' on it

IN view of its importance to the study of the chemical properties and specific biological functions of nucleic acids, in recent years much attention has been devoted to the heterogeneity of this group of compounds[1-4].

In earlier papers[5,6] we reported the elaboration of a new method and the results obtained with it in a study of the heterogeneity of ribonucleic acid obtained from rabbit liver and labelled with phosphorus-32 *in vivo*.

The present communication describes the heterogeneity of ribonucleic acid obtained from Guérin carcinoma transplanted into rats and labelled with phosphorus-32 *in vivo*; further, the effect on this heterogeneity of 1,6-*bis*-(-β-chloroethylamino)-1,6-deoxy-D-mannitol-dihydrochloride ('Degranol'; B.C.M.)[7].

Inbred albino rats weighing 120–150 gm. were inoculated subcutaneously with Guérin carcinoma, and divided into two groups. One group was given intravenously a 50 mgm./kgm. dose of 'Degranol' 14–16 days after the transplantation of the tumour, and the other was left untreated. The animals received a 100 μc./100 gm. intraperitoneal dose of phosphorus-32 at 48 hr., and were decapitated at 72 hr. after 'Degranol'. Each of the resultant tumours was worked up separately and the ribonucleic acid was recovered from the whole tumour by the method of Pain and Butler[8], modified inasmuch as the ribonucleic acid precipitated by the addition of 96 per cent ethanol was dissolved in 0·2 M sodium chloride and dialysed for 24 hr. at + 4° C. against 0·2 M sodium chloride. A quantity of 6–10 mgm. of ribonucleic acid was adsorbed on a 6 cm. × 1·5 cm. 'Dowex-2' resin column (Cl-form, 10 per cent cross-linkage, 200–300 mesh) and eluted with sodium chloride solutions of continually increasing concentration. The reservoir contained 2·8 M sodium chloride, and the 225-ml. mixing flask, initially, 0·3 M sodium chloride. The rate of flow was 0·25 ml./min. 5-ml. fractions were collected, and aliquot parts of these were used to determine radioactivity and ribonucleic acid content, the latter by the orcinol reaction as modified by Ceriotti[9].

Fig. 1 shows that the ribonucleic acid isolated from whole tumour is heterogeneous; moreover, that the individual fractions of ribonucleic acid differ in specific activity. This difference permits the conclusion, which is consistent with that drawn from our earlier heterogeneity studies of rabbit liver ribonucleic acid[6], that in the living organism the phosphorus-32 exchange in the individual ribonucleic acid fractions proceeds at different rates.

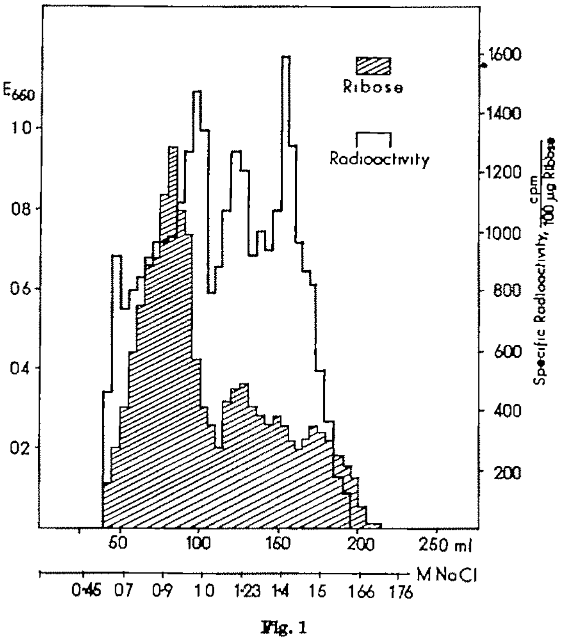


Fig. 1

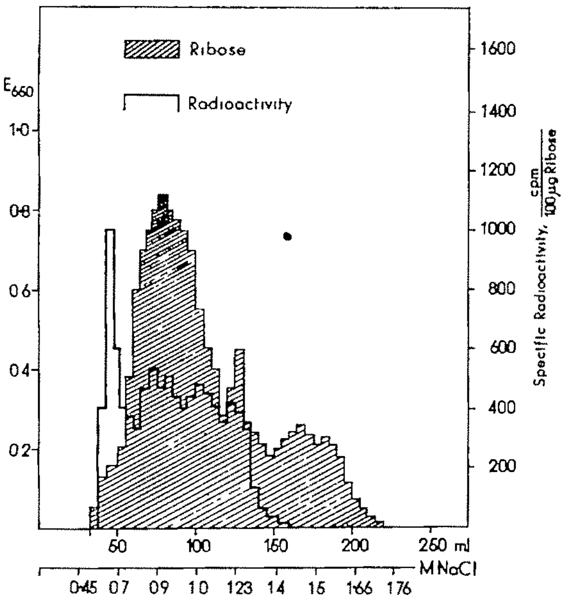


Fig. 2

Kellner *et al.*[10,11] have shown that morphologically the peak effect of 'Degranol' appears between 48 and 72 hr. after treatment, manifesting itself in extensive cellular and nuclear disintegration in the florid parts of the tumour. Hidvégi *et al.*[12,13] have observed a substantial decrease at that same period of time in the relative specific activity of the phosphorus-32 in the deoxyribonucleic acid, and a less notable, but still significant, fall in the ribonucleic acid of the nuclei and the cytoplasma. For these reasons, in our experimental animals we have studied the heterogeneity of the tumour ribonucleic acid at 72 hr. after 'Degranol', when the drug has been established to exert its maximum effect.

On the evidence of Fig. 2, 'Degranol' causes no change in heterogeneity in ribonucleic acid but does give rise to essential differences in the incorporation of phosphorus-32. Appreciable radioactivity was only measured in fractions which could be eluted at lower sodium chloride molarities.

F. ANTONI
E. J. HIDVÉGI
Institute of Biochemistry,
Medical University,
Budapest.

K. LAPIS
Research Institute of Oncopathology,
Budapest.

[1] Bendich, A., Fresco, J. R., Rosencranz, H. S., and Beiser, S. M., *J. Amer. Chem. Soc.*, 77, 3671 (1955).

[2] Miura, Kin Ichiro, and Suzuki, Kenshi, *Biochim. Biophys. Acta*, 22, 565 (1956).

[3] Bradley, D. F., and Rich, A., *J. Amer. Chem. Soc*, 78, 5898 (1956).

[4] Osawa, Syozo, and Sakaki, T., *Biochim. Biophys. Acta*, 25, 195 (1957).

[5] Antoni, F., Josepovits, G., Hidvégi, E. J., and Székessy-Hermann, V., Fourth Internat. Congr. Biochemistry, Vienna (1958).

[6] Antoni, F., Varga, L., and Hidvégi, E. J., *Acta Physiol. Hung.*, 16, 1 (1959).

[7] Vargha, L., *Naturwiss.*, 42, 582 (1955).

[8] Pain, R. H., and Butler, J. A. V., *Biochem. J.*, 66, 290 (1957).

[9] Cerlotti, G., *J. Biol. Chem.*, 214, 59 (1955).

[10] Kellner, B., and Németh, L., *Z. Krebsfschg.*, 61, 165 (1956).

[11] Kellner, B., *Acta Morph. Hung.*, 7, 215 (1956).

[12] Hidvégi, E. J., Antoni, F., Lapis, K., and Szarka, G., Third Congr. of Hungarian Biochemists, Debrecen (1959).

[13] Hidvégi, E. J., Antoni, F., and Lapis, K., *Brit. J. Cancer* (in the press).

ANIMAL PHYSIOLOGY

Effects of 1,4-Dihydrazinophthalazine on the Catechol Amines

IN a previous communication in *Nature*[1] some effects of 'Nepresoline' on the catechol amines in various organs of rats and on the adrenal medullary secretion in cats were described. Further experiments using chiefly the same technique have been carried out.

A total of 165 male albino rats with an average body-weight of 250 gm. were divided into groups of five and injected with 5–50 mgm./kgm. 'Nepresoline' subcutaneously twice a day on three consecutive days. The control groups were given an equivalent amount of vehicle. The rats were killed with a blow on the head on the first, third and fifth day after the last injection, respectively. The content of adrenaline and noradrenaline in adrenals, brain, heart and spleen was determined fluorimetrically after purification by absorption on aluminium oxide. All values were measured in μgm./gm. organ weight.

The effect of intravenous injection of 5 mgm./kgm. 'Nepresoline' on the secretion from the left adrenal after sectioning the corresponding splanchnic nerve was studied on 5 cats weighing 3–4 kgm., anæsthetized with 'Nembutal' (40 mgm./kgm. intraperitoneally). In one case the spinal cord was divided at *C* 1.

Venous blood from the left adrenal was collected at intervals before and after giving 'Nepresoline', using an adrenolumbar-femoral vein shunt technique. The adrenal vein plasma samples were assayed biologically on the cat's blood pressure and the hen's rectal cæcum.

In the rats, a dose of 5 mgm./kgm. caused in some experiments a marked depletion of noradrenaline in heart and adrenal. However, this effect was irregular. With higher doses of 'Nepresoline' a definite reduction of the content of both adrenaline and noradrenaline in the adrenals was found. With a dose of 50 mgm./kgm. a low level of noradrenaline was occasionally found in the brain. The only organ which showed complete regularity in response was the adrenal (Table 1).

Table 1. MEAN VALUES FOR CATECHOL AMINE CONTENT OF THE RAT'S ADRENAL AFTER VARIOUS DOSES OF 'NEPRESOLINE'
The corresponding values for controls, injected with an equivalent amount of solvent, are given within brackets

'Nepresoline' dose	Adrenaline		Noradrenaline	
	μgm./gm. organ	per cent of control values	μgm./gm. organ	per cent of control values
10 mgm./kgm.	578 (803)	71	118 (137)	86
50 mgm./kgm.	266 (680)	39	77 (137)	56

In cats, after adrenal denervation, 'Nepresoline' caused a much less definite secretory response than was found in cats with intact innervation. In one case no response was seen, whereas in four cats a slight stimulation of the medullary secretion occurred. In the spinal cat preparation, no definite increase in the secretion was found.

The effects of 'Nepresoline' on various organs in rats show a surprising and disturbing variation. However, it seems that, if fairly high doses are used, consistent reduction of the amount of adrenaline and noradrenaline in the adrenal was found.

As mentioned in the previous communication, low noradrenaline values were found for the heart after 'Nepresoline'. This effect we have not been able to confirm in more recent experiments. In the brain, after higher doses of 'Nepresoline', a reduction of the noradrenaline-level occurred occasionally. The variability in the response of these organs to 'Nepresoline' remains unexplained.

The results of the cat experiments suggest that the effect of 'Nepresoline' on the adrenal secretion is mainly mediated through the nervous system. In our previous report it was mentioned that baroreceptor denervation by vagotomy and carotid sinus denervation did not abolish the response. Thus it seems likely that the effect is not reflexly elicited by fall of blood pressure, but is due rather to the direct action of 'Nepresoline' on some structure in the central nervous system and possibly to some extent on the adrenals.

Further experiments to elucidate the mechanism of the 'Nepresoline' effects on the adrenal are in progress.

This investigation has been supported by grants from Karolinska Institutet and Svenska Sällskapet for Medicinsk Forskning.

M. Bygdeman
L. Stjärne

Department of Physiology,
Karolinska Institutet,
Stockholm.
Feb. 8.

[1] Bygdeman, M., and Stjärne, L., *Nature*, **184**, 1646 (1959).

Diurnal Temperature Variation in the Rhesus Monkey under Normal and Experimental Conditions

A diurnal temperature variation has been previously reported[1] in the unrestrained rhesus monkey (*Macacca mulatta*) the confirmation of which was the object of the present study. An accurate estimate of diurnal temperature variation is a necessary prerequisite for assessing basal body-temperature in this species.

Temperature recordings were made routinely with a clinical thermometer per vaginam in nine mature female rhesus monkeys which had become accustomed to handling in a previous study[2]. The monkeys during the control period were kept one to a cage, in quarters previously described[3] in which ambient temperature and humidity conditions were held constant and artificial lighting (virtually the only source of illumination) was controlled. Lights were on during 8 a.m.–4 p.m. each day, preceded and followed by dawn and dusk, night-time (near total darkness) intervening.

Temperature recordings were made at 10 a.m., 1.30 p.m., 5 p.m., and 10 p.m. over a period of one month. The former two temperature recordings were made in artificial illumination, the latter two recordings under conditions of near total darkness.

As previously observed[1], if a monkey was inclined to struggle during handling, its temperature slightly increased. If the monkey was purposely stressed by being chased, a temperature increase of 1° F. promptly occurred. With repeated recordings, the monkeys became acclimatized, and temperature values obtained were not believed to be due in part to incidental struggling.

In 6 of the 9 animals studied, the mean temperature values (and associated standard deviations) over the 12-hr. period of recording are plotted individually (Fig. 1). The range of the temperature variation under the control or normal condition in each animal is given in the upper right-hand corner of the respective graph and is plotted along a 24-hr. abscissa in a solid black line. The number of recordings upon which the control or normal variation is based is indicated in the upper right-hand corner under the value of the range.

The highest temperatures recorded were obtained usually in the early afternoon, the lowest temperatures at 10 p.m., about 5 hr. after the onset of near total darkness.

The animals were further studied for 3 months in an isolated, light-tight environment in which temperature and humidity conditions of the control period were maintained and held constant, but lighting conditions altered. Periods of 14 hr. of total darkness were followed by periods of 16 hr. of bright light. This 30-hr. dark-light period, and the relative absence of daily noise were the two most marked differences between the control and experimentally modified environmental conditions.

In the experimental environment, temperatures were recorded at the approximate midpoint during the light period, and at 5 and 10 hr. after the onset of total darkness. Temperatures were recorded in the total darkness in the light-tight experimental environment by first darkening the ante-chamber before entering the totally darkened room, so that recordings could be made with minimal disturbance to the animals.

The variation in temperature encountered in the experimental environment is plotted individually (dotted lines, Fig. 1), and in the upper right hand corner of each individual graph is the number of

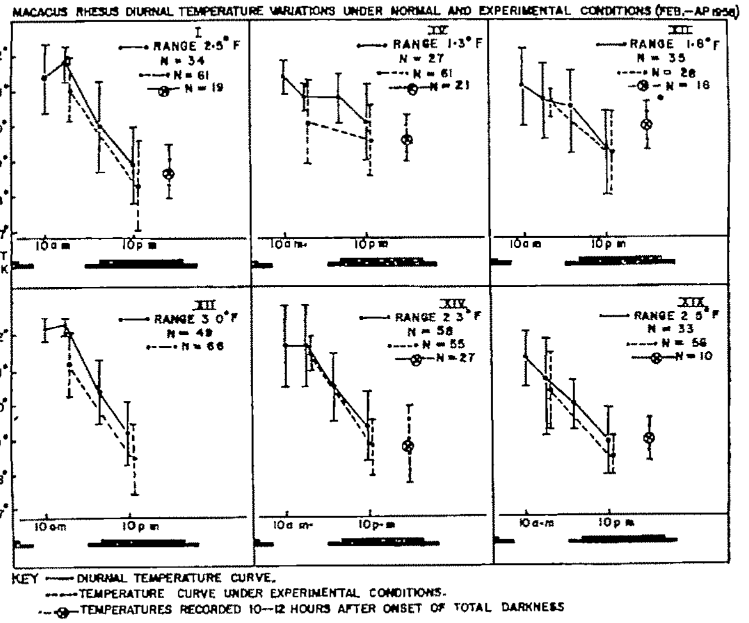


Fig. 1

recordings upon which the experimental temperature variation is based.

The temperature-range over the 30-hr. light-dark period has been plotted in terms of the 24-hr. time-base of the control environment to make similar periods of temperature recordings comparable. It may be noted that the temperatures in the experimental environment, both at the midpoint of the light period and 5 hr. after the onset of total darkness, were of the same approximate magnitude, but in all cases somewhat less than those encountered at comparable times diurnally, so that similar slopes between diurnal and experimental temperature curves resulted when the values were plotted.

In order to ascertain the period of greatest temperature depression in the experimental environment, temperature recordings were made at both 5 and 10 hr. after the commencement of total darkness. The latter mean temperature value (based on the number of recordings indicated in the upper right-hand corner of individual graphs) has been plotted in 5 of the 6 animals studied. In 4 out of 5 of these animals, mean temperatures 10 hr. after the onset of total darkness were slightly higher than the temperatures occurring 5 hr. after the onset of total darkness, but less than temperatures recorded in the light. In the fifth recorded animal (XIV, Fig. 1) the mean temperature value 10 hr. after the onset of darkness was the same as that occurring 5 hr. earlier.

The slight, but systematic reduction in temperatures in the experimental environment compared with diurnal values can be explained in two possible ways: (1) the relative absence of diurnal noise, and (2) the fact that the monkeys were out of sight of other monkeys of the main colony room, the isolation from which deprived them of sensory stimuli. The fact that depressed temperatures 5 hr. after the onset of total darkness in the experimental environment were less than those recorded diurnally may be due to the condition of total darkness achieved experimentally, but not achieved during the control night-time periods.

Table 1

Animal				Temperature (° F.)
XIII	*Macacca*	*mulatta*	female	3·0
I	,,	,,	,,	2·6
XIX	,,	,,	,,	2·5
XIV	,,	,,	,,	2·3
III	,,	,,	,,	2·1
XII	,,	,,	,,	1·8
X	,,	,,	,,	1·7
IV	,,	,,	,,	1·3
			Mean:	2·16
			S.D.	1·47

Table 1 illustrates the range of diurnal temperature variation encountered in the nine animals studied. The diurnal range in two *Macacca mulatta* previously studied[1] was of the order of 3° F., a finding which the present study confirmed. It may be concluded that the diurnal range in temperature variation in the *Macacca mulatta* is largely a light-dependent phenomenon.

LLOYD B. ERIKSON

Department of Anatomy,
University of British Columbia,
Vancouver.

---

[1] Simpson, S., and Galbraith, J. J., *Trans. Roy. Soc. Edin.*, 45, 65 (1906).

[2] Erikson, L. B., *Anat. Rec*, 130, No. 2, 297 (1958).

[3] Wood, A. J., and Kennard, M. A., *Canad. J. Comp. Med.*, 20, 294 (1956).

Body-weight and Liver —SH Levels of Mice

DURING the course of some recent work[1] the —SH levels of the liver tissue of groups of mice were determined. In any one group (10 animals) most figures fell very close to the mean figure, but an occasional case occurred showing a considerable divergence from the mean. The impression was gained that those animals whose liver —SH diverged most from the mean figure were either the smallest or largest in any group. This point has now been checked experimentally and the findings are presented below.

A batch of twenty inbred 'Strong *A*' mice of 12 weeks age were taken. Apart from this selection on an age basis no further selection was undertaken. The animals were treated individually and for each one the total body-weight and total liver (less gall bladder) weight were recorded. Using slices from the liver (85–140 mgm.) the —SH content was determined by the method described by Calcutt and Doxey[2]. The —SH content was calculated as a value per 100 mgm. wet weight of liver and also as total liver content. No correlation whatever was detectable between the total body-weight and liver-weight or between total body-weight and total liver —SH. However, a plot of total body-weight against the —SH value per 100 mgm. of liver (wet weight) appeared as in Fig. 1. The apparent inverse relationship between body-weight and —SH per unit mass indicated by this figure is in keeping with the impression gained in earlier work as —SH values were calculated on a unit mass basis during those experiments.

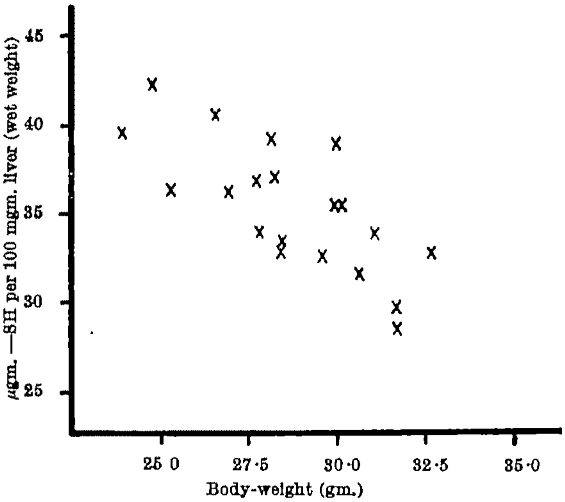


Fig. 1. —SH per 100 mgm. of liver (wet weight) against total body-weight. 'Strong *A*' males

As confirmation of these findings a parallel experiment has been carried out using a batch of 20 female 'Strong *A*' mice. The age of this group was 20 weeks. Once again no correlation could be determined between total body-weight and liver-weight, or between total body-weight and total liver —SH level. The plot of body-weight against liver —SH per 100 mgm. wet weight of liver is shown in Fig. 2. In this case the body-weights fell within a more restricted range than in the case of the males and the liver —SH values showed a wider scatter. Nevertheless, a similar inverse relationship between body-weight and —SH level per unit mass is apparent.

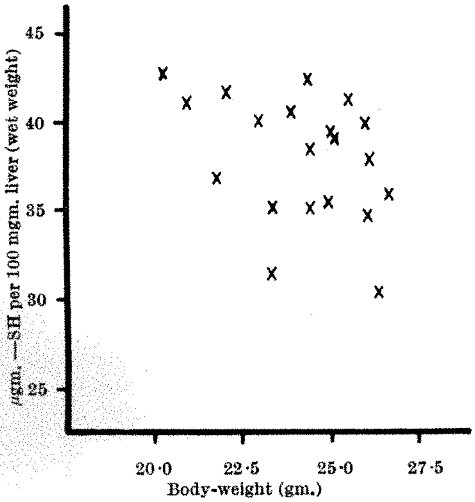


Fig. 2. —SH per 100 mgm. of liver (wet weight) against total body-weight. 'Strong *A*' females

The relationship found in the above experiments is a rather puzzling one and the only suggestion to explain it is the following. Unit masses of the various livers from any one group of animals contain approximately equal numbers of cells and it is the —SH level per cell which varies inversely with body-weight. Since the cell is a balanced biochemical system these findings suggest that other cell constituents may also vary in level according to body-weight. Such a consideration leads to the conclusion that, for biochemical work involving measurements of small differences, all animals used should be carefully selected on the basis of both age and weight.

G. CALCUTT

Department of Cancer Research,
Mount Vernon Hospital and the Radium Institute,
Northwood, Middlesex.

[1] Calcutt, G., Doxey, D., and Coates, Joan, *Brit. J. Cancer* (in the press).

[2] Calcutt, G., and Doxey, D., *Exp. Cell. Res.*, **17**, 542 (1959).

Essential Fatty Acids of Normal and Atherosclerotic Aortas from Chickens receiving Differently Saturated Fats for Three Years

SINCLAIR's suggestion[1] that atherogenesis may be associated with a relative essential fatty acid deficiency has received considerable attention in many laboratories. On the basis of fatty acid analyses of atheromatous plaques, several investigators have concluded that Sinclair's hypothesis is not substantiated[2,3]. Very recently, Sinclair[4] has joined issue with those who drew these conclusions by suggesting that the fatty acid analytical techniques employed do not differentiate between the essential fatty acids (linoleic and arachidonic) and non-essential fatty acids of similar unsaturation. Although in the present study no attempt was made to differentiate between linoleic and arachidonic acid on one hand, and other di- and tetra-enoic acids on the other, the results herein presented may contribute to a better understanding of the relationship between essential fatty acids and plaque formation.

Three groups of 12-week old Leghorn pullets were fed for three years on: (1) a standard low fat laying ration; (2) the same ration supplemented with 10 per cent corn oil; or (3) supplemented with 10 per cent animal tallow. After killing the hens at the end of three years on the above diets the aortas were removed from the heart to the iliac bifurcation, cleaned of adhering tissue and visually scored[5]. Since significant plaque formation affects primarily the abdominal region of the aorta only this segment was used for the fatty acid analyses. From each of the three fat treatment groups four abdominal aortic segments with the severest atherosclerotic involvement (out of a total of 15–17 per group) were carefully dissected into plaque and clear areas. Lipids were extracted with chloroform/methanol (2 : 1) from the pooled plaque and clear tissues as well as intact abdominal segments from the three treatment groups showing little or no atherosclerotic involvement, the extracts filtered and analysed for iodine numbers and polyunsaturated fatty acids by the methods of Luddy *et al.*[3] and of Morris and Riemenschneider[6].

The results of these analyses are shown in Table 1. It can be seen that in all but one instance the di- and tetra-enoic fatty acid concentration of the lipids from the plaque areas was lower than for the clear areas from the same aortic segments. However, even the concentration of these fatty acids from the clear areas was lower than for the non-affected abdominal segments. Table 1 further shows that there is an inverse relationship between the severity of the atherosclerotic involvement (visual score) and the level of essential fatty acids in the plaque tissue. While these observations lend support to Sinclair's original suggestion, the fact that considerable atherogenic development occurred even in the birds fed with corn oil the aortas of which contained a comparatively high essential fatty acid concentration, would strongly suggest that plaque formation does not owe its origin to an essential fatty acid deficiency.

Table 1. FATTY ACID COMPOSITION (PER CENT) OF LIPID EXTRACT FROM ABDOMINAL AORTAS OF CHICKENS FED DIFFERENTLY SATURATED FATS FOR THREE YEARS

Fatty acids	Abdominal aortic tissue								
	Unaffected			Affected					
				Plaque area			Clear area		
	No fat	Corn oil	Animal fat	No fat	Corn oil	Animal fat	No fat	Corn oil	Animal fat
Saturated	56·9	56·2	51·6	74·2	54·9	50·1	56·5	46·3	45·5
Monoenoic	26·9	14·7	35·0	17·8	27·1	35·6	30·7	33·0	42·3
Dienoic	*12·0*	*22·2*	*10·3*	*6·2*	*15·5*	*11·4*	*10·1*	*17·4*	*9·7*
Trienoic	0·9	1·2	0·9	0·7	0·9	1·2	1·0	0·9	0·7
Tetraenoic	*1·5*	*1·6*	*1·5*	*0·6*	*1·0*	*0·9*	*1·0*	*1·8*	*1·0*
Pentaenoic	0·2	0·2	0·2	1·0	0·1	0·2	0·2	0·2	0·2
Hexaenoic	0·5	0·5	0·5	0·4	0·5	0·6	0·4	0·4	0·6

Visual scoring: 1 = unaffected; 6 = most severe involvement. Scores for the affected abdominal aortas were: No fat, 3·0; corn oil, 2·2; animal fat, 2·3.

This work was supported in part by grants-in-aid from the U.S. Public Health Service and New Jersey Heart Association.

H. Fisher
A. S. Feigenbaum

Department of Poultry Science,
Rutgers University,
New Brunswick,
New Jersey.

[1] Sinclair, H. M., *Lancet*, 381 (1956).

[2] Böttcher, C. J. F., Keppler, J. G., Romeny-Wachter, C. C., Ter Haar, Boelsma-Van, E., and Van Gent, C. M., *Lancet*, 1207 (1958).

[3] Luddy, F. E., Barford, R. A., Riemenschneider, R. W., and Evans, J. D., *J. Biol. Chem.*, **232**, 843 (1958).

[4] Sinclair, H. M., *Lancet*, 789 (1959).

[5] Weiss, H. S., *J. Gerontol.*, **14**, 19 (1959). (All aortas were graded by Dr. H. S. Weiss, whose assistance we gratefully acknowledge.)

[6] Morris, S. G., and Riemenschneider, R. W., *Arch. Biochem. Biophys.*, **78**, 138 (1958).

HÆMATOLOGY

Elevation of Serum Haptoglobin in Rabbits in Response to Experimental Inflammation

NORMAL human serum contains sufficient haptoglobin to bind approximately 130 mgm. of hæmoglobin per 100 ml. (ref. 1). A number of other mammalian species, including the rabbit, have much lower serum haptoglobin-levels[2]. In order to have available a plentiful source of rabbit haptoglobin a method was sought by which the normal serum level could be elevated. Observations on patients with various diseases suggested that tissue inflammation might provide a means to this end[3]. Accordingly, the effect of administering turpentine to rabbits was investigated.

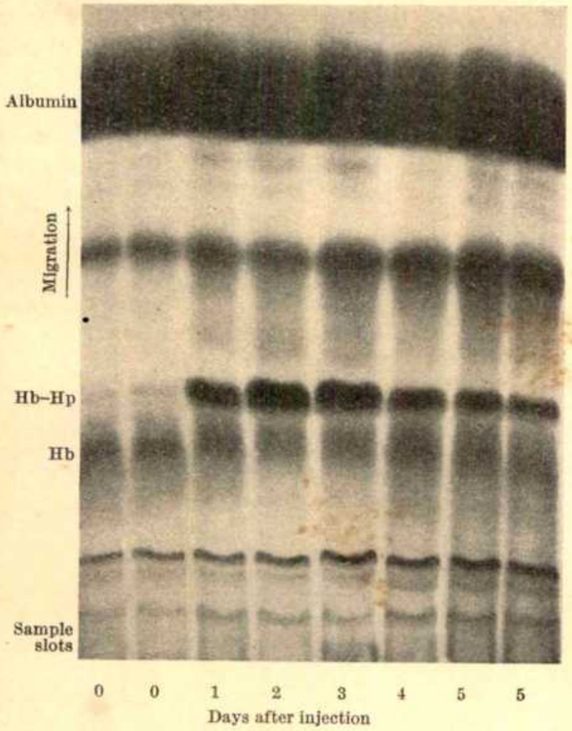


Fig. 1. Starch-gel electrophoresis (ref. 5) of serum samples from a rabbit following injection of turpentine. The buffer composition was 0·021 *M* boric acid 20 per cent neutralized with sodium hydroxide. Hæmoglobin was added to all samples in amounts sufficient to bind all free haptoglobin. The samples on the two edges of the gel are duplicates of the neighbouring samples. The position of the hæmoglobin zone is indicated by the symbol Hb, the hæmoglobin–haptoglobin zone by Hb–Hp

The range of serum haptoglobin concentration[4] in 32 rabbits was 2–35 mgm. with a mean of 10 mgm., expressed in milligrams hæmoglobin-binding capacity per 100 ml. Fifteen rabbits of various ages received a 1-ml. dose of turpentine injected subcutaneously in the dorsolumbar region. In these animals the serum haptoglobin concentration increased to 150–300 mgm. per 100 ml. The rise began at approximately 12 hr. after injection and reached a peak at 48 hr. The level afterwards decreased and fell to one-half of the maximum in 2½–3 days.

The changes in starch gel electrophoretic pattern[5] following turpentine injection are illustrated in Fig. 1. Although the increase and subsequent decrease in the hæmoglobin–haptoglobin zone is the most striking feature, there are changes in several other zones, particularly in those migrating between albumin and the hæmoglobin–haptoglobin complex. Analysis of serum samples for total protein-bound carbohydrate[6] and total protein[7] were also performed. Serum glycoprotein concentration doubled during the initial 48 hr. after injection. More than half the increase of the serum glycoprotein at 48 hr. could be attributed to haptoglobin. No appreciable changes in the total serum protein level were observed.

Whether the rise in haptoglobin represents net synthesis or liberation of pre-formed haptoglobin has not been elucidated. The site of synthesis or of liberation also remains unknown. However, it is unlikely for the following reasons that the haptoglobin is released into the blood at the site of injection: (1) the haptoglobin-level of exudate withdrawn from the site of injection at 24 and 48 hr. was found to be much lower than the haptoglobin-level of serum; (2) the injection of 2·0 *N* hydrochloric acid which caused local ulceration failed to produce marked elevation of serum haptoglobin; (3) when repeated daily injections of turpentine were administered to one rabbit at different sites, the maximum level of haptoglobin and the rate of disappearance were within the limits observed when only a single dose was given. These observations suggest that a tissue pool of haptoglobin may exist normally, possibly in the liver, and that the protein is released into the blood stream in response to inflammation.

This work was supported by a grant from the National Research Council of Canada. One of us (R. K. M.) holds a Graduate Medical Research Fellowship of the National Research Council of Canada.

R. K. Murray
G. E. Connell

Department of Biochemistry,
University of Toronto.

[1] Nyman, M., *Scand. J. Clin. and Lab. Invest.*, Supp. No. 39, 11 (1959).

[2] Liang, C. C., *Biochem. J.*, **66**, 552 (1957).

[3] Jayle, M. F., Boussier, G. C., and Batias, M. J., *C.R. Soc. Biol.*, **149**, 46 (1955).

[4] Connell, G. E., and Smithies, O., *Biochem. J.*, **72**, 115 (1959).

[5] Smithies, O., *Biochem. J.*, **71**, 585 (1959).

[6] Winzler, R., "Methods of Biochemical Analysis", **1**, edit. by Glick, D. (Intersci. Pub., New York, 1955).

[7] Gornall, A. G., Bardawill, C. S., and David, M. M., *J. Biol. Chem.*, **177**, 751 (1949).

Effect of Manganese Edetate on Blood Formation in Rats

It has been reported by Sullivan[1] that anæmia developed in immature rats fed on a diet containing those metallic complexes of edetic acid having stability constants lower than ferrous iron, the anæmia being preventable by simultaneous iron injections. Other authors[2-4] had reported that these complexes given to adult rats orally or by injection produced no alteration of the blood picture compared with controls. It seemed probable therefore that the chelates were capable of producing an iron deficiency anæmia in immature rats but less readily or not at all in adult animals, and this problem has been further investigated.

Control and treated groups of rats were matched according to age and sex, and received a diet of powdered rat cubes with water to drink *ad lib.* Treated rats received, in addition, 4 per cent manganese edetate in the diet. This complex has a stability constant slightly lower than ferrous iron, which it would thus be expected to chelate, but somewhat higher than complexes formed by sodium, magnesium and calcium, so that any abnormalities in treated rats due to deficiency of these cations would be avoided. Blood for investigation was obtained either by amputating the tip of the tail or by decapitation under ether anæsthesia.

Table 1 shows the results obtained. Group 1 consisted of adult rats treated for 50 days. Although there was a significant difference between the hæmoglobin values of control and treated rats, those of the treated animals were only slightly reduced, and no other abnormalities in the blood picture were discovered.

Groups 2 and 3 consisted of young immature rats which were treated for 50 and 40 days respectively. The hæmoglobin values of treated animals were much lower than controls in both groups, particularly in the more immature rats in group 3. The red cells of treated rats in group 2 were microcytic. The mean corpuscular hæmoglobin concentration of treated animals in group 3 was significantly lower and the blood film confirmed a hypochromic anæmia.

After 50 days treatment with manganese edetate, rats in groups 1 and 2 were returned to a normal diet for 30 days. Blood investigations were then repeated, and no significant differences between treated and control rats remained.

In these experiments, a severe but reversible iron deficiency anæmia was produced among immature but not adult rats. The more immature the rats, the more severe was the anæmia. Previous results[1] indicate that this effect can be produced by many heavy metal chelates less stable than ferrous edetate. There are reports that manganese may affect blood formation but these are contradictory[5].

All animals gained weight, although the gain of treated rats in group 3 was poor compared with their controls. Taste cannot be excluded as a cause for this since rats were not pair-fed. This group of rats also differed from the others in that they had just been weaned.

I wish to thank Prof. R. S. Stacey and Dr. M. S. R. Hutt for advice and assistance, and Dr. J. K. Aiken of the Geigy Co., Ltd., Manchester, for supplies of manganese edetate.

T. J. Sullivan
Department of Pharmacology and Therapeutics,
St. Thomas's Hospital Medical School,
London, S.E.1.

---

[1] Sullivan, T. J., *Arch. Int. Pharmacodyn.* (in the press).
[2] Child, G. P., and Leonard, P., *Fed. Proc.*, **10**, 286 (1951).
[3] Child, G. P., *Science*, **114**, 466 (1951).
[4] Massachusetts General Hospital Conference Report, *Arch. Indust. Hyg.*, **7**, 137 (1953).
[5] Cotzias, G. C., *Physiol. Rev.*, **38**, 503 (1958).

Table 1. Blood Investigations on Rats receiving 4 per cent Manganese Edetate in the Diet, compared with Controls. Figures are given in Italics where $P < 0.05$

Groups	No. of rats	Mean initial body-weight (gm.)	Weight increase (per cent)	Hæmoglobin (gm./100 ml. blood)	MCHC	Red blood cells (millions/cu. mm.)	MCV (cu. μ)
(1) Controls	5	247	3	15	31	8·53	58·5
Treated	5	242	9·5	*13·4*	30	7·57	59·5
(2) Controls	5	52	213	14·5	30	8·59	57
Treated	5	51	184	*9·9*	28	8·25	*41·5*
(3) Controls	4	34	305	13·6	31	—	—
Treated	6	34	104	*7·7*	*26*	—	—

MCHC, Mean corpuscular hæmoglobin concentration; MCV, mean corpuscular volume.

Rivanol in the Preparation of Plasminogen (Profibrinolysin)

The most commonly used technique for preparing plasminogen is that worked out by Kline[1] using fraction III as a starting material. Plasminogen seems to be a rather resistant protein, for extreme *p*H's are used in the above-mentioned method. It would be interesting to compare the profibrinolysin prepared by the Kline technique with a product obtained by a completely different method.

Rivanol (diamino-ethoxyacridine lactate) has been used for the preparation and purification of several plasma proteins such as γ-globulin[2], β_1-metal combining globulin[3], ceruloplasmin[4], haptoglobin[5] and thrombin[6]. So we were interested to study the behaviour of plasminogen during subfractionation of fraction III by rivanol.

The fibrinolytic activity of each sample obtained after streptokinase activation ('*SK* Diamant') is measured by a technique using purified and relatively plasminogen-free fibrinogen (Kekwick *et al.*[7]) and thrombin (unpublished) preparations following the technique of Kowalski *et al.*[8]. Small concentrations of rivanol do not interfere with the detection of fibrinolytic activity. Samples freed of the acridine derivative by treatment with charcoal at *p*H 8·5 showed almost the same activity.

Ceruloplasmin can be prepared, as recently described[4], by treating fraction III with rivanol. We found that plasminogen is precipitated together with ceruloplasmin as revealed by the screening test for fibrinolytic activity.

The rivanol–protein complex obtained in step 2 is dissociated at *p*H 4 and 50 per cent alcohol concentration. The precipitate is then extracted by acetate buffer 0·5 *M*, *p*H 6·5 (final *p*H 5·9). This solution contains ceruloplasmin but has no fibrinolytic activity. The plasminogen is not destroyed and is still present in the bulk of denatured proteins. Plasminogen is more soluble in dilute salt solutions and so we treated the precipitate remaining after the extraction of ceruloplasmin by dilute saline at pH near neutrality.

This saline extract freed from rivanol by treatment with charcoal at pH 8·5 is highly active as shown by fibrinolytic activity tests.

Further work is in progress and will be published elsewhere.

M. Steinbuch
S. Niewiarowski

Centre National de Transfusion Sanguine,
Paris.

[1] Kline, D. L., *J. Biol. Chem.*, **204**, 949 (1953).
[2] Horesi, I., and Smetana, R., *Acta Med. Scand.*, **2**, 550 (1948).
[3] Boettcher, E. W., Kistler, P., and Nitschmann, H., *Nature*, **181**, 490 (1958).
[4] Steinbuch, M., and Quentin, M., *Nature*, **183**, 329 (1959).
[5] Steinbuch, M., and Pejaudier, L., *Nature*, **184**, 362 (1959).
[6] Miller, K. D., *Nature*, **184**, 450 (1959).
[7] Kekwick, R. A., Mackay, M. E., Nance, M. H., and Record, B. R., *Biochem. J.*, **60**, 671 (1955).
[8] Kowalski, F., Kopec, M., Latallo, Z., Roszkowski, S., and Sendys, N., *Blood*, **8**, 436 (1958).

PLANT PHYSIOLOGY

Specific Interaction of Native Protein and Inorganic Salts

Under the action of certain inorganic salts, native serum proteins release a phytohormonal fraction inhibitory to the growth of plant roots, as may be seen by comparing Fig. 1 with Fig. 2.

Fig. 1 shows the average increment in millimetres in 24 hr. of roots of *Lupinus albus* (the Macht–Livingston technique[1]) grown in nutrient solutions containing five different concentrations of serum in five independent experiments, that is, one with each concentration of serum. The nutrient solutions were made up of 1–10 per cent serum (v/v) diluted partly with water and partly with a well-balanced triple-salt solution consisting of 2·5 mM calcium nitrate, 7·5 mM magnesium sulphate and 9·0 mM potassium dihydrogen phosphate (after Shive[2]). The serum originated from five different samples of blood, one for each experiment, taken from the same proband.

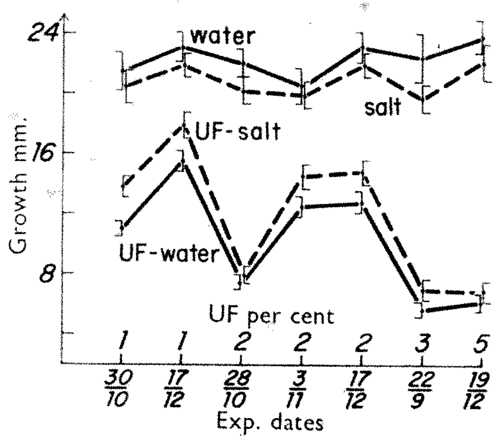


Fig. 2. Growth of roots in water and salt solutions with or without addition of an ultra-filtrate of denatured serum in six independent experiments (two ordinate values are partially common in one experiment (December 17, 1958)). Ordinates: growth in mm. in 24 hr. at 15° C.; abscissæ: (1) dates of experiments (1958), (2) percentage (v/v) of ultra-filtrate (UF) in water or salt solution in two lower curves. Ultra-filtrate of serum from various probands, freshly taken the day before each experimental date. Vertical transverse lines on curves: 95 per cent fiducial limits

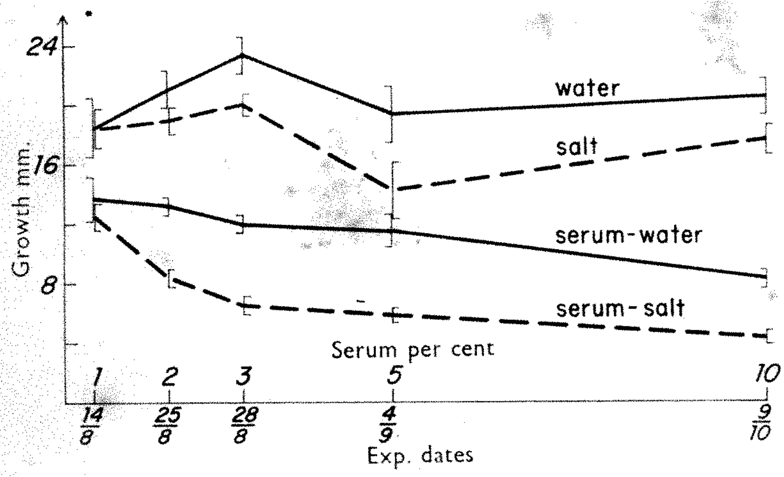


Fig. 1. Growth of *Lupinus albus* roots in water and salt solutions with or without serum added, in five independent experiments. Ordinates: growth in mm. in 24 hr. at 15° C.; abscissæ: (1) dates of experiments (1958), (2) percentage (v/v) of serum in water or salt solution in the two lower curves. Serum from one proband, freshly taken on each experimental date. Vertical transverse lines on curves: 95 per cent fiducial limits

The curve marked 'water' in Fig. 1 shows the increment in distilled water, while that marked 'salt' indicates the increment in the triple-salt solution. As previously demonstrated by Ekdahl[3] and by me[1], in a 24-hr. experiment in water the increment is greater or of the same order as in the triple-salt solution. The vertical transverse lines on the curves indicate fiducial limits at the 5 per cent level (variation within experiments).

The curves marked 'serum–water' and 'serum–salt' show the growth in water and in the triple-salt solution, respectively, with serum added at the concentrations indicated on the axis of abscissæ. The curves marked 'serum–water' and 'serum–salt' are at a lower level than the 'water' and 'salt' curves, indicating that serum causes reduced growth of the roots.

Fig. 1 thus clearly shows two effects, namely, (1) a salt–root effect and (2) a serum–root effect. A third effect is also shown in Fig. 1, but it is more distinct if the values of the 'serum–water' curve in Fig. 1 are converted into percentages of the values of the 'water' curve in Fig. 1, while the values of the 'serum–salt' curve in Fig. 1 are converted into percentages of the values of the 'salt' curve in Fig. 1. As percentages, the values of the 'serum–salt' curve fall below those of the 'serum–water' curve.

Is this third effect due to a salt–root action, so that the sensitivity of the roots to serum action has been changed in the saline dilution, or is it due to a salt–serum action?

The answer must be sought in Fig. 2, which shows the results of six growth experiments, in which an ultra-filtrate (UF) of a heat-denatured 33 per cent serum–water solution has been used as nutrient medium, diluted partly with water and partly with the triple-salt solution already mentioned. The concentrations of the ultra-filtrate in the solutions are plotted as abscissæ, the solutions having been diluted so that the percentages refer to the original serum concentration before heat-denaturation and ultra-filtration. By heat-denaturation all bound phytohormones will be released from the serum proteins[4].

Like the curves in Fig. 1, those in Fig. 2 also show three effects. Two of these, namely, (1) a salt–root effect and (2) a ultra-filtrate–root effect, correspond to the salt–root effect and serum–root effect already mentioned. The third effect shown in Fig. 2 is that the increment in the ultra-filtrate–salt solution constitutes a higher percentage of the increment in the salt solution without ultra-filtrate, as compared with the percentage which the increment in ultra-filtrate + water constitutes of the increment in water without the ultra-filtrate. This third effect in Fig. 2, where an ultra-filtrate of denatured serum is used as a specific nutrient medium, is thus directly contrary to the corresponding effect in Fig. 1, where native serum is used as a specific nutrient medium.

The *p*H of the solutions cannot be the cause of the difference recorded in the activity of native serum on one hand and an ultra-filtrate of denatured serum on the other, since all solutions containing Shive salt have a lower *p*H value than the corresponding solutions in which distilled water is used as diluting agent. In Fig. 1 the most acid serum–salt solution has thus the greatest root-growth inhibition, whereas in Fig. 2 the most acid ultra-filtrate–salt solution has the smallest root-growth inhibition.

An ultra-filtrate of denatured serum contains all its phytohormones in the free, unbound form, whereas native serum contains most of its phytohormones in the bound form[4]. Since a nutrient solution in which all phytohormones are found in the free form (the curves with ultra-filtrate in Fig. 2) has thus shown an effect contrary to that of a nutrient solution in which the same phytohormones are present in partially bound form (the curves with serum in Fig. 1) but where otherwise all other factors are alike, the difference must be due to the serum protein component in Fig. 1. In an experimental arrangement analogous to that of the experiments in Figs. 1 and 2, four experiments with varying concentrations of urine, which, in some respects, may be regarded as an ultra-filtrate of serum, have shown the same effect as found in the experiments with an ultra-filtrate of denatured serum. This also suggests that the difference between the results shown in Figs. 1 and 2 is due to the protein component in the nutrient solutions in Fig. 1.

That native serum diluted with a salt solution has thus shown the greatest inhibition of root growth, relatively as well as absolutely, compared with its effect when diluted with water, must therefore be interpreted as being due to a protein–salt effect rather than to a salt–root effect.

Since phytohormones can only be imagined to affect roots when present in the free form, the increased phytohormonal effect in serum diluted with a salt solution must be due to the fact that the salts release quantities of phytohormones from the native serum proteins.

For grants enabling me to carry out the present work, I am indebted to the P. Carl Petersen's Foundation and the Johan Weimann, Merchant of Odense, and Hanne Weimann, *née* Seedorff, Foundation.

FOLKE RØNNIKE

Department of Plant Physiology,
Royal Agricultural and Veterinary College,
and
Surgical Department, Frederiksberg Hospital,
Copenhagen. Sept. 1.

[1] Rønnike, F., *Physiol. Plant.*, **11**, 421 (1958).

[2] Shive, J. M., *Amer. J. Bot.*, **2**, 157 (1915).

[3] Ekdahl, I., *Ann. Roy. Agric. Coll., Sweden*, **23**, 497 (1957).

[4] Rønnike, F., *Acta Pharm. et Toxicol.*, **16**, 46 (1959).

2,6-Dichlorobenzonitrile: a New Herbicide

IN the course of a screening programme investigating the herbicidal activity of various benzonitriles and related compounds it was found that many of these substances inhibited the growth of young oat plants and the germination of seeds of many weed species.

The most active compound in this series proved to be 2,6-dichlorobenzonitrile (code No. *H* 133). The germination of seeds is especially inhibited by very small amounts of *H* 133. This inhibition is illustrated in Fig. 1, where millet seeds (*Panicum miliaceum*) have been sown on a 2 per cent agar containing the indicated amounts of 2,6-dichlorobenzonitrile per ml. The tubes contained 10 ml. of the agar solution. A concentration of 5×10^{-5} mgm. of *H* 133 per ml. strongly inhibited germination. In a comparison with *iso*propyl-N-phenylcarbamate (I.P.C.), the same degree of inhibition occurred at a dose of about 5×10^{-3} mgm.

H 133 is easily absorbed by seeds either from a solution or from the vapour. In laboratory experiments the germination of wild oats was completely inhibited if flats were sprayed with amounts of *H* 133 corresponding to doses of 0·5–4 kgm. per hectare depending on the type of soil. Seeds of some plant species, for example, rice, groundnuts, maize and sunflower, showed a distinct resistance to *H* 133.

Besides inhibition of germination the effects of *H* 133 appear in general killing or stunting the growth of young plants. Older and also full-grown plants were not damaged by this compound. After application of small amounts of *H* 133 various effects on plants could be observed. Growing tips are obviously very sensitive to this compound. *H* 133 thus acts via the roots as well as by way of the green parts of the plants.

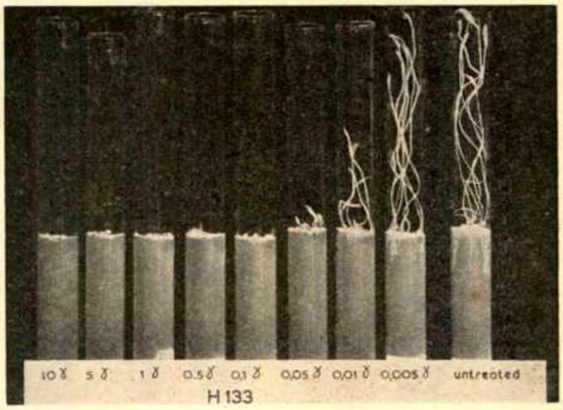


Fig. 1

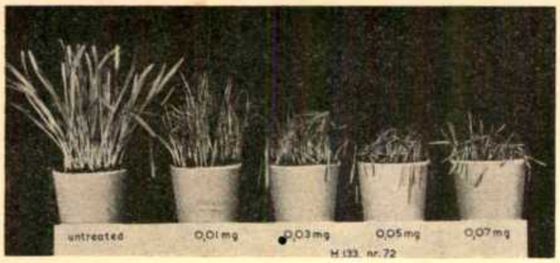


Fig. 2

When applied in a lanolin paste to the stem of bean plants a local swelling of the stems occurred, mainly caused by an increase in diameter of the parenchyma cells. The stems of sunflower and groundnut plants also showed a characteristic swelling. In plants like tobacco and *Salvia*, leaf growth is inhibited simultaneously with an increase in thickness of the leaf.

H 133 is very active in vapour form, in spite of the low vapour pressure (3×10^{-6} mm. mercury at 20° C.). A characteristic effect is illustrated in Fig. 2, where young oat plants were exposed to the vapour of *H* 133 during 24 hr. by covering them with glass bells containing in the top a piece of filter-paper with a certain amount (0·01–0·07 mgm.) of *H* 133. The young leaves toppled over and all cells in the actively growing meristems collapsed (Fig. 2).

The same effect may be observed under appropriate conditions 10 min. after spraying the plants.

Sprouting of stored potato tubers is completely inhibited by exposure to *H* 133 vapour.

In an *Avena* coleoptile section test an antiauxin effect was observed. Concentrations of 10^{-4} mgm. of *H* 133 per 0·5 ml. buffer inhibited the growth stimulation of 10^{-3} mgm. of indole acetic acid per 0·5 ml. buffer solution.

Experiments in which respiration or photosynthesis was measured in a Warburg apparatus showed that neither respiration nor photosynthesis of tobacco leaves was inhibited, if the leaves were placed in a saturated solution. The solubility of *H* 133 in water is 18 p.p.m.

A specific effect of *H* 133, for example, the toppling over of young oat plants, was not observed, if known herbicides, as phenoxyacetic, phenylacetic or benzoic acids, were used. On the other hand, leaf modifications as caused by phenoxyacetic and benzoic acids have never been shown.

The acute toxicity of *H* 133 for warm-blooded animals is low. The acute oral *LD*50 for mice is >6 gm./kgm. body-weight; the acute intraperitoneal *LD*50 for mice is >3 gm./kgm. body-weight.

These effects of *H* 133 indicate its possibilities as a herbicide. It is active against many weeds, for example, wild oat (*Avena fatua*), bracken (*Pteridium aquilinum*), chickweed (*Stellaria media*) and cleavers (*Galium aparine*), whereas some crops have proved resistant to it.

A full account of these investigations will be published elsewhere.

H. KOOPMAN

Chemical Research Laboratory,
N.V. Philips-Duphar, Weesp, Holland.

J. DAAMS

Agrobiological Laboratory,
'Boekesteyn', N.V. Philips-Duphar,
's-Graveland, Holland. Oct. 6.

Volvox Colonies and Snail 'Cytase'

HAVING seen the very striking way in which snail 'cytase' brings about the dissolution of cell walls in angiosperm roots (following the suggestion for its use in cytological techniques[1]), I wondered what effect this substance might have on a colonial organism such as *Volvox*. Would it be possible to separate the cells of the colony into a swarm of *Chlamydomonas*-like creatures, or, better still, would it be possible to liberate the protoplasts as free-swimming naked individuals?

Small quantities of a culture of *Volvox aureus* Ehr. were placed in watch glasses and sufficient of the coffee-coloured 'enzyme' (obtained from the crop of the edible snail) was added to each to bring the strength of the enzyme up to about 20–25 per cent of the total bulk of the liquid.

The treated colonies were kept at room temperature and examined under the microscope from time to time for up to three days. At no time did any of them show any signs of separating into individual free cells. The only visible effects of the treatment were (*a*) the production of one or more large dimples in most of the colonies, presumably due to slight plasmolysis, and (*b*) a slight swelling of the outer region of each colony.

The ability of the colonies to resist dissolution was quite unexpected, especially since the 'enzyme' is known to contain at least twenty constituents capable of acting on a wide range of carbohydrates. As a check on the activity of the snail enzyme under the conditions and at the dilution described above, a little ground wheat endosperm was added to some of the watch glasses after 12–24 hr., and in each case both the starch grains and the cellulose endosperm walls were readily dissolved.

Thus although it is possible to obtain a positive cellulose reaction on *Volvox* by treatment with iodine and sulphuric acid, it seems that in the living condition the material forming the matrix of a colony must either be very different from that of the walls of higher plants, or it must be protected in some way by the incorporation of some substance (such as protein) which is not attacked by the snail enzyme.

I wish to thank Miss E. H. Evans for supplying the snail enzyme and the Cambridge Culture Collection for the culture of *Volvox aureus*.

B. C. SHARMAN

Botany Department,
Bedford College,
Regent's Park,
London, N.W.1.

---

[1] Faberge, A. C., *Stain Tech.*, **20**, 1 (1945).

RADIOBIOLOGY

Significance of Adrenals for Increased Oxygen Consumption in Rats during Irradiation

THE first minute of exposure to ionizing radiation produces in animals many changes which may be explained as stress reaction. In my previous communication I had shown a significant increase in oxygen consumption in rats during irradiation with a dose-rate of 50 r./min.[1]. Since I believe that this increased oxygen consumption is a demonstration of stress reaction too, I should like to explain the role of adrenals in these changes in the following experiment.

I used 60 female rats (Wistar strain), average weight 200 gm. Bilateral adrenalectomy was performed on 50 rats, sham operation on 10 rats. The adrenalectomized rats were fed on a standard Larsen diet and drinking water was replaced by saline solution. The division in groups was as follows: (1) experimental group: (adrenalectomized, irradiated rats) (40 rats); (2) control group: (adrenalectomized rats without irradiation) (10 rats); (3) control group: (sham operated, irradiated rats) (10 rats).

The methods of measuring and irradiation was described in my previous communication[1].

The course of oxygen consumption in experimental and control rats is given in Fig. 1. In all irradiated groups, the oxygen consumption was already significantly increased in the first minute of irradiation with a dose-rate of 50 r./min. The difference in oxygen consumption between group 1 and group 2 is statistically significant ($P < 0{\cdot}01$). The oxygen consumption in rats after sham operation has increased much more ($P < 0{\cdot}005$) than in the experimental groups.

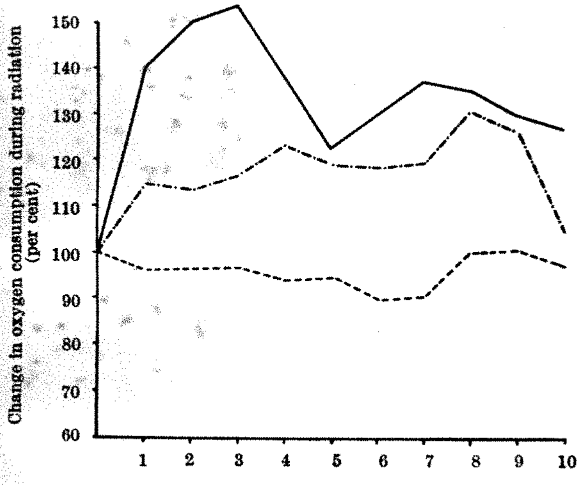


Fig. 1. ——, Sham operated, irradiated rats; —.—.—, adrenalectomized, irradiated rats; — — —, adrenalectomized, non-irradiated rats

As oxygen consumption was increased during irradiation in all adrenalectomized rats I believe that an increase in oxygen consumption could not be explained as the influence of accidental accessory suprarenals. In accordance with Selye's experiments, I do not exclude the possibility that the changes in oxygen consumption during irradiation are a manifestation of radiation stress[2].

The difference in the increased oxygen consumption during irradiation, both in experimental and control irradiated rats, indicated that the change in oxygen consumption is higher in presence of the adrenals. I assume that adrenals, too, take part in the increasing oxygen consumption. But the velocity of the increase in oxygen consumption in the first minute of irradiation rather indicates a presumably reflex mechanism of these changes. I suggest that the increase in oxygen consumption has been produced, on one hand, by a direct influence of the nervous system on tissue metabolism, and, on the other hand, these changes are later accompanied by humoral factors.

A. VACEK

Institute of Biophysics,
Czechoslovak Academy of Sciences,
Brno.

[1] Vacek, A., *Nature*, **184**, 197 (1959).

[2] Selye, H., *Endocrinol.*, **21**, 169 (1937).

Hazard of Tritium as a Deoxyribonucleic Acid Label in Man

IN the Recommendations of the International Commission on Radiological Protection[1,2] (1955, 1960) on maximum permissible body burden, tritium is considered only in water which is widely and uniformly distributed throughout the body. It is pointed out in the Recommendations that great care must be taken in applying these data to other chemical forms which may give a different localization. However, this fact is still not always appreciated and although it is particularly serious for tritium. The average range of its beta-particles is only about 1μ (maximum range about 7μ) and the local dose-rate will have reached about half the maximum for a deposit of isotope in a volume of the order of only $10\mu^3$. Further, an increased relative biological effectiveness is to be expected for these low-energy beta-particles compared with gamma radiation, and from observations of radiation effects on cell growth, Pinson and Langham[3] have suggested that a value of 1·7 should be used.

One of the frequent applications of tritium is in labelling precursors of deoxyribonucleic acid such as thymidine. These will be taken up specifically by the limited number of cells in the period of synthesis of deoxyribonucleic acid prior to division. The radioactive material will then be associated with the chromosomes and will produce local irradiation of an essential part of the cell, being particularly likely to interfere with division or to produce gene mutations. A concentration of only 0·03 μc./gm. within a nucleus of $500\mu^3$ could deliver a dose of 0·06 rad (0·1 rem) in one week within that nucleus, and such an uptake in some 10^{12} dividing cells would constitute a body burden of 15 μc. (ref. 4) only 1/167 of the latest International Commission on Radiological Protection value[2].

We have directed attention to the possibility of appreciable radiation effects from the amounts of tritium-labelled thymidine used in autoradiography[4,5]. In fact, marked toxic effects have been observed in tissue culture by Osgood[6], and by Painter and Drew[7], who reported that 0·1 μc./ml. medium for 24 hr. or 0·02 μc./ml. medium for 72 hr. resulted in the death of 90 and 50 per cent of cells respectively.

Painter, Drew and Hughes[8] compared the effects of tritium-labelled water and tritium-labelled thymidine in the medium for 24 hr., on the inhibition of growth of Hela cells. Comparable depressions were produced by 5,000 μc./ml. medium and 5 μc./ml. respectively. Allowing for a relative biological effectiveness of 1·7 this implied a 'concentration' factor of 590/1. This is a greater difference than suggested above in connexion with body burden; but it must be realized that in this latter case the dose of 0·1 rem was averaged over the total nuclei incorporating the material. However, the range of the particles is so short that the radiation effect is limited to small volumes even within these nuclei. A particle of the average energy (0·055 MeV.) can be considered to dissipate this energy within a sphere of only 1μ diameter, corresponding to a dose within this small volume of some 168 rads (286 rems if a relative biological effectiveness of 1·7 in fact applies), so that a single particle is capable of producing very marked radiation effects within its limited range. This represents 5–10 times more energy than would be left in a similar volume, adjacent to the point of emission, by the first part of the track even for a beta-particle from carbon-14, and the difference is even greater for particles of higher energy.

Johnson and Cronkite[9] have found comparable radiation effects on mouse spermatogonia *in vivo* at 60 hr. after an injection of tritium-labelled thymidine 1 μc./gm. of body-weight, or a single dose of 5 r. of gamma radiation. This amount of tritium is about that needed to produce a good autoradiograph of cellular uptake, which requires some 6 × 10^4 atoms per nucleus of 500μ^3 volume corresponding to some 6 μc./gm. of nucleus[4]. Thus, a concentration factor of the order of 10 applies in this case between the concentration of thymidine in nuclei and in whole body; but, of course, the uptake in any particular type of cell will depend on the local pool of thymidine, which will vary from tissue to tissue[10]. An average concentration of 6 μc./gm. will give a dose of 4 rads (or 6·8 rems) per 60 hr., which is, in fact, similar to the observed equivalent gamma radiation dose.

There would be a difference between the cells initially receiving damage in these two cases. Gamma radiation would damage a certain proportion of all cells at random, although this damage might not become obvious until the cells attempted division at some later time. Following a single injection, thymidine would be taken up specifically by cells already preparing for division and only these cells would initially show damage. However, the nature of the tritium localization in chromosomes of dividing cells would favour production of mutations (with consequent risk of carcinogenesis, leukæmia, etc.). Further, although there are at present no data on the biological half-life of deoxyribonucleic acid pyrimidines *in vivo*, it is known that deoxyribonucleic acid purines from damaged cells are re-utilized efficiently for synthesis of deoxyribonucleic acid[5]. In the event of tritiated thymidine being given continuously, all dividing cells would in the end receive radioactive material, and, if there is appreciable re-utilization of material, the maximum cell content could gradually increase.

Thus, the particular nature of uptake and the lack of knowledge on local pools and re-utilization make it very difficult to lay down any maximum permissible body burden for tritiated thymidine. It is certain that appreciable organ radiation effects may be observed after even the low doses necessary for autoradiography. However, in general, with tritiated deoxyribonucleic acid precursors the main concern is not with organ damage (as only the proportion of cells in synthesis of deoxyribonucleic acid at the time of administration will be affected), but rather with mutagenic effects in those cells which have a long life span and several mitotic cycles in the body (for example, bone marrow stem cells and any 'stem' population). In these cells it is meaningless to consider rads per nucleus, as the uneven distribution of energy within the nucleus may or may not affect a vulnerable volume by chance.

R. OLIVER
L. G. LAJTHA

Department of Radiotherapy,
Churchill Hospital,
Oxford.

---

[1] International Commission on Radiological Protection Recommendations, *Brit. J. Radiol.*, Supp. 6 (1955).

[2] International Commission on Radiological Protection Recommendations (Pergamon Press, 1960).

[3] Pinson, E. A., and Langham, W. H., *J. App. Physiol.*, **10**, 108 (1957).

[4] Lajtha, L. G., and Oliver, R., *Lab. Invest.*, **8**, 214 (1959).

[5] Lajtha, L. G., "Kinetics of Cellular Proliferation", 173 (Grune and Stratton, 1959).

[6] Osgood, E. E., "Kinetics of Cellular Proliferation", 185 (Grune and Stratton, New York, 1959).

[7] Drew, R. N., and Painter, R. B., *Rad. Res.*, **11**, 535 (1959).

[8] Painter, R. B., Drew, R. M., and Hughes, W. L., *Science*, **127**, 1244 (1958).

[9] Johnson, H. A., and Cronkite, E. P., *Rad. Res.*, **11**, 825 (1959).

[10] Nygaard, O., and Potter, R. L., *Rad. Res.*, **10**, 462 (1959).

BIOLOGY

Age Determination in the Harbour Seal, *Phoca vitulina* L.

RECENT detailed investigations of the life-histories of several arctic and antarctic phocids[1–3] have established the use of incremental layers in the dentine and cementum of canine teeth as accurate indicators of age. Such studies have relied on seasonal differences in the rate and type of deposition for determining the annual nature of the layers, but so far as we are aware, the results obtained have never been validated by examination of teeth from an animal of known age.

Recently, we acquired from Dr. Victor B. Scheffer and Mr. Dale W. Rice, of the U.S. Fish and Wildlife Service, the right upper canine of an old adult male harbour seal from the Seattle Zoo. This animal had been kept in captivity since its capture as a pup, and its age was therefore known to within a few months.

The tooth is illustrated in longitudinal section in Fig. 1, which shows that the bulk of the cementum is confined to the lower half. A thin-ground section in the same plane reveals that the cementum contains many well-defined layers, which are better resolved in the transverse section (Fig. 2) cut at the level marked in Fig. 1. Each layer is about 125μ in width and consists of a wide band of opaque cementum and a narrow translucent band. Examination

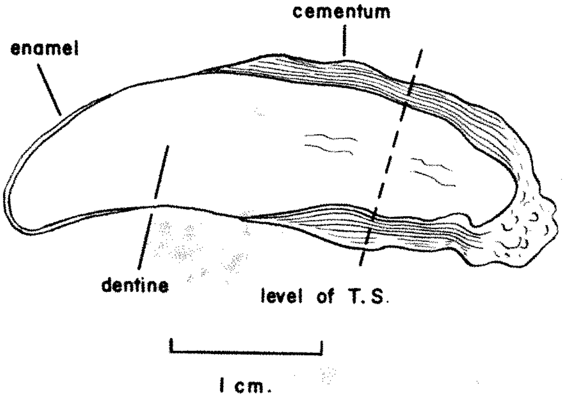


Fig. 1. Diagrammatic longitudinal section of the right upper canine of an old male harbour seal

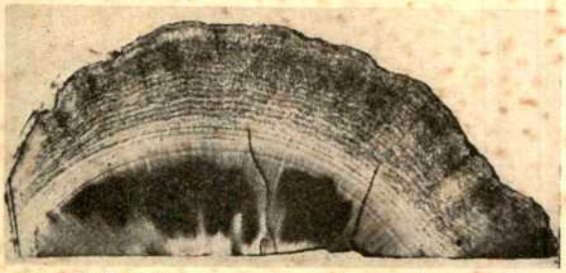


Fig. 2. Half of a transverse section of the same tooth cut at the level shown in the diagram. At least eighteen layers can be counted in the cementum

of other specimens shows that the translucent band is laid down in the spring and early summer and may represent a period of minimal feeding during the breeding period and the moult, as is found in some other phocids[1,3].

Preliminary counts gave the number of cementum layers as 18–20, the lower figure being finally chosen since it was the most certain. After our examination had been made, we learned from Dr. Scheffer that the seal was 19½ years old, a fact which confirmed the annual nature of the cementum layers. There were no clearly marked dentinal layers in this particular tooth, but examination of other canines from both male and female harbour seals has shown that, where dentinal layers are present, they agree in number with those in the cementum.

A. W. MANSFIELD
H. D. FISHER

Arctic Unit,
Fisheries Research Board of Canada,
505 Pine Avenue West,
Montreal 18.

[1] Fisher, H. D., Fish. Res. Board Canada, MS. Rep. Series (Biological), 588 (1954).

[2] Laws, R. M., Falkland Islands Dependencies Sci. Rep., 8 (1953).

[3] McLaren, I. A., Fish. Res. Board Canada, Bull. 118 (1958).

Anomalies in the Microscopic Structure of Some Wools

THE bilateral division of the cortex of merino wool into ortho and para sections has been clearly shown by many workers[1,2], and can easily be demonstrated by dyeing the fibres with methylene blue at the boil, at pH 7·4. When this experiment is carried out with Southdown or Corriedale fibres the shape of the two portions is often anomalous. Near the division between stained (ortho) and unstained (para) portions there often appears a core, often within the paracortex, but stained more deeply than the ortho. When the experiment is repeated at pH 6 (at which very little segmentation is discernible in Merino) this core remains deeply stained and clearly distinguishable from the ortho-cortex, which is relatively pale (Fig. 1). It is concluded from this experiment, and other similar experiments with fine crossbred wools, that in some types of wool a core more basophilic than the ortho-cortex exists, usually at the junction between the ortho and the para portions, and sometimes completely in the para-cortex. In a sample of Southdown fibres one-third had such a core, and in Corriedale about two-thirds. When whole fibres are examined this core is towards the inside of the curve of the crimped fibre. It is proposed to call this core the meta-cortex.

The position and basophilic nature of this meta-cortex suggest that it might be related to the medulla, but, of course, no medulla is found in these fine crossbred wools. However, when a sample of white alpaca fibres was likewise stained at pH 6, it was possible to pick out fibres with a broken medulla joined by deeply stained cores. When slides of these fibres, viewed in the microscope, were flooded with acetic acid the blue stains of the core disappeared leaving the medulla portions still visible. Occasionally, fibres stained at pH 6 showed a length of core with a few vacuoles along one edge (Fig. 2) and sometimes a concentration of vacuoles at one end. A sample of Masham wool similarly treated showed a mixture of core and medulla similar to that found in alpaca. One fibre showed some portions with two medullæ (as is often found in llama) of which one was continuous throughout, and the other, which was thin, was replaced in portions by a single line of deep blue spindle-shaped cells, sometimes in line and sometimes overlapping. This again suggests a relation between the medulla and the core or meta-cortex.

It would also seem that the three regions of the cortex are different in sulphur content. Thorsen[3] has published pictures of Rambouillet, Suffolk and Navajo wool fibre cross-sections, stained in sodium plumbite, in which there is an unstained core as well

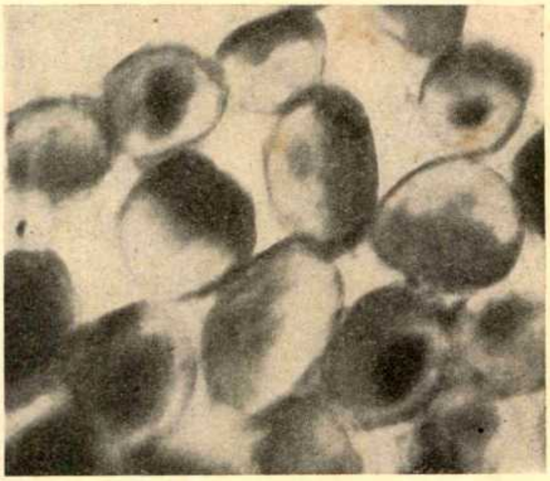


Fig. 1. Southdown wool stained with methylene blue at pH 6

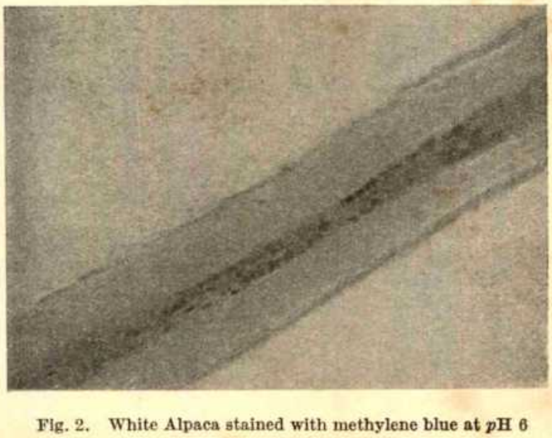


Fig. 2. White Alpaca stained with methylene blue at pH 6

as two regions corresponding to the ortho- and para-cortex. When Southdown and Corriedale fibres are similarly stained in sodium plumbite, some of them exhibit an unstained, sulphur-deficient, core near the junction of the dark brown para- and the light brown ortho-, often within the para-cortex. The fraction of such fibres is similar to the fraction of those showing a meta-cortex when stained with methylene blue at pH 6. A similar phenomenon can be seen in white alpaca stained with sodium plumbite. The medullated fibres (the majority) show a white, sulphur-deficient, ring around the medulla, often within the para-cortex, and unmedullated fibres simply show the white core in the same position. The apparent sulphur deficiency of the meta-cortex and the known sulphur deficiency of the medulla[4] are thus consistent with the association between meta-cortex and medulla noted earlier.

These observations would indicate that the medulla and the meta-cortex may be similarly derived within the fibre follicle.

T. D. BROWN

Keighley Technical College
and School of Art,

W. J. ONIONS

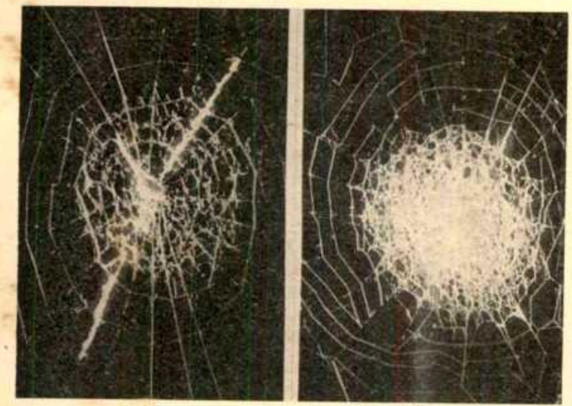
Department of Textile Industries,
University of Leeds.

[1] Horio, M., and Kondo, T., *Text. Res. J.*, **23**, 373 (1953).
[2] Mercer, E. H., *Text. Res. J.*, **23**, 388 (1953).
[3] Thorsen, W. J., *Text. Res. J.*, **28**, 185 (1958).
[4] Blackburn, S., *Biochem. J.*, **43**, 114 (1948).

Unusual Web Pattern made by an Unfertilized Female of the Spider *Uloborus walckenaerius* Latreille

A MATURE female of *Uloborus walckenaerius* was found in May 1959 in the precincts of Jerusalem. The female lived about four months in the laboratory and reached a large size; she did not lay eggs and was probably not fertilized.

A few weeks after bringing her into the laboratory an unusual pattern appeared in her web. Besides the usual radial stabilimentum, an additional design appeared, forming a lace-like delicate pattern in the centre (Fig. 1a). During the following days the pattern became denser and its area larger. Towards the end of this process the additional threads completely covered the normal stabilimentum and the whole central area (Fig. 1b). The new formation resembled a compact white spot in the middle of the web, the dense area reaching in some webs about 5 cm. in diameter.



(a) (b)

Fig. 1. Central part of the web of *U. walckenaerius* with additional pattern. *a*, Initial stage; *b*, final stage

After the web was destroyed the spinning process was repeated. The unusual additional stabilimentum pattern appeared in large normal webs as well as in small ones, which resembled primitive cocoon webs. The rate of spinning activities of this unusual pattern is variable.

At the same time some females of another species of *Uloborus* were also found, in outward appearance and size very similar to *U. walckenaerius* but distinctly differing in colour. Unfortunately the species has not so far been determined. One of these females, probably also unfertilized, spun similar additional stabilimentum patterns in her webs. In addition, during July this female spun an unusually large but empty cocoon, resembling in form a typical cocoon of *U. walckenaerius*, and placed it on a cocoon web beside her web. On the fourth day the empty cocoon was torn off (probably by the spider itself) and found lying beneath the web. The spinning of an empty cocoon confirms the supposition that the female was not fertilized.

Both phenomena, the unusual web pattern and the spinning of the empty cocoon, in an unfertilized female show that: (1) increased silk production in the mature female is probably independent of fertilization, and leads to an unusual stabilimentum pattern in the web; (2) making the cocoon may be independent of egg-laying.

Although it is difficult to judge by a single observation of throwing away an empty cocoon, it nevertheless suggests the existence of some action to control the completed cocoon. This latter suggestion needs further investigation.

I am grateful to Dr. A. Shulov for identifying *U. walckenaerius*.

RASZA SZLEP

Department of Zoology,
Hebrew University,
Jerusalem.

Perfect Stage of *Microsporum gypseum*

IN 1927, Nannizzi[1] reported the discovery of the perfect stage of *Microsporum gypseum* (Bodin) Guiart and Grigoraki and named it *Gymnoascus gypseum* Nannizzi. This work was criticized on a number of grounds, and, as there has been no record of its successful repetition, it has been generally disregarded.

I, by chance, rediscovered this same perfect stage in April 1959 when I noticed the presence of cleistothecia typical of the Gymnoascaceae associated with *Microsporum gypseum* growing on hair resting on the surface of moist soil in a laboratory experiment. This conclusion is supported by the following evidence: (a) macro-conidia of *M. gypseum* were borne directly on the characteristic peridial hyphæ of the cleistothecia; (b) both ascospores and macro-conidia gave rise to colonies producing both the sexual and asexual stage, although the sexual stage was only produced if the fungus was grown on hair mixed with moist soil, in the confirmatory tests the whole system having been sterilized prior to inoculation. Although the cleistothecial characteristics of the present isolate differ in certain respects from Nannizzi's diagnosis of his isolate, the differences are explicable and I regard the two to be conspecific.

The species is only doubtfully a member of the genus *Gymnoascus*, but no change in generic position is proposed as yet. Full details will be published elsewhere.

Considered with the recent discovery of the perfect stage of the closely allied *Keratinomyces ajelloi*[2], the case for the gymnoascomycete derivation of this important group of dermatophytes is strengthened.

D. M. GRIFFIN

School of Agriculture,
University of Sydney.
Dec. 2.

---

[1] Nannizzi, A., *Atti R. Accad. Fisiocritici Siena*, **10**, 2, 89 (1927).

[2] Dawson, Christine O., and Gentles, J. C., *Nature*, **183**, 1345 (1959).

Occurrence of the Slipper Limpet, *Crepidula fornicata* L., in Ireland

In May 1959, during an investigation of the intertidal ecology of the Kenmare River, Co. Kerry, full-grown single individuals of this American gastropod were found to be common below mid-tide level at Kilmakilloge Harbour, a shallow and protected inlet on the southern shore of the estuary. This species is well known as a pest of oyster beds on the eastern and southern shores of England, and is also present in Wales[1], but is believed not to have been recorded previously from Irish waters. Studies on the biology of *Crepidula* have shown that distribution on ships is the main, if not the only, means of remote dispersal[2]. It is therefore probable that this species has reached Ireland attached to vessels previously laid up in British harbours. As part of the survey, a special search was also made for the Australasian barnacle *Elminius modestus* Darwin which, though now widespread in Britain[3], has in Ireland only been reported from Lough Ine, Co. Cork[4]. However, *Elminius* was not found anywhere within the Kenmare River, nor was *Crepidula* noted at other localities.

D. C. ARNOLD

Department of Biology,
Wayne State University,
Detroit.

---

[1] Bassindale, R., and Barrett, J. H., *Proc. Bristol Nat. Soc.*, **29**, 227 (1957).

[2] Cole, H. A., Min. Agric. Fish., Fish Invest., **17**, paper 7 (1952).

[3] Crisp, D. J., *J. Mar. Biol. Assoc. U.K.*, **37**, 483 (1958).

[4] Beard, D. M., *Nature*, **180**, 1145 (1957).

A Mesozoic Microflora from South Africa

In 1948 I examined a specimen of low-grade coal from the Gamtoos River, Eastern Cape Province, South Africa, and found it to be particularly rich in microspores. Carbonaceous mudstones and shales in the Wood Beds of the Uitenhage series in the Gamtoos River basin were afterwards found to contain a comparable, though much less rich, spore assemblage, thus giving a fairly consistent picture of a Mesozoic flora of the region.

At the time of investigation it did not seem possible to name many of the sporomorphs; but owing to the progress in sporomorph taxonomy of the past ten years many can now be named, at least tentatively. Of particular interest are three species of saccate sporomorphs. One of these is similar to, if not identical with, *Pityosporites ellipticus* (Cookson) Balme, a form known from Australia and New Zealand[1]. Another is *Podosporites* c.f. *micropterus* (Cookson and Pike) Balme, this genus being known from India and Australia. Both sporomorphs have been regarded as likely Podocarpaceae. The third is *Caytonipollenites pallidus* (Reissinger) Couper, identical in form with pollen of *Caytonanthus* (Caytoniales) and very likely referable to this widespread group of Mesozoic Pteridospermae[2].

Other sporomorphs include *Classopollis torosus* (Reissinger) Couper, *Tsugaepollenites* sp., *Ginkgocycadophytus* sp., *Cicatricosisporites* c.f. *brevilaesuratus* Couper, and trilete spores resembling those of Cyatheaceae, Dicksoniaceae, Matoniaceae, Schizaeaceae and Gleicheniaceae. A total of about thirty sporomorph species has so far been distinguished.

The age of the Uitenhage Wood Beds is regarded as Wealden[3]. The spore assemblage, so far as it has been studied at present, is quite consistent with this, though not proving it, as the microflora is typically mid-Mesozoic, closely comparable with Upper Jurassic and Lower Cretaceous ones and apparently lacking certain forms which seem to be typical of the Lower Cretaceous of Australia, such as *Cicatricosisporites australiensis* (Cookson) Balme and *Microcachrydites antarcticus* Cookson.

Mid-Mesozoic microfloras of South Africa have not been investigated, and the present study suggests some resemblances to both northern and southern floras of about the same age, that is to say, a southern and a cosmopolitan element are present. In view of the occasionally mooted theory of southern origin of angiosperms in lower or mid-Mesozoic times, it is perhaps worth stressing that the present limited evidence is only negative. A fuller taxonomic account of the material is in preparation.

I am indebted to Dr. J. Hewitt, formerly director of the Albany Museum, Grahamstown, for material; to the Council for Scientific and Industrial Research, South Africa, for a grant for palynological studies; and to the Commonwealth Scientific and Industrial Research Organization, Coal Research Section, New South Wales, for assistance in nomenclature.

A. R. H. MARTIN

Botany School,
University of Sydney.

---

[1] Balme, B. E., *Fuel Research, T.C.*, **25** (C.S.I.R.O., Australia, 1957).

[2] Couper, R. A., *Palaeontographica*, B, **103** (4–6), 75 (1958).

[3] Du Toit, A. L., "Geology of South Africa", 3rd ed. (Oliver and Boyd, London, 1952).

Cell Wall Formation in Spores of the Fungus *Allomyces*

In attempts to elucidate the details of plant cell wall formation, it is obvious that certain types of cells may be more useful than others. The investigation of cells which begin their existence devoid of a wall but which acquire one later may possibly show structural features uncomplicated by the cumulative effects of growth and differentiation. It has been shown by Nicolai[1], who investigated cell wall formation in the green alga, *Chaetomorpha*, that spores of lower plants can fulfil the special requirements for investigations of this kind. She observed that the motile reproductive cells of this alga were able to form a well-defined cell wall within 24 hr. after cessation of motility. Furthermore, changes in the form and crystallinity of the cell wall constituents

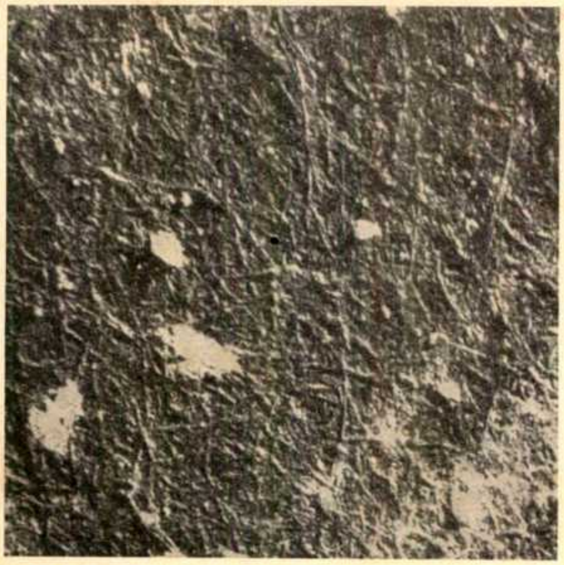


Fig. 1. Electron micrograph of a portion of the cell wall of a 24-hr. 'sporeling'. (Shadowed with platinum. × 36,000)

were detected by electron microscopy and X-ray analyses.

We thought it would be of interest to examine a similar situation in fungi. For this purpose, zoospores of *Allomyces* were used. These uniflagellate spores are considered to be without cell walls at the time of their formation and liberation from sporangia[2]. At this stage they are quite fragile and it has not been possible, thus far, to obtain preparations showing the structure of the surface of motile spores. Within 24 hr., however, observations in a light microscope show that a cell wall is present. We have made a preliminary electron microscopic study of the walls of these 24-hr. old 'sporelings'. They have been found to contain microfibrils in random arrangement, embedded in amorphous material (Fig. 1). By collecting a large number of zoospores and suspending them in a dilute nutrient medium for 24 hr., enough material was obtained for an X-ray analysis. Fig. 2 shows a comparison between X-ray powder diagrams of purified wall material from mature hyphae and partially purified material from 'sporelings'. Major reflexions attributable to chitin are present in both cases.

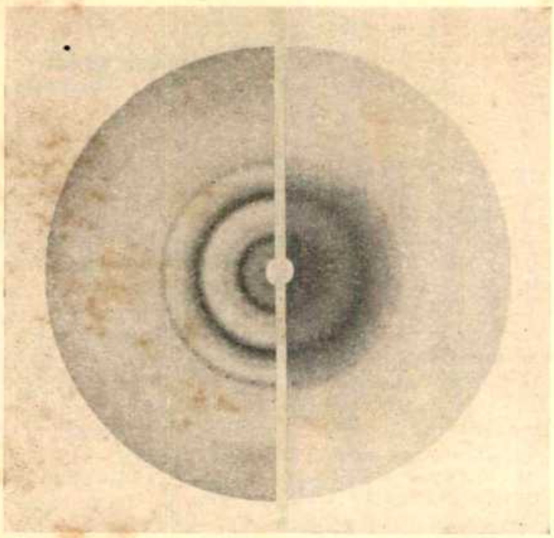


Fig. 2. X-ray powder diagrams of purified chitin from walls of mature hyphæ (left), and partially purified wall material from 'sporelings' (right)

Thus it is clear that, at a very early stage in development, the structural component of the cell wall of this fungus consists mainly of chitin microfibrils as has been found to be the case with the walls of mature hyphæ[3]. In so far as this investigation goes, it offers no evidence for an earlier suggestion that chitin is not the principal constituent of the walls during early stages of growth[4]. It seems, however, that the chitin is not as highly crystalline as that found later in mature hyphæ.

No attempt has been made to observe ontogenetic changes in wall structure from earlier stages or from the 24-hr. stage onward, and the precise time of formation of the first chitin microfibrils is unknown.

This work constitutes part of a programme supported, in part, by a postdoctoral research fellowship and supply grants awarded to one of us (J. M. A.) by the U.S. National Institutes of Health, Department of Health, Education and Welfare.

J. M. ARONSON*
R. D. PRESTON

Biophysics Sub-Department,
Botany Department,
The University,
Leeds, 2.

* Present address: Department of Biology, Wayne State University, Detroit 2, Michigan.

[1] Nicolai, E., *Nature*, **180**, 491 (1957). See also, Nicolai, E., and Preston, R. D., *Proc. Roy. Soc.*, B, **151**, 244 (1959).

[2] Fitzpatrick, H. M., "The Lower Fungi: Phycomycetes", 24 (McGraw-Hill Book Co., Inc., New York, 1930).

[3] Aronson, J. M., and Preston, R. D., presented to *Proc. Roy. Soc.* and *J. Biochem. Biophys. Cytol.*

[4] Aronson, J. M., and Machlis, L., *Amer. J. Bot.*, **46**, 292 (1959).

ENTOMOLOGY

Mechanisms of Resistance of the Adult Housefly (*Musca domestica*) to 'Cyclodiene' Insecticides

EXPERIMENTS have been conducted with isodrin and endrin labelled with carbon-14 in the terminal unchlorinated ring[1] and with aldrin and dieldrin labelled in the chlorinated ring (from the Radiochemical Centre, Amersham). Adult insects used were of a susceptible strain (S) and dieldrin-resistant strains (R_1) and (R_2). R_1 arose from the S-strain by exposure of the larvæ to dieldrin and R_2 from R_1 by removal of the dieldrin pressure after 19 generations[2].

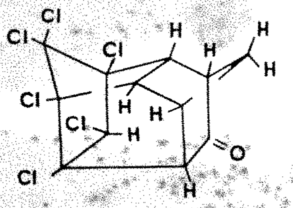
Topically applied isodrin and endrin are less toxic than aldrin and dieldrin to S-flies[3], but the converse is true for the resistant strains described. Thus, in a 10 hr. observation (female flies without food or water), 20 μgm. aldrin topically applied in acetone did not affect R_1-flies but with isodrin the $KD50$ was about 3·0 μgm. R_2-flies were less resistant to aldrin and the $KD50$ for isodrin was about 1·0 μgm. It was of interest to compare the behaviour of these compounds in the three strains.

The radioactive insecticides were applied topically in 2 μl. acetone to the dorsal thorax of adult females in groups of 10–25 while under mild *cyclo*-propane anæsthesia and kept in fresh air at 25° without food or water. The method of confinement and subsequent analytical techniques were those described previously[2].

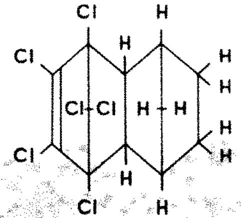
The results of experiments in which 2 μgm. of aldrin or isodrin were applied are given graphically in Fig. 1, which shows *internal* behaviour of the insecticides. *Total* recoveries were 75–85 per cent applied dose.

Penetration. A 2-μgm. dose of any of the insecticides produced severe signs of poisoning in *S*-flies in 1 hr., and at this time after application of aldrin the absorbed material (aldrin + dieldrin + acetone insoluble material in tissues) was similar for *S*- and R_2-strains, but greater in the R_1-strain. Subsequent penetration is similar in both *R*-strains but lower in *S*-flies (now knocked-down). Dieldrin penetrates into *S*- and R_2-flies at the same rate and faster than aldrin. Penetration is slower into R_1-flies, possibly due to the presence of inbred dieldrin in their tissues. The 2-μgm. dose of isodrin causes knock-down in the R_2-strain after 6–7 hr., but the penetration pattern is similar to that of aldrin; there was increased recovery of applied material in these experiments. Resistance does not appear to involve penetration differences and *R*-flies can survive with concentrations of absorbed insecticide in excess of those which would cause the death of *S*-flies.

Metabolism. All strains enzymically converted isodrin and aldrin to the corresponding epoxides endrin and dieldrin. Mixtures with the authentic epoxides could not be resolved by paper chromatography.



(I)



(II)

Acetone rinses from live insects following application of aldrin or isodrin also contained amounts of the corresponding epoxide which increased with time to about 8·0 per cent of the applied dose (50 per cent of the unabsorbed insecticide) after 8 hr. Epoxides were not formed either outside or inside heat-killed insects. This suggests that enzymic oxidation may also occur on or in the insect cuticle. Topically applied dieldrin was recovered from insects unchanged. Acetone extracts of live *S*- and *R*-insects treated with isodrin or endrin (this otherwise unchanged) contained similar small amounts of a water-insoluble product (Fig. 1*E*) which behaved as the ketone (I), a known rearrangement product of endrin[4], under the conditions of chromatography used. This ketone is virtually non-toxic when topically applied to *S*-flies. The conversion of aldrin and isodrin to their epoxides is shown in Fig. 1 (*C* and *D*).

The linear nature of these curves during the first 4 hr. when there are marked changes in the concentrations of aldrin or isodrin in the tissues suggests that oxidation is independent of precursor concentration. This might be due to rapid saturation of the oxidation site by the substrate.

The similarity between rates of production of dieldrin and endrin is interesting in view of the greater toxicity of the latter to the *R*-strains. Both aldrin and its oxidation product or isodrin and its oxidation product are present together in the tissues at the time of 'knock-down'. It is therefore difficult to decide whether either precursor or product or both are responsible for the toxic action. Perry *et al.*[5] noted the latent period between application of heptachlor to an *S*-strain and onset of symptoms which is not due to lack of penetration and cites this as an indication that death may be due to the action of the epoxide rather than to heptachlor. This is also true of aldrin. However, the reduction product (II) of aldrin, which cannot be oxidized, is still as toxic as chlordane[6], which suggests that the aldrin type of molecule has an intrinsic toxicity independent of metabolism possibilities. The results in Fig. 1 also show that resistance is not associated with a lower rate of oxidation *in vivo*.

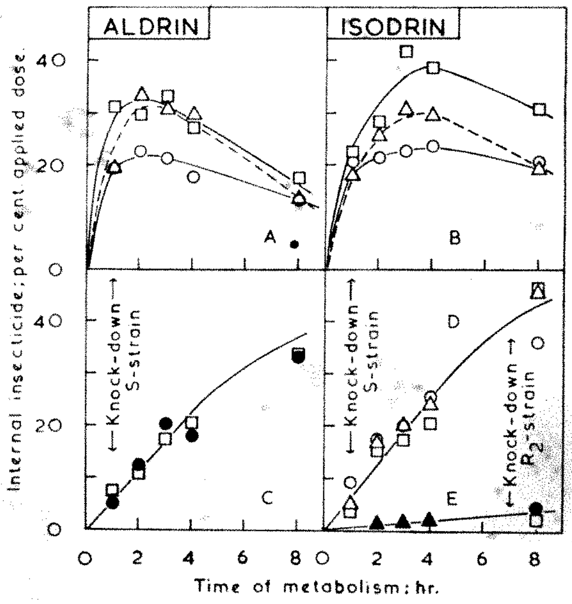


Fig. 1. Internal metabolism of ^{14}C-aldrin and ^{14}C-isodrin by adult ♀ houseflies exposed to a 2 μgm. dose. Curves: *A*, aldrin; *B*, isodrin; *C*, dieldrin production; *D*, endrin production; *E*, fast running fraction. ○—○, *S*-strain; △—△, R_2-strain; □—□, R_1-strain; ●—●, *S* and R_2; ▲–▲, all strains

Excretion. There was no reliable evidence in these experiments that radioactive material is excreted. Groups of insects with ani sealed[2], used as controls, lost as much radioactive material to the carrying papers as did the test groups, and analysis of this material revealed the same pattern. This loss by contamination may explain the appearance of epoxide in this fraction for both control and test groups after application of aldrin or isodrin, since epoxides were found on the insect cuticle.

Residual material in tissues. This fraction rose to 1–2 per cent of the applied dose (aldrin or dieldrin) for all strains at 8 hr. With isodrin and endrin there was an increase with time in all strains to the same level. This fraction was not extractable by water. The rather lower content in the R_1-strain which already contains inactive (carrier) dieldrin suggests that it may be unchanged insecticide intimately associated with the tissues.

These experiments suggest that resistance of *R*-flies to dieldrin is not due to lack of cuticular penetration, differences in metabolism, or excretion of the insecticide. Studies of the aldrin–dieldrin system and the isodrin–endrin system have not revealed marked differences between *S*- and *R*-insects within a system, or differences between the systems which would explain the differing toxicities to the resistant strains. More detailed study of these systems may, however, be useful from the mode-of-action aspect, since the observations suggest that physiological factors are involved in the resistance mechanism.

These experiments are part of an investigation into the mechanism of dieldrin resistance in diptera, supported in part by a grant from the World Health Organization.

G. T. BROOKS

Pest Infestation Laboratory,
Slough, Buckinghamshire.

[1] Brooks, G. T., *J. Chem. Soc.*, 3693 (1958).
[2] Winteringham, F. P. W., and Harrison, A., *Nature*, **184**, 608 (1959).
[3] Busvine, J. R., *Nature*, **174**, 783 (1954).
[4] Bellin, R. H., *et al.*, U.S. Patent 2,768,181 (1956).
[5] Perry, A. S., Mattson, A. M., and Buchner, A. J., *J. Econ. Ent.*, **51**, 346 (1958).
[6] Lidov, R. E., U.S. Patent 2,635,979 (1953).

Effect of Sub-Zero Temperatures on Diapause Eggs of *Acheta commodus* (Walk.)

IT has come to be accepted that the optimum temperature for the removal of diapause varies from one insect species to another in a way that is related to the temperatures prevailing in the climatic zone inhabited by the species concerned. Thus, Danilyevsky[1] gives a series of instances in which the colder the climatic zone of the insect the lower is the optimum temperature for removal of diapause.

The range of temperatures effective in terminating diapause is quite wide and has been shown to extend below zero for a number of species. These species are all from cold climates and for most of them a long period of exposure to sub-zero temperatures is necessary. For insects generally, it can be said that, although the range of effective temperatures may extend below zero, the optimum temperature for the removal of diapause has been found to be between 0° and 15° C. It should be pointed out, however, that so far as species from temperate climates are concerned, very few experiments on the effect of sub-zero temperatures on diapause removal have been reported.

Previous work on the diapause of the common field cricket *Acheta commodus* indicated conformity with the above principles. *Acheta* is found in the temperate and sub-tropical regions in eastern Australia and has been quoted by Lees[2] as an example of an insect from a warmer environment that requires higher temperatures for the termination of diapause. Browning[3] has reported that the range of effective temperature extends from 8 to 27° C. with an optimum at about 13° C.

In these circumstances it is of interest to report that diapause in eggs of *Acheta* can be terminated by a short period of exposure to sub-zero temperatures. In these experiments diapause was induced by holding the eggs at 23° C. for 14 days. The period of exposure necessary to terminate it decreased progressively as the temperature was lowered.

At 12·8° C. the median duration of exposure was 20–60 days, depending on the strength of diapause in the eggs being tested. At −7·2° C. the mean value over a series of tests was 5 hr., while in one test at −16·5° C. a period of only 20 min. was required. At the latter temperature a proportion of the eggs was killed before the diapause reactions had been completed.

A further notable effect is that, at any one sub-zero temperature, a progressive decline in the percentage hatching occurs if the eggs are held beyond the optimum time for the elimination of diapause at that temperature. As the period of exposure was increased the proportion of eggs resuming development decreased to nil. When given the normal incubation, that is, 15 days at 26·7° C., such eggs showed no indication of development, and, when cleared by a method previously described[4], the embryos were found to be still in the diapause stage, but were abnormal in appearance. They remained in this condition even with prolonged incubation. It is presumed, therefore, that they were incapable of development and that the treatment had been lethal.

A more detailed description of this work will be published elsewhere.

I wish to acknowledge the capable assistance of Miss J. Kenyon in carrying out the experiments.

T. W. HOGAN

Plant Research Laboratory,
Department of Agriculture,
Melbourne.

[1] Danilyevsky, A. S., *Ent. Oboz.*, **30**, 194 (1949).
[2] Lees, A. D., "The Physiology of Diapause in Arthropods", 150 (Camb. Univ. Press, London, 1955).
[3] Browning, T. O., *Aust. J. Sci. Res.*, B, **5**, 344 (1952).
[4] Hogan, T. W., *Nature*, **183**, 269 (1959).

Nervous Control of Movements in the Foregut of *Schistocerca gregaria* Forsk.

OBSERVATIONS on the nervous control of movement in the foregut of insects were first made by Marchal[1], who showed that in *Dytiscus marginalis* L. swallowing movements were abolished by the removal of the frontal ganglion. Yeager[2], in *Periplaneta fuliginosa* Serv., and Chauvin[3], in *P. americana* L., showed that the movements of the crop were independent of the intact nervous system. Further, Chauvin found that in *P. americana* L. the movements of the gizzard were dependent upon the presence of an intact nervous system; but in *Locusta migratoria* L. movements occurred in the whole isolated gut and were unaffected by agents such as acetylcholine and eserine. In general, movements of the gut are thought to be influenced by the ganglia of the visceral nervous system; but, with the exception of the work of Marchal, this does not appear to have been actually demonstrated in any insect. Arising from work still in progress upon the movements of the gut of *Schistocerca gregaria* Forsk., evidence presented in this communication was obtained of the visceral nervous control of some of the movements of the gut.

Preliminary investigations showed that a constant and repeatable pattern of gut movements could be obtained by starving the locusts for 160–170 hr. at 28° C. and 70 per cent relative humidity prior to the observation. All records refer to male adult locusts which had been pretreated in this manner. The whole gut, together with the brain, sub-œsophageal ganglion and intact visceral nervous system, was dissected out and placed in saline in a water-bath at 33° C. Several salines made to different formulæ were tried, but only that of Griffiths[4] gave satisfactory results and was used throughout these experiments. To avoid the anæsthesia which results from immersing the whole insect in saline and to prevent the preparation drying out during the dissection, the hæmocœle was irrigated with saline immediately after the first incision had been made until the completion of these preliminary stages.

Records of gut movements were made by arranging the gut so that the posterior end was fixed and the anterior end fastened by a hook to a light balsa wood lever, tensioned by a weak spring and writing on a smoked drum. The gut was immersed in Griffiths–Ringer at 33° C. through which a slow stream of air was bubbling.

In each experiment, after normal contractions had been recorded for a minimum time of 20 min., the preparation was removed from the water-bath, placed under a binocular dissecting microscope and the appropriate operation performed. During this procedure care was taken to avoid changes in temperature. The operated specimen was then returned to the water-bath and its contraction recorded for a further period of at least 20 min. This process was repeated when further operations were performed upon the same specimen, in all cases care being taken to interfere with the preparation as little as possible.

The following operations were performed, results of which are shown in the accompanying figures.

(1) The brain and sub-œsophageal ganglion were removed by cutting through the circumœsophageal connectives and freeing these ganglia from the other tissues and the visceral nervous system. In all cases this operation was without effect upon the movements of the gut (Fig. 1*a*).

(2) The hypocerebral ganglion only was removed, by cutting through the inner and outer œsophageal nerves and the recurrent nerve. This changed the normal pattern of contraction and relaxation by appreciably slowing the relaxation which followed each major contraction (Fig. 1*b*). The smaller contractions and relaxations which come between the major ones do not appear to be affected by this operation.

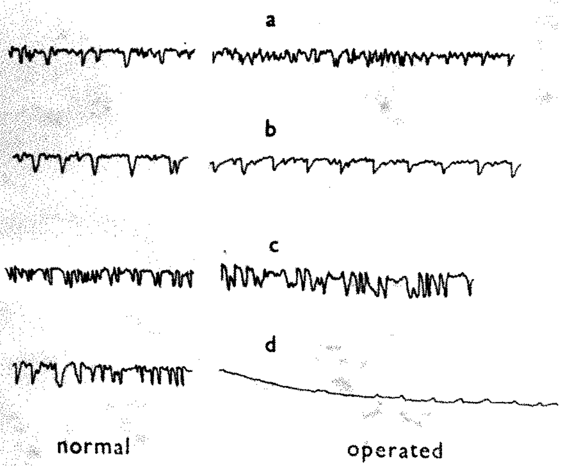


Fig. 1. Tracings of smoked drum records of gut movements of *Schistocerca gregaria*. The break in the tracing represents the moment at which the operation was performed. Time-scale shows minute intervals; the break represents a 5-min. interval. *a*, Removal of the brain and sub-œsophageal ganglion; *b*, removal of hypocerebral ganglion; *c*, severance of the outer œsophageal nerve; *d*, severance of the ventricular nerves

(3) The outer œsophageal nerves only were cut at a point approximately midway between the hypocerebral and ventricular ganglia. This operation had no effect upon the movements of the gut (Fig. 1*c*).

(4) The whole of the nervous system was intact and only the nerves arising from the ventricular ganglion and going to the gut were cut. This resulted in a complete cessation of the movements of the gut which lasted for some time, but eventually small infrequent movements appeared in the record (Fig. 1*d*).

As a result of these experiments the nervous control of gut movement may be interpreted as follows. The ventricular ganglion plays a major part in the control of gut movement and, in this respect, since movements continue normally when it is isolated from the rest of the visceral system, it is autonomous in its effects. The hypocerebral ganglion has an effect upon the movements of the gut: the negative results obtained after severing the outer œsophageal nerves show that this is not mediated through the ventricular ganglion. It presumably operates, therefore, either through the inner œsophageal nerves or through the recurrent nerve, and it influences the rate of relaxation of the gut musculature. The removal of the brain and subœsophageal ganglion was without effect upon the gut movements and therefore presumably plays no part in their control. This agrees with the observations of Chauvin[3] in *Locusta migratoria* L.

The certain identification of precisely which movements of the gut were producing which records on the smoked drum is still in progress. The movements observed here can almost certainly be attributed to the foregut, since visual observations show a corelation between these records and movements of the foregut. Further, the results of the above experiments on the visceral nervous system which innervates the foregut are in accordance with this view.

K. U. Clarke
H. Grenville

Department of Zoology,
University of Nottingham.

[1] Marchal, P., "Dictionnaire de Physiologie de Charles Richet", 273 (1911).
[2] Yeager, J. F., *Ann. Ent. Soc. Amer.*, **24**, 738 (1931).
[3] Chauvin, R., "Physiologie de l'Insecte", 95 (1949).
[4] Griffiths, J. T., *Iowa State Coll. J. Sci.*, **16**, 57 (1941).

Environmental Determination of Sex in a Parthenogenetic Parasite

In the Hymenoptera, the great majority of species reproduce by arrenotoky, fertilized eggs giving rise to females and unfertilized eggs to males, but some species reproduce by thelytokous parthenogenesis, the females arising from unfertilized eggs. In thelytokous species, it is not unusual for occasional males to occur.

Ooencyrtus submetallicus (Howard) (Encyrtidae), which is such a thelytokous species, is an egg-parasite of *Nezara viridula* (L.) (Pentatomidae). The males, which have no reproductive function, usually form less than 1 per cent of the adults. Individuals occur—normally very rarely—which are basically female but possess male areas of variable extent in the anterior portion of the body. It seems likely that these individuals are gynandromorphs, that is, that they comprise genetically male and female tissues. *O. submetallicus* reproduces within a temperature range of 60–90° F. At temperatures above 85° many progeny die before reaching the adult stage.

Sex in *O. submetallicus* is dependent on temperature, and 85° is critical for sex determination. At 84° or lower, lines consist almost entirely of females; at 85°, lines cease in 2–5 generations with the sole production of males and gynandromorphs; and at 86° or higher, lines cease in the second generation similarly.

Sex is determined by the temperature to which the parent is subjected prior to deposition of the eggs concerned: it is not affected by the temperatures to which the deposited eggs are subjected. The period of parental life in which exposure to temperature determines sex of progeny includes the developmental period prior to emergence and the oviposition period after emergence. The sex of eggs deposited during the first few days of adult life is determined by the temperature to which the parent was exposed before emergence, and, as many eggs are deposited during these days, pre-emergence temperatures have an important effect on sex ratio.

The sex of the progeny laid after the first few days of adult life may be largely determined by the temperature experienced by the parent after emergence. There is a time-lag between an alteration in the temperature to which a parent is exposed and the consequent change in the sex of the progeny deposited. The rapidity of the change differs according to whether the alteration is from female-producing to male-producing temperatures, or vice versa. It appears that male-producing temperatures in the developmental period of the parent produce more profound or persistent effects on the sex of progeny than do female-producing temperatures.

The gynandromorphs arise when a parent is exposed, evidently at a critical stage of egg development, first to female-producing and then to male-producing temperatures. Variability in the degree of maleness is probably a function of the time in egg development at which this change takes place. Ability to reproduce is retained only by gynandromorphs showing slight signs of maleness.

Though males are normally rare, and gynandromorphs extremely rare, both can be produced in large numbers, or to the exclusion of females, by temperature manipulation.

The experimental data, which will be published elsewhere, appear to constitute the first proof of temperature determination of sex in any uniparental hymenopteran.

F. WILSON
L. T. WOOLCOCK

Division of Entomology,
Commonwealth Scientific and
Industrial Research Organization,
Canberra.

Selection for High-Order Resistance to 'Dieldrin' in *Lucilia cuprina* Wied.

HOMOZYGOUSLY DDT-resistant strains of *Musca domestica*[1] and 'Dieldrin'-resistant strains of *Anopheles gambiae*[2] have been developed in a single generation by the application of discriminating dosages which are lethal to susceptible and hybrid phenotypes in heterogeneously resistant strains of these insects. Selection experiments with chlordane on *Musca domestica* also imply that pure resistant lines follow one generation of selection with heterogeneous resistant strains[3].

Strains of *Lucilia cuprina*, free from both susceptible and hybrid phenotypes, may also be obtained with one generation of selection from partially resistant strains, providing the parent family lines contain a proportion, no matter how small, of males and females, which tolerate the high male and female discriminating dosages, established in the course of genetical experiments on the inheritance of resistance in this blowfly[4].

The selection procedure, employed during the past year, is as follows: Flies from heterogeneous strains are allowed to emerge from batches of pupæ on the first day into colony cages, after which the larger unhatched pupæ are isolated. Female flies mainly hatch from the segregated pupæ on the second day and are supplied with sugar, water and sliced liver.

When the male flies of the first day hatching are approximately 12 hr. old, the high male discriminating dose (2 μgm. of 'Dieldrin' per fly) is applied and surviving males at the conclusion of the holding period of 24 hr. are mated to the virgin female flies, which have hatched overnight. The female high discriminating dose (4 μgm. of 'Dieldrin' per fly) is applied to the female flies, 3–5 days from emergence. Male and female progeny from the selection tolerate their respective high discriminating doses, without mortality.

A further observation has been made in regard to this selection procedure with *Lucilia cuprina*. The progeny of parents, found by means of applying the high discriminating doses, tolerate significantly larger amounts of 'Dieldrin' than the parents. Is this merely vigour tolerance? For example, a strain in which considerable reversion towards susceptibility had occurred by the tenth generation contained no male or female flies able to tolerate 10 μgm. of 'Dieldrin' per fly. Five female and three male flies from this reverted strain survived their respective high discriminating doses. The male and female progeny from the parents not only tolerated the high discriminating dosages of 2 and 4 μgm. of 'Dieldrin' per fly, respectively, with complete survival, but, in addition, female flies were able to withstand 10 μgm. of 'Dieldrin' per fly, again with nil mortality. Inconsistent survival occurs with male flies at this dosage-level following a single generation selection, but 50–75 per cent survival often results with male flies.

A full account of both observations in connexion with the development of high-order resistance to 'Dieldrin' in *Lucilia cuprina* will be published elsewhere in conjunction with reversion data on selected strains. In regard to reversion of resistant strains, initial experiments have shown that during the process of reversion towards susceptibility the lower limit of tolerance to 'Dieldrin' of successive generations of a strain, developed by means of one-generation selection, progressively approaches the high discriminating dose-levels. Once hybrid flies appear, usually by the sixth generation, susceptible flies are diagnosable in subsequent generations.

G. J. SHANAHAN

School of Wool Technology,
University of New South Wales,
Sydney.

[1] Milani, R., *Riv. Parassit.*, **18**, 43 (1957).
[2] Davidson, G., *Bull. World Health Org.*, **18**, 579 (1958).
[3] La Face, L., *Riv. Parassit.*, **13**, 57 (1952).
[4] Shanahan, G. J., *Nature* (in the press).

BACTERIOLOGY

Enhancement of Staphylococcal Virulence for Mice by Intraperitoneal Cortisone Acetate, Cholesterol and Lecithin

THE intraperitoneal administration of bile salts and of certain surfactants, followed by an ordinarily non-lethal inoculum of micro-organisms belonging to a number of different species, results in marked enhancement of the virulence of the latter for mice as manifested by a high incidence of fatal bacteræmia in these animals[1]. A similar capability of enhancement of virulence on the part of intraperitoneally administered cortisone acetate, cholesterol or lecithin with *Staphylococcus aureus* is reported in this communication.

Cortisone acetate suspension (Merck), 50 mgm./ml., as well as its vehicle, a saline solution containing suspending agents and 0·9 per cent benzyl alcohol, were obtained from commercial sources. Cholesterol (Fisher), 2·5 per cent, was prepared by suspending the amount indicated in distilled water, autoclaving at 15 lb. for 15 min., homogenizing in sterilized conditions in a Waring blendor to break up particles, after which the suspension, because of its settling tendency, was vigorously shaken immediately prior to each injection. Lecithin (Pfanstiehl), 2·5 per cent, was wet ground with a small amount of distilled water, brought to final volume with the same diluent and autoclaved. 5 per cent gastric mucin (Type 1701, Wilson) was prepared according to Miller[2]. *Staphylococcus aureus* strains were coagulase positive, hæmolytic and fermented mannitol. The above adjuvants were injected intraperitoneally in the amount indicated followed by 0·25 ml. of an 18-hr. culture of the staphylococci in trypticase soy broth at 37° C. into groups of 10 albino male Swiss mice weighing 15–20 gm. Deaths occurring within 48 hr. were noted. Post-mortem heart-blood cultures were streaked promptly upon expiration if death occurred during the day, and early morning if the animals died during the night, upon plates containing 1 part homogenized milk and 2 parts trypticase soy agar, which greatly favours pigment production by staphylococci, and positive results were tabulated.

The number of fatal bacteræmias produced within 48 hr. by the three test staphylococcal strains with 25 mgm. of each adjuvant under test and with 0·5 ml. of gastric mucin 5 per cent, for comparison, is noted in Table 1. Adjuvants by themselves all failed to evoke any mortality in preliminary toxicity tests. More than 90 per cent of the mice that died succumbed within 24 hr. As may be observed from Table 1, a high incidence of fatalities with septicæmia was achieved with the aid of each adjuvant under consideration whereas a similar intraperitoneal injection of staphylococci without their use proved innocuous. The effect of cortisone acetate suspension cannot be attributed to its suspending agent since the latter, alone, failed to elicit any mortality.

Table 1. MOUSE MORTALITY/10 AND POSITIVE POST-MORTEM HEART-BLOOD CULTURES ELICITED BY VARIOUS INTRAPERITONEAL ADJUVANTS WITH *Staphylococcus aureus* TEST STRAINS

Adjuvant	Dose (ml.)	*S. aureus* strain *A*	*S. aureus* strain *B*	*S. aureus* strain *C*
Physiological saline	0·5	0	1 (1)*	0
Gastric mucin, 5 per cent	0·5	10 (9)	10 (8)	8 (5)
Cortisone acetate suspending solution	0·5	0	0	0
Cortisone acetate, 50 mgm./ml.	0·5	10 (5)	10 (8)	9 (8)
Cholesterol, 2·5 per cent	1·0	9 (7)	9 (5)	9 (7)
Lecithin, 2·5 per cent	1·0	9 (6)	8 (7)	8 (5)

* No. of post-mortem heart-blood cultures positive for *Staphylococcus aureus*.

Table 2. DAILY MOUSE MORTALITY ELICITED WITH INTRAMUSCULAR CORTISONE ACETATE FOLLOWED BY *Staphylococcus aureus* STRAIN *A* OR PHYSIOLOGICAL SALINE, INTRAPERITONEALLY

Intramuscular cortisone acetate (mgm.)	Intraperitoneal injection (0·25 ml.)	Time of intraperitoneal injection	Mortality* Day 1	2	3	4	5	6	7	8	9
25	Physiological saline	Stat	0	0	0	1	3	0	0	1	0
25	*S. aureus* strain *A*	Stat	0	0	0	0	1	3	2	3	0
25	*S. aureus* strain *A*	24-hr post-intramuscular cortisone	0	0	0	0	1	3	0	3	0
5 – 3 × daily for 2 days	Physiological saline	Following final intramuscular cortisone	0	0	1	0	3	1	0	2	0
5 – 3 × daily for 2 days	*S. aureus* strain *A*	Following final intramuscular cortisone	0	0	2	0	2	3	0	1	0

* 10 mice in each group.

Cortisone is known to exert a profound systemic action wherein the resistance of laboratory animals is depressed to a wide variety of bacterial, viral, protozoal and fungal agents. It was of interest to ascertain whether or not the enhancement observed above might not be attributable to this generalized effect. The corticosteroid was therefore administered extraperitoneally via the intramuscular route in equivalent doses at varying periods prior to the intraperitoneal injection of bacteria or of physiological saline, both in one single dose and in a 2-day course of 3 injections daily. When the preparatory cortisone injection was administered by the extraperitoneal route no deaths occurred within 48 hr. after the intraperitoneal injection of the micro-organisms (Table 2). Those deaths that did occur came later and were the result of the toxic effect of large doses of cortisone, possibly by activation of latent intrinsic infections, since the number of deaths and the times of their occurrence were essentially the same regardless of whether bacteria had been injected. It is therefore concluded that enhancement of staphylococcal virulence for mice by intraperitoneally administered cortisone acetate is by virtue of its local rather than general effect.

No common property or factor is evident between gastric mucin, the most thoroughly investigated of the infection promotion substances reviewed by Olitzki[3,4] and those at present and previously[1] reported upon by us that might account for their virulence-enhancing capability with the possible exception of their common ability to lower surface tension significantly. The exact mechanism whereby mucin exerts its effect has not been completely established. Although it may exert a growth stimulatory effect under certain conditions[5,6], weight of evidence would seem to indicate that its action is directed primarily against the host's defence mechanism by interference with phagocytosis, intraphagocytic digestion and the bactericidal action of peritoneal fluid upon the bacteria because of their coating. Surfactants, by virtue of their surface depressive action, may similarly protect intraperitoneally injected micro-organisms from the defence reaction of the host. Cortisone acetate, cholesterol and lecithin as well as gastric mucin in the concentrations employed are all capable of lowering surface tension, their surface tensions measuring 40·0, 37·3, 42·2 and 43·3 dynes/cm. respectively with the Fisher surface tensiometer at 25° as compared to 75·7 for physiological saline. Capability of lowering surface tension *per se* may not, however, be the only determinant since 'Tween 80', even though it lowers surface tension considerably, is incapable of enhancing bacterial virulence for mice[1].

Other factors of possible contributory significance are chemical composition, viscosity and physical state. The effective adjuvants are of varied chemical composition. Gastric mucin is a mucopolysaccharide or glucoprotein. Surfactants are chemically diverse; the anionic detergents include sulphated alcohols, paraffin, alkylaryl and petroleum sulphonates, whereas non-ionic detergents consist of polyesters and ethers formed as condensation products from fatty acids, alcohols and phenols. Lecithin, on the other hand, is a mixture of the diglycerides of stearic, palmitic and oleic acids linked to the choline ester of phosphoric acid. Bile salts, cortisone acetate and cholesterol are all steroids characterized by the *cyclo*pentenoperhydrophenanthrene nucleus. As for viscosity, only gastric mucin of the above is significantly viscous, its relative viscosity being 2·5, as compared to the others, the relative viscosities of which measure approximately 1·0, as computed by determining efflux time from a calibrated tube of uniform bore at constant temperature. Considering physical state, while the subject adjuvants of this report and gastric mucin are suspensions containing particulate matter, bile salts mixture and the surfactants previously found effective form clear solutions. Further studies are in progress in an attempt to elucidate the mechanism whereby these chemically and physically diverse substances convert ordinarily non-lethal intraperitoneal infections in mice into rapidly fatal ones.

This investigation was supported in part by Research Grant No. *E*-2687 of the U.S. Public Health Service, National Institutes of Health.

DANIEL AMSTERDAM
S. STANLEY SCHNEIERSON

Department of Microbiology,
Mount Sinai Hospital, New York.

[1] Amsterdam, D., and Schneierson, S. S., *Proc. Soc. Exp. Biol. and Med.*, **101**, 396 (1959).
[2] Miller, C. P., *Proc. Soc. Exp. Biol. and Med.*, **32**, 1136 (1935).
[3] Olitzki, L., *Bact. Rev.*, **12**, 199 (1948).
[4] Olitzki, L., *Bull. Res. Council Israel*, **6**, E, 193 (1957).
[5] McLeod, Ch., *Amer. J. Hyg.*, B, **34**, 41 (1941).
[6] Maccabe, A. F., and King, H. K., *J. Path. Bact.*, **43**, 756 (1951).

Isolation of a Phagocytosis-inhibiting Substance from Culture Filtrates of an Encapsulated *Staphylococcus aureus*

COAGULASE-negative strains of *Staphylococcus albus* added to suspensions of rabbit polymorphonuclear leucocytes in normal rabbit serum are rapidly phagocytosed and destroyed; in contrast, coagulase-positive strains of *Staphylococcus aureus* resist ingestion and survive extra-cellularly. The addition of anti-serum prepared against heat-killed *S. aureus* results in efficient phagocytosis and intracellular killing of the homologous organism[1]. The present communication describes the isolation and properties of a substance obtained from culture filtrates of a encapsulated *S. aureus* which interferes with it phagocytosis.

The organism utilized was *S. aureus* 'Smith' (phag type 44*A*/42*E*, hæmolytic, coagulase-positive, and mouse virulent). Bacterial cells were removed b centrifugation and filtration from 15 l. of an 18-hr culture grown in the medium and apparatus describe by Goebel *et al.*[2]. The supernatant fluid was concentrated *in vacuo* and lyophilized after dialysis against distilled water. Absolute ethanol was added to 1 per cent solution of the material in aqueous sodium acetate. A fraction was isolated which was solubl in six but insoluble in eight volumes of ethanol. This fraction was deproteinized by repeatedly extractin a 0·5 per cent solution in 0·02 *M* acetate buffer *p*H 5·0, with chloroform–octanol. The lower phas was then dialysed against distilled water and lyophilized.

1 gm. of white amorphous material was obtained which had the following physical and chemical properties. A 0·5 per cent solution in isotonic saline sedimented as a single peak when examined in the analytical ultracentrifuge; $S_{20} = 1{\cdot}3$ Svedberg units. An essentially homogeneous boundary appeared upon free electrophoresis of a 1·0 pe cent solution in veronal buffer, *p*H 8·6, ionic strength 0·1; the mobility was $-11{\cdot}4 \times 10^{-}$ cm.²/volt-sec. The nitrogen and phosphorus contents were 7·4 and 0·18 per cent, respectively Marked humin production was noted upon heating in dilute mineral acid. Analysis of hydrolysed sample revealed the presence of the following components amino-acids—28·9 per cent (alanine—9·1 per cent glutamic acid—6·7 per cent, lysine—6·6 per cent aspartic acid—4·8 per cent, glycine—1·1 per cent threonine—0·25 per cent and serine—0·25 per cent) lipid—0·0 per cent; reducing sugar—15 per cent and hexosamine—12·4 per cent. The remainder of the carbohydrate moiety apparently consisted of one or more non-reducing sugars as yet unidentified Neither muramic acid nor sialic acid was demonstrated.

The isolated substance reacted promptly in capillary precipitin tests, with rabbit anti-sera prepared against homologous, heat-killed organisms, but were not precipitated with normal rabbit serum. The end point occurred at a final concentration of less than 0·5 μgm./ml. At a concentration of 1 mgm./ml. a single band was formed with immune rabbit serum in double diffusion precipitin tests in agar gel. Pooled human globulin (16·5 per cent γ-globulin) also formed a single band in this reaction. Several attempts to stimulate formation of antibodies by injecting the compound into experimental animals have thus far been unsuccessful.

When immune rabbit serum against *S. aureus* 'Smith' was absorbed with the material at the equivalence point, the serum no longer agglutinated the bacterial cells. The opsonizing capacity of the absorbed serum was then compared with that of unabsorbed immune serum. Rabbit polymorphonuclear leucocytes free from erythrocytes and other leucocytes were obtained from glycogen-induced peritoneal exudates. Previously described suspending media and conditions for performing the phagocytic tests were employed[1]. Each suspension contained 10 per cent fresh normal rabbit serum to provide adequate amounts of complement.

Results from a representative experiment are presented in Fig. 1. Addition of absorbed anti-serum

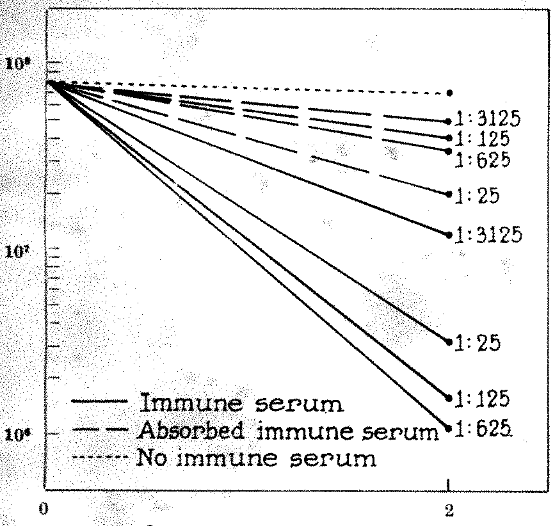


Fig. 1. The fate of *S. aureus* Smith in suspensions of rabbit polymorphonuclear leucocytes

d little effect upon bacterial survival, whereas a arked reduction in the number of viable units curred upon addition of even small quantities of absorbed immune serum. Enumeration of viable cteria in the supernatant fluid following deposition the phagocytes by low-speed centrifugation vealed that all the viable staphylococci were e in the extracellular fluid. This observation tablished that the effects noted were dependent on differences in phagocytosis and not a reflexion intra-leucocytic survival. It was furthermore own that agglutination of bacteria did not play a gnificant part in the phagocytosis assay and that e substance itself was not inherently leucotoxic.

Thus, absorption of immune serum with the purified mpound isolated from the staphylococcal culture trate resulted in a loss of both agglutinating and sonizing properties against the homologous organm. The biological properties and method of isolation ggest that the material is located on the bacterial rface and is perhaps of capsular nature. Experiments e in progress to determine the complete chemical mposition of this substance, its occurrence in other rains of *S. aureus*, and its role in the pathogenesis staphylococcal infection.

I wish to express my gratitude to Drs. Walther F. oebel, Margeris A. Jesaitis and Zanvil A. Cohn for eir aid and advice.

STEPHEN I. MORSE

Rockefeller Institute,
ew York 21. Jan. 12.

---

ohn, Z. A., and Morse, S. I., *J. Exp. Med.*, **110**, 419 (1959).

oebel, W. F., Barry, G. T., and Shedlovsky, T., *J. Exp. Med.*, **103**, 135 (1956).

MISCELLANY

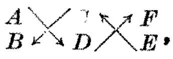
Arrow Symbol in Biology

THE great value of this symbol in representing hemical reactions has tempted biologists to extend s use, in diagrams and 'schemes', to represent other ctivities. This in principle is far from objectionable : iagrams and schemes are very helpful and this ymbol is a clear, meaningful piece of shorthand, but unfortunately so many different activities have come to be represented by it that it has more than lost in specificity what it has gained in comprehensiveness.

The representation $A \rightarrow B$ has been used with the following meanings, among others : (1) molecule A is converted to molecule B ; (2) entity A produces, gives or donates entity B ; (3) entity A is converted (in various senses) into entity B ; (4) A induces the formation of B ; (5) A stimulates or acts on B ; (6) entity A causes an activity B ; (7) A moves to place B, and even (8) I wish you to transfer your attention from item A to item B. When many of these occur in a single scheme or diagram the result may be as difficult to read as a long-hand text and far less precise and explicit. It can be at least confusing and at the worst grossly misleading : "holding issues even that are nothing mated", all the more insidious because readers are less critical of diagrams and may only half-recognize their own misapprehension. Indiscriminate lumping of issues that are not mated is contrary to good scientific practice and inimical to its best interests.

Ideally the symbol should undergo 'adaptive radiation' so as to convey the specificity of each significant type of activity for which it becomes indispensable. In fact, at present the irreducible number of such types probably is small enough to permit a reasonable and useful differentiation of this kind. To be reasonable and useful the variants of the symbol should readily convey their respective meanings and they should be easy both to write and to print. Also as far as possible they should evolve naturally and spontaneously, and command the general approval of usage. A minimum of suggestions therefore should be made at this juncture.

(1) The type of representation $A \rightarrow B$ naturally will continue to be used for chemical reactions, with the usual further conventions for reversible reactions ; it is accepted to mean 'A produces B', and there seems no objection to extending it to entities other than molecules, provided that the action is producing, donating, giving, etc.

(2) Where complete systems of chemical reactions are to be represented, and particularly the cyclic systems so common in biology, the formulation of Baldwin[1] is admirable and has already the sanction of general usage. The simple scheme 

, for example, indicates that molecules A and C interact to give B and D ; D then interacts with E to give F and to restore C, which continues to react cyclically. This also has potential application to other entities.

(3) The symbol $A \Rightarrow B$, incorporating the 'equals' sign, conveniently could express a direct and total conversion or transformation of A into B. Chemists well might prefer it to the simple arrow to distinguish isomeric changes from orthodox reactions, but it is for the biologist that the distinction is particularly important. The symbol would represent ontogenetic, phylogenetic, seasonal and other transformations of any entity. The transformations are often complex by chemical standards, with much renewal of material by metabolic turnover, but in biological conceptions a persisting identity of the entity is often the main emphasis.

(4) The symbolism $A \dashrightarrow B$ usefully could represent A moves to B, the dashes pictorially representing the actual steps. It could cover affine conceptions: A is donated to B, etc., wherever movement is implied.

(5) The type of activity: A acts upon B, where A and B are entities other than molecules and not necessarily entities of the same kind, as when a hormone acts on an organ, conveniently could be represented by $A \nearrow\!\searrow\!\bullet B$, which pictorially puts A into the correct relationship. The existing use of this and other symbols in specialist branches of chemistry is not likely to cause serious confusion.

There remain a number of possible simple variants of the symbol for other distinct activities. All could be double-headed when required to represent reciprocal interactions and reversible processes. The present practice of writing the names of promoters of an activity over the shaft of an arrow should be extended and similarly the names of inhibitors, associated with short intercepts across the shaft. A convention that promotors are placed above a horizontal, and to the right of a vertical, arrow, and inhibitors on the opposite side, also seems reasonable. With advantage, authors might accept the conventions of Occam's axe in introducing new symbols; an apparently new relationship will often be covered by existing symbols or a combination of them, for example, $A \rightarrow B \dashrightarrow C$: '$A$ produces B and donates it to C'. Another convention which seems reasonable is that A, B, etc., must be entities and not activities, which are always represented by arrows. Thus the representation (6) above, namely, 'A causes an activity B', which might be the conversion of C to D, should be written $C \overset{A}{\Rightarrow} D$.

A. E. NEEDHAM

Department of Zoology and Comparative Anatomy,
University Museum,
Oxford.

---

[1] Baldwin, E., "Dynamic Aspects of Biochemistry", 2nd ed. (Cambridge Univ. Press, 1953).

A Simple Method for obtaining Perforated Supporting Membranes for Electron Microscopy

SUPPORTING membranes with holes are usually used for testing the axial astigmatism of the objective lens in electron microscopy. In the case of specimens which are difficult to focus they facilitate the focusing. Supporting membranes with a large percentage of open area are of great advantage for mounting thin sections, because the gain in contrast is considerable[1]. It applies also to specimens for testing the resolving power of the electron microscope or high-resolution work, when a very thin film of collodion can be mounted on these perforated membranes[2]. The holes will then enable not only the focusing but also a continuous control of the axial astigmatism. Several methods for obtaining holes in supporting membranes have been described[3-5]. Mostly 'Formvar' film is used; but to obtain reproducible results the methods are relatively complicated.

We have developed a simple method for obtaining holes in collodion films. This method does not differ from the others in principle, as it is based on the introduction of minute water droplets into the film; but it does not require any special equipment ar makes it possible to prepare the membranes or ne very quickly and in a reproducible way.

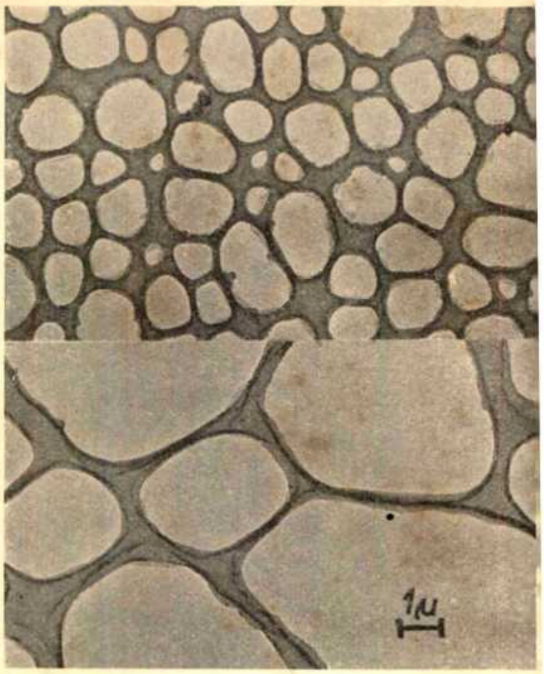


Fig. 1

A solution of 0·2–0·3 per cent collodion solutio with *iso*amyl-acetate as solvent filling up about half of a small glass vessel is used. A thorough mechanically cleaned microscope slide is dipped int the solution and held for about 30 sec. in a vertic position above the solution surface. Then the slide removed from the vessel and breathed upon aft some few seconds. Breathing upon the film on t slide may be repeated several times at intervals of few seconds as long as the solution is evaporatin The forming of the film area with holes can be easil followed by observing the film, because this area h a 'foggy' appearance. According to the length an intensity of the breathing a narrower or broad strip of film with holes is formed. The film from th slide is easily floated off on to a water surface an the areas with holes are transferred to specimen grid Before using, the film with holes is stabilized b evaporation of carbon or metal.

The size of the holes depends on the width of th 'foggy' strip. For most purposes a width of abou 1·5 mm. is suitable. In a narrower strip small hole arise; in broader ones a net is formed. If the are with holes is too broad the net is likely to shrin when being floated off. Electron micrographs of hole obtained in this way are shown in Fig. 1.

V. DRAHOŠ
A. DELONG

Laboratory of Electron Optics,
Czechoslovak Academy of Sciences,
Brno.
Jan. 7.

---

[1] Sjöstrand, F. S., *Exp. Cell Res.*, **10**, 657 (1956).

[2] Leisegang, S., *Optik*, **11**, 397 (1954).

[3] Bradley, D. E., Proc. Third Internat. Conf. Electron Microsc 478 (London, 1954).

[4] Sjöstrand, F. S., Proc. Stockholm Conf. on Electron Microsco 120 (1956).

[5] Sakata, S., *J. Electronmicroscopy*, **6**, 75 (1958).

CHEMICAL LABORATORY
Date 20.5.60
SCIENCE COLLEGE

Pure Chemistry Library,
SCIENCE COLLEGE,
92, Upper Circular Road,
CALCUTTA.

A STAFF COLLEGE FOR TECHNICAL TEACHERS

It is fitting that, in what is likely to be his last public pronouncement as chairman of Britain's largest limited liability company, Sir Alexander Fleck should be identified with an appeal to set up a staff college for technical teachers. It was in the evening classes of a technical college that, many years ago, Fleck began a career as a student chemist which was later to take him to fellowship of the Royal Society and the chief executive's position in Imperial Chemical Industries, Ltd.

The idea of a staff college for teachers in technical institutions in Britain was first mooted by the Education Committee of the Federation of British Industries in 1956. It had grown out of the experience of members of the Committee who belonged to large industrial undertakings and whose companies had found it advantageous to establish a centre where they could send senior staff for a short intensive course designed to enlarge their personal qualities and ability. The idea was taken up afterwards by the Special Committee on the Supply and Training of Teachers for Technical Colleges appointed by the Minister of Education, of which Sir Willis Jackson was chairman, and it was discussed in the Committee's report*. This recommendation was widely supported by many authorities, including the Minister of Education's own Advisory Councils on Education for Industry and Commerce, and for the Training and Supply of Teachers. The latter Council, at the Minister's request, made a more detailed study of the proposal through a new sub-committee, of which Sir Willis Jackson was again chairman.

The place of the staff college as a means of developing quality in advanced technical education has been well put in a memorandum prepared by this sub-committee (not published). At the top level of the technical teaching profession there is a need for men with the breadth of outlook, attitude of mind and authority required to stimulate up-to-date teaching and research work of high standard, to talk with conviction to executives of industry and to exert an influence on thought and action outside as well as inside the colleges. Existing facilities for teacher training, or for keeping teachers in touch with new developments by means of short courses, do not provide the right kind of experience for senior staff; and the normal contacts which a teacher makes with local industry through advisory committees, and the day-to-day operation of technical courses, do not bring him into close enough contact with a sufficiently wide range of industry.

To fill the gap, a national centre is needed where carefully selected senior staff from the colleges can exchange information, ideas and experience, by direct contact and personal discussion, with each other and with personnel from industry, the universities and associated fields. Experience with staff colleges organized by industry has already shown that this function can be discharged most effectively within small groups working in close personal association.

It is not only senior teachers in technical colleges who would benefit from the establishment of the proposed staff college. Industry would benefit indirectly through the improved quality of technical education which should result, but could also benefit directly through participation in courses by those responsible for training schemes in industry or for co-operation with technical colleges on research projects.

The staff college envisaged by the Willis Jackson sub-committee would be a small establishment providing a series of short courses throughout the year under the general supervision of a permanent director of studies. The courses would be limited to about twenty teachers, together with about half that number of individuals drawn from industry and commerce. As there are about 17,000 full-time teachers in technical colleges in Britain, those selected to attend would probably belong to the 3,300 or so among that number who are of the grade of senior lecturer or higher. Probably not more than about 200 teachers a year would pass through the college.

What could such a college achieve ? Its main object would be to ensure an adequate supply of key personnel for the technical colleges—the future principals, heads of departments and other key staff. Ultimately, success of the Government's policy for expanding facilities in technical colleges, for which the sum so far authorized is about £150 millions, will depend upon these men. Already well-versed in some particular branch of technology, good teachers, and experienced administrators, they would be given the opportunity of discovering in themselves further qualities of leadership and authority.

Such a college would not strictly be regarded as a teaching institution. The composition of a group would vary according to the subject of the course. There would be no 'instruction' in the ordinary sense. The participants would jointly study some main problem or topic in the field of technology, with particular reference to its significance for teaching and administration in the technical colleges. The members of a group would be their own teachers in a co-operative study to which each individual would make a reponsible contribution. For this reason, the number of the directing staff would be kept as low as possible, but they would have to be of very high quality.

---

* Ministry of Education. The Supply and Training of Teachers for Technical Colleges: Report of a Special Committee appointed by the Minister of Education in September 1956. Pp. xiv+68. (London: H.M. Stationery Office, 1957.) 4s. net.

A remarkable and highly commendable feature of the way in which the proposal for a staff college has developed is that it can truly be called a co-operative venture between industry and education. The idea originally came from industrial representatives; it was taken up and developed by a committee set up by the Ministry of Education. An approach by industry was therefore made to the Ministry about the way such a college could be financed. The Ministry of Education consulted local education authorities, and the scheme put forward by Sir Alexander Fleck can now command the support of industry, central and local government.

To establish such a college an initial sum of £100,000 will be required. The annual running cost would be about £30,000. Exchanges between Sir Alexander Fleck and the Minister of Education have revealed that, if industry would find the original £100,000, the running costs would largely be met from public funds. To keep fees for courses down to a reasonable figure, the Ministry itself is prepared to pay an annual grant of up to £10,000 to the college. This subvention, amounting to about one-third of the running cost, should enable the college to offer its facilities for a fee of about £75 for a three-week course. For the most part these fees will be paid by local education authorities as the employers of the teachers attending the course. The remainder would come from fees paid by the employers of other participants, including industrial and commercial firms.

In private approaches to some thirty firms, Sir Alexander has already been promised £60,000 of the capital cost. He, and the industrial sponsors, have shown their wisdom by making a public appeal to any firms which care to participate. If all the money had been collected from a comparatively few large firms, the college would have got off to a bad start. From the beginning it should be regarded as one in which all industrial organizations in Britain have had the opportunity to participate; it is to be hoped that many small firms will contribute.

It is not only in finance that the proposed college can be regarded as a joint enterprise between education and industry. Sir David Eccles has discussed the proposals in general with the associations of local authorities and agreed that, on the governing body, there should be equal representation of local authorities, technical teachers and industry and commerce, together with a university representative. What is even more noteworthy is that the Minister has already asked Sir Alexander to accept the chairmanship of this non-existent governing body and that Sir Alexander has accepted.

Apart from the intrinsic merits of the proposal to set up this staff college, a number of features commend themselves. First, it is an excellent example of the way in which industry and education should come together to promote the development of technological education. Secondly, it shows that a Government department can act quickly when the right approach is made to it by industry. Thirdly, the small group of men, who first put forward the idea some four to five years ago and met a stone wall, hard and apparently unclimbable, may now rejoice that the first courses in the new college should take place before the end of 1961. There is little doubt that such a college will be the centre of much interest, not least among those responsible for the administration of universities.

ROCKET PROPULSION

Rocket Propulsion

By Marcel Barrère, Prof. André Jaumotte, Prof. Baudouin Fraeijs de Veubeke and Jean Vandenkerckhove. Pp. xxxi+829. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1960.) 135*s*.

A GOOD book on rocket propulsion has long been awaited, and I received this one with hope. I regret to say that my hopes have not been realized, and this is all the more disappointing because of the standing of the four authors. It would have been enlightening to know the type of reader whom the authors had in mind when compiling this book. It is not satisfactory as a text-book for students, who require instruction in basic principles and only sufficient technology to show how principles are applied, nor is it satisfactory for people actually engaged in rocket design and development. In this latter respect it is perhaps doubtful whether a good book on rocket technology can yet be written because the predominantly military application of rockets brings in its train security difficulties. The net result is that the 'technology' which can be revealed is either obsolete, or even misleading, and in this context it must be realized that something done two years ago may be obsolete.

Reverting to the possibility of regarding this book as a basic work for students, it fails in many respects, and the text contains much irrelevant matter which I found distracting, nay confusing.

Chapter 1, "Rocket Propulsion Elements", scarcely lives up to its name. "Specific Impulse", that all-important criterion of rocket performance, receives brief initial mention on p. 33, surrounded by trivia on "Useful Power" and "Propulsive Efficiency". Surely the latter part of this chapter headed "Nuclear Energy" is nothing but misplaced padding, but a more serious criticism relates to the section of this chapter headed "Conclusion". A completely unjustifiable assumption relating a portion of the rocket weight to specific impulse is made on p. 52, leading, as one might expect, to a completely erroneous conclusion regarding optimum specific impulse: a sad beginning to more disappointments.

Chapter 2 has the title "Nozzle Theory and Characteristic Parameters". Perhaps we can forgive the misuse of the word 'parameter', which occurs frequently throughout the book, but this chapter occupies 71 pages, yet the authors state in their second paragraph, "Whilst refraining from going into detailed theory of nozzles, we shall summarize the principal relationships needed for our purpose". Certainly they refrain from devoting just one page to derive the expression:

$$\frac{dA}{A} + \frac{dv}{v}\left[1 - \frac{v^2}{a^2}\right] = 0$$

where A is the cross-sectional area of the nozzle; v is the corresponding velocity of the gases in the nozzle; a is the local velocity of sound, from which the convergent–divergent nozzle 'emerges'. Its introduction might have saved the authors twenty pages of print and given the reader a true appreciation of the Laval nozzle.

So the text goes on for a total of 811 pages with much that is of little positive value. Very few of the basic conclusions are derived, and on many occasions important statements are made for which one would rightly expect some proof. But, no. Surely one is justified in expecting a short proof that if n is the index of the burning pressure, governing the burning-rate of solid propellents, equilibrium can be established only if n is less than unity. Incidentally, on p. 240 one reads that if n is greater than unity an explosion will occur. In fact, if n is equal to unity an explosion will occur—a slight but most important difference. Erosive burning is referred to on pp. 201 and 202 and again on pp. 259 and 260, and the two references show little connexion with each other. Why could not the authors deal with it once, and once only?

Many examples of wrong statements may be quoted and one or two will be sufficient to indicate the worries created in my mind. On p. 317 we find "The nozzle weight is found to be approximately proportional to total impulse". This is just not true, and there is no reason why it should be. Yet again, in section 7.2.5, "Geometry of the Combustion Chamber", one reads that there are 'trends' in combustion chamber shape and infers that they are subjected to the same whims of fashion as ladies' waists and hem-lines. If this were true, why did the authors devote 100 pages and more in Chapter 7 to the problems of liquid-propellent rocket combustion chambers and another 60 pages in chapter 10 to combustion instability? Yet, throughout, the authors make implicit assumptions on chamber shape. On p. 468 we read that "the Mach number in the chamber is low, being of the order of 0·1, we can neglect its influence". Thus, whether the authors realized it or not, they are implying that the ratio:

$$\frac{\text{combustion chamber cross-sectional area}}{\text{nozzle throat area}}$$

is greater than 5 : 1. To say the least, this is at variance with earlier remarks on 'trends'.

Occasionally we get glimpses of the true position in rocket research and development as in paragraph 10.4 on p. 707. "A change in the scale can completely alter the stability conditions of the power plant, and it is difficult to predict the operating stability of a large rocket on the basis of experimental results obtained on small-scale models." I certainly accept this as true and regard it as an incentive to do some basic work to rectify the position. The book takes 50 pages to say the same thing.

To anyone diligent enough to pursue some of the numerous references given at the end of each chapter there is a more enlightened story awaiting them. It is noteworthy that most of these references refer to American documents, and the authors can scarcely be blamed for the paucity of references to British work.

After 'scanning' this book, I am a sadder, but no wiser, man.

J. E. P. Dunning

NEUTRON PHYSICS

Introduction to Neutron Physics

By L. F. Curtiss. (Van Nostrand Nuclear Science Series.) Pp. xi+380. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1959.) 73*s*.

There is now an extensive literature on neutron interactions and on the techniques used in their study. A student starting work in this field is frequently confused by the proliferation of original papers, and needs a text-book which will give him a grounding in this subject of neutron physics. It is the aim of Dr. Curtiss's book to do just this; and on the whole it succeeds.

The emphasis of the book is on experimentally demonstrated facts and widely used techniques. The level of presentation is fairly elementary, but the book is easy to read and the style is clear and flowing. A student should have no difficulty in mastering the text and doing the problems which are found at the ends of the chapters. There is a lot of simple details which will help to give the student a 'feel' for this subject, but there is little critical discussion which would lead the student into the more complex parts of neutron physics.

In writing a book of this type it is often difficult to keep it up to date. This review will appear some eighteen months after the author wrote his preface, but from an examination of the text and the references it seems that the literature is covered up to 1956 only, so that the book is effectively four years old already. Of course all authors and publishers are familiar with this problem, and to counteract it some type of general bibliography covering the last few years might well have been included during the final preparation. In spite of this defect, this book covers all the groundwork of its subject.

Although most branches of neutron physics receive attention, there are occasional lapses. For example, the linear electron accelerator is not mentioned in the discussion of pulsed neutron sources; and inelastic scattering of thermal neutrons is entirely omitted. In discussing thermal neutron interactions Dr. Curtiss uses the term 'diffuse' cross-section in place of the now almost universally used term 'incoherent' cross-section, which may confuse some of his readers.

Nevertheless this book will command a wide audience and will be found both necessary and useful in many laboratories. The presentation is good, the diagrams are clear and there are very few misprints. The author and the publishers are to be congratulated on the result of their labours.

P. A. Egelstaff

INSECT PHOTOGRAPHY

Les Plus Beaux Insectes

Textes de A. Villiers. (Collection "Nature et Beauté".) Pp. 96 (154 illustrations). (Paris: Larousse, 1958.) n.p.

This quarto volume is one of the Larousse series "Nature et Beauté", and is primarily an atlas of more than one hundred and fifty photographs of insects. These are from a variety of sources, some showing insects in natural, or quasi-natural settings, others from pinned and set specimens, formally arranged into a plate. Twenty-four full-page plates are in colour, printed on an art paper with a lustre surface which is pleasant to the touch, and which displays the colours well, without any troublesome reflexions.

The reproduction of colours is good for the browns and yellows. The Orthoptera in Figs. 31*a*, 31*b* and the Hymenoptera in Figs. 63*a*, 63*b* are full of life, as well as structural detail. The reds are much less strident than in some French colour-plates of insects. Least successful colours are the pastel blues and greens, so that *Agrion splendens* belies its name in Fig. 7, and the long-horned grasshopper in Fig. 26 has a ghostly appearance. Definition and reproduction of detail are excellent in nearly all plates, black-and-white as well as colour.

The captions usually give the natural size of the insect, but it is to be regretted that quite a number of them wrongly identify the insects shown. Sometimes the whole caption is inappropriate, as if another photograph had been substituted for the original. Figs. 44*a*, *b*, *c* have clearly been re-arranged for artistic effect, leaving each of them with the wrong caption. This trouble seems to apply particularly to the Diptera, and it is unfortunate that the very first page of text is accompanied by a large head of a female *Tabanus* labelled "Gasterophilus equi".

The text is more extensive than in many pictorial works of this kind, and is quite detailed enough for the general reader. Occasionally it descends to such banalities as: "La ponte des Hémiptères n'est pas très originale : . . .".

Apart from the incorrect captions, this is altogether a pleasant work to possess. Since no price is quoted it cannot be said whether or not it is good value for money. H. OLDROYD

MEYRICK'S MICROLEPIDOPTERA

Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick

By J. F. Gates Clarke. Vol. 3: Tortricidae; Olethreutidae; Noctuidae. Pp. iv+600. (London: British Museum (Natural History), 1958.) 120*s*.

THIS, the third volume of a planned series of six or seven, is the second of those devoted to illustrating the type-specimens of species described by Meyrick. It deals with some 380 species of Tortricidæ, and 567 of Olethreutidæ, while the inclusion of a single noctuid results from an original misidentification at family level. A prefatory note states that several old names of long-standing use have been dropped. As a result of this and other redispositions new combinations abound, notably in *Acleris*, *Archips* and *Olethreutes*. It is explicitly stated, however, that the new combinations do not necessarily represent a definitive evaluation; but there is no indication which combinations have such provisional status.

In each family the arrangement is alphabetical, both for genera and species, with cross-references to specific synonymy but not to intergeneric transfers. The latter omission is apt to occasion the reader a long search if he should fail to locate a species in its customary genus. The text referring to each species gives the original bibliographical reference, and the wing-span and locality of capture of the type, the number and sexes of the original series, an indication or designation of the type specimen, and an explanation of the accompanying illustrations. Comment is sparse and usually restricted to correction of errors or clarification of obscurities. The 298 plates illustrate photographically the fore- and hind-wing of each species, the genitalia of most and the labial palpi of some. Where the type is the basis of a genus, a line illustration of the wing venation is also given.

The task of presenting taxonomically significant data by means of photographs has been successfully accomplished (though some of the genitalic photographs are barely free from ambiguity) and the uniform arrangement of the illustrations makes the plates satisfying as well as informative. So far as possible, the illustrations have been arranged to face the text to which they refer, a real convenience which justifies an occasional unwelcome displacement of species. The volume, like its immediate predecessor, gives enough data to permit identification of almost all the species discussed, and will be a mine of source data in revisionary work.

Considered from the point of view of a pioneering work in dissemination of critical data on type specimens, this series may well form a pattern for later catalogues of Lepidoptera; but it is to be feared that in comparatively few other groups of insects will photographic representation meet the standard of illustration required. R. G. FENNAH

PROBLEMS OF HUMAN FERTILITY

Modern Science and the Human Fertility Problem

By Richard L. Meier. Pp. xiii+263. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959. Sponsored by the Conservation Foundation, New York.) 48*s*. net.

HERE is a book which was badly needed. It deals with one of the most urgent of the many problems facing mankind at the present time—the menacing increase in the world population. In an early chapter entitled "Equilibrium in Human Population", the author states that "the foreseeable limit is set by the quantity of energy that is steadily reaching us from the Sun". It depends also upon an estimate of the minimum human (*per capita*) "requirements for energy in efficiently organized civilizations". The present rate of population increase works out at 1·6 per cent, and the author estimates that the limits of continuous energy supply may be overtaxed by A.D. 2100, a date which is only five or six generations ahead of us from now.

Dr. Meier's review of the situation is the completest that I have yet come across. In an early chapter he examines the population problem on a miniature scale as it exists in the island of Puerto Rico, where the general population density now exceeds that of any European country. He made a personal study of the situation among the poorer families and also the attitude of the Puerto Ricans to attempts of the authorities to introduce contraceptive measures. He describes the unexpected popularity of surgical sterilization of overburdened mothers, and the reactions of the various religious denominations to birth-control measures in general. Finally he tells us that the situation has been prevented from becoming critical in Costa Rica by a continuous overflow of the population on to the mainland. The author also made a similar study of the problem in the over-populated island of Mauritius.

Later chapters of his book deal with the future measures which will be required for staving off disaster, and the discovery of an ideal method of contraception is the most pressing need of all. All experts on this subject agree that what is required is a preparation which can be taken by the mouth and which is guaranteed to cause no harm. This pill may work in various ways; by inhibiting ovulation or the nidation and the development of the fertilized ovum; or by inhibiting spermatogenesis in the male. But there are other links in the chain of fecundation which might be broken artificially and these possibilities are reviewed by the author in an appendix. He rightly deplores the fact that whereas immense sums of money can easily be raised for research on a cure for cancer, there is little financial support for what is a far more urgent human problem. But Dr. Meier does not despair. He believes that the situation "is such that we must not reasonably expect to find that the first mass manufacture and use of oral contraception will come into being before the 1970–75 period".

Dr. Meier's book is the completest and the best survey of the world population problem which has yet appeared, and it is a work which is indispensable to everybody who is interested in this all-important subject.

KENNETH WALKER

TEXTILE ENGINEERING

Textile Engineering Processes

Edited by Prof. A. H. Nissan. Pp. ix + 366. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1959.) 60*s.*; 9.25 dollars.

MODERN textile industry is becoming increasingly dependent for its future prosperity on the recruitment of graduate scientists and engineers, so that it can derive the greatest benefit from modern scientific discoveries arising from research and development into textile materials and processing. Several books are available in which the chemical and physical aspects of textiles are discussed, but little has been written with the needs of engineers in mind. Such a book has become more necessary now that the Institution of Mechanical Engineers has created an option in textile engineering in the examination for the associate membership.

The present volume is intended to give to engineers a concise account of the processes involved in converting fibres into fabrics, special attention being paid to the mechanical aspects of the subject. Difficulties of writing such a work are considerable, for the textile industry is divided into many specialized sections. Prof. Nissan has, however, been successful in obtaining several collaborators, each of whom is a specialist in his own field. It is impossible to survey all the important aspects of textiles in the space available, and consequently attention has been limited to the following topics: physical properties of textile fibres, yarns and fabrics; the principles and techniques of yarn and cloth production, including knitting; wet finishing, and dyeing and printing machinery. Rather more specialized accounts of the important topics of drying, humidity control, and automatic control complete the volume. Each chapter is in effect an essay on a particular aspect of textile processing. The various authors appear to have interpreted their terms of reference rather differently, but all have given clear and concise accounts of their subject. Some have treated topics in a general descriptive way while others have chosen to discuss specific aspects in greater detail. These differences are offset to some extent by the suggestions for further reading given at the end of each chapter.

The book is a welcome addition to the literature on textiles. As an introduction to the subject, engineers and physicists will find it useful particularly in its treatment of yarn and cloth manufacture, while those already acquainted with textiles will appreciate the parts dealing with more specialized topics. It is unfortunate that the book is so expensive; if the present trend in the price of text-books continues, students will soon be unable to buy them.

C. S. WHEWELL

BONDS BETWEEN RUBBER AND METAL

Rubber to Metal Bonding

By Dr. S. Buchan. Second edition, revised. Pp. xiv + 300 + 35 plates. (London: Crosby Lockwood and Son, Ltd., 1959.) 42*s.* net.

THE first edition of Dr. Buchan's book, published in 1948, described the technological situation as it existed after the intense effort of the War. Most of it was concerned with the very successful brass plating method of achieving bonds between rubber and metal, and Buchan's own work, aimed at understanding the mechanism as well as rigidly controlling the product, was naturally described in great detail. The evidence he presented pointed strongly to a sulphur bond between the copper of α-brass and the rubber. A further ten years have passed; but our knowledge remains where it was, and one is led to question the usefulness of printing a second edition. True, the revision has been thorough, as all chapters bear evidence by the addition of more recent information from the literature and from the author's experience with the newer chemical bonding agents, but the scientific situation remains unaltered and the chapter on the nature of the rubber-to-metal bond, although rewritten, is weak.

Technologically, the book is still comprehensive and indispensable because it gives practical details, formulæ and, most important, the test results obtained. Some processes, such as latex-blood albumen, are now obsolete and could have been deleted, while the space devoted to the brass-plating method, although valuable, would give the newcomer a false idea of its present popularity. The reviewer knows of no new plants for producing bonded rubbers by this method, while some have actually closed down or retracted in scale. The new chapters on chemical methods added to the second edition do not make this point nor do they give any indication of comparative processing or capital costs. Is it just this factor that has told against the brass-plating process?

There are a few minor blemishes for which the publisher must be blamed. A large proportion, in fact nearly all, of the graphs shown are not professionally drawn, and the lettering is bad. 'm.m.' for 'mm' is irritating as well as wrong. 'G.R.S.' for 'GR-S' is inelegant and in any event it was superseded during 1957 by 'SBR', which is now universally used as the abbreviation for butadiene-styrene rubber.

W. C. WAKE

The Morphology and Anatomy of American Species of the Genus *Psaronius*

By Jeanne Morgan. (Illinois Biological Monographs, No. 27.) Pp. vii+108. (Urbana, Ill.: University of Illinois Press, 1959.) Paperbound, 3 dollars; Clothbound, 4 dollars.

THE name *Psaronius* is applied to certain fossil tree-fern stems of Permian and Carboniferous age. The author in this monographic treatment of the American *Psaronii* describes three new species of Pennsylvanian Age from the United States and suggests that there are in all six valid species of the genus in America. From a careful study of about twenty-three specimens she has been able to allocate them to the three new species. There is considerable variation among the specimens allocated to any one species; but this variation, which is principally manifested in varying complexity in the polycyclic stelar anatomy, is due, she assumes, to ontogenetic variation such as is found in existing tree-ferns where the relatively small and simple stelar arrangements at the base of the tree formed in its sporeling state are succeeded higher up by increasingly complex cyclic polystelic arrangement. Some corroborative evidence in support of this assumption is obtained from specimens in which a considerable length of a stem has been found. She gives an account of the complex relationship between the several cycles of meristeles and the leaf-trace system connected to it. She also shows how the phyllotaxy may change between the base and upper parts of a stem, new orthostichies being intercalated and sometimes a spiral phyllotaxy is replaced higher up by a whorled arrangement of leaves. In places her descriptions are difficult to follow; a greater use of lettering on the diagrams would have helped the reader to follow her arguments. She places these fossils in a separate natural order, Psaroniaceae, although a good deal of evidence supports the view that they are related to the Marattiaceae. It is, however, a very useful contribution to our knowledge and is well illustrated and adequately indexed. JOHN WALTON

Astronomical Photography at the Telescope

By Thomas Rackham. Pp. 232+11 plates. (London: Faber and Faber, Ltd., 1959.) 36*s*. net.

MOST popular works on astronomy are illustrated by a series of impressive photographs taken with the world's largest telescopes. The casual reader may therefore get the impression that the photographs taken with smaller telescopes of the size owned by the average amateur astronomer are correspondingly poor and uninteresting. However, this is not necessarily the case, and in this book Mr. Rackham explains to the reader the techniques which he has perfected by many hours at the telescope. After clearing the ground with a lucid account of the basic photographic process, he proceeds to describe in detail the instruments and accessories used—nearly all capable of construction by the intelligent layman. The most common subjects of photography for the amateur astronomer are the Sun, Moon, Mars, and Jupiter, of which the individual difficulties are discussed at length. The photography of star fields, either through a telescope or by means of an ordinary camera, is not treated so fully; for this the reader is referred to King's "Manual of Celestial Photography". The chapters on practical processing and darkroom technique should answer all conceivable queries, although the professional astronomer will be surprised to find film almost invariably used instead of plates.

In conclusion, the book can be best summarized in the author's own words—"The amateur's work may not always be of scientific value . . . but it will introduce him to the many wonders of astronomy where they are properly to be found—not in books, but in the sky". D. H. P. JONES

Physical Geography

By Philip Lake. Fourth edition, edited by J. A. Steers. Pp. xxviii+483+25 plates. (Cambridge: At the University Press, 1958.) 25*s*.

PHILIP LAKE'S "Physical Geography" was first published in 1915 and so quickly established itself as to be reprinted a dozen times before the author's death in 1949. It was in that year that the second edition appeared, re-written rather than revised by a team of Cambridge geographers under the leadership of J. A. Steers. Whether or not one accepts the definition of geography as human ecology it will be universally agreed that a proper understanding of man's environment demands a knowledge—it may be general but must be soundly based—of the physical factors of that environment. The successive editions of Lake have sought to incorporate the results of work in the now numerous related fields of study. To the old three-fold division into the atmosphere, the ocean and the land, still preserving such empirical chapters as 'coral reefs', 'volcanoes' and 'lakes', have been added in this latest edition three more chapters on floods and storms—a by-product of Prof. Steers's special concern with the East Coast floods of 1953—on soils by A. T. Grove, which brings in some, but not very much ecology, and on marine life by A. J. Lee. It has sometimes been said that a student entering the Cambridge School of Geography will enjoy excellent series of lectures by specialists but will be left to discover for himself the integrated whole which modern geography should be. Something of the same criticism applies to the latest edition of Lake's "Physical Geography". L. DUDLEY STAMP

Classification and Indexing in Science

By B. C. Vickery and D. J. Foskett. Second edition, enlarged. Pp. xix+235. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1959.) 30*s*.; 6 dollars.

THE second edition of this book has been considerably expanded without affecting its character as a study of method rather than a manual of classification and indexing. The first three chapters and appendixes are almost unaltered apart from some transpositions in the appendix dealing with historical aspects and an extended treatment of the Universal Decimal Classification. Those on "Indexing" and on "Classification and Mechanical Selection" have been transposed: the former now includes a brief section discussing the indexing of chemical compounds and the latter some account of mechanisms used for retrieving information and examples of the subject analysis and coding used. The bibliographies of these two chapters and also of the following chapter "The Future of Information Retrieved", which has been completely re-written to take account of developments reported to the International Conference on Scientific Information at Washington in November 1958, have been expanded. R. BRIGHTMAN

THE ROYAL SOCIETY'S EXPEDITION TO HALLEY BAY DURING THE INTERNATIONAL GEOPHYSICAL YEAR

ON February 4 the Royal Society spent a day listening to accounts by various members of the expedition to Halley Bay of the work done in Antarctica by the British team during the International Geophysical Year.

The discussion was led by Sir Graham Sutton, who began by recalling that although a proposal to mount an international expedition to explore the Antarctic continent had been made as long ago as 1861, it was not until the present century that any significant progress was made. The initial phase, of wooden ships and animal or man-drawn sledges, culminated in the large expeditions of 1910–15, and although conditions are vastly different to-day, there are still hardships and even perils to be faced. The choice of a site in the Weddell Sea area was dictated by a number of factors ; but there is no doubt that, from the geophysical aspect, the area is of great interest.

Mr. J. MacDowall (who was the leader of the expedition in 1958) opened the discussion with an account of the work done in seismology, glaciology and meteorology. The observatory was built on a floating ice shelf 29 m. above sea-level in latitude 75° 31′ S., longitude 26° 37′ W. Considerable microseismic activity was observed during the summer (December–February), especially with on-shore winds, and he gave examples to show the relation between microseisms and wind force. The short-period three-component Willmore seismograph used on the floating ice shelf was found to detect P-waves at most epicentral distances, but S-waves were badly recorded. The shelf itself had a yearly addition of about 1 m. of snow of mean density $0\cdot36$ gm. cm.$^{-3}$. Considerable ablation occurred, even in winter, and it is not easy to account for this in terms of the energy balance.

Mr. MacDowall directed attention to the small range of monthly mean air-temperature through the troposphere compared with the very large difference in extremes in the stratosphere, where the records indicate a range of 59° C. at the 30-mb. level. Another interesting fact is that there is a notable difference between the northern and southern hemispheres in the seasonal change in atmospheric ozone. The spectrophotometer measurements of the total amount of ozone made at Halley Bay during 1956–58 do not appear to fit into the hitherto accepted global pattern of seasonal and latitudinal variations, and only the short-period fluctuations were found to be related to upper-air measurements. In south-east England both the long- and the short-period variations are related.

Mr. J. M. C. Burton described observations on the nature of the ice shelf and drew the conclusion that it is partially grounded to the east-north-east, but floating to the south. He suggested that the Dawson Lambton glacier should be taken as the true coastline. The Allan MacDonald glacier, which Shackleton reported in 1914 some 30 miles north of the Dawson Lambton glacier, was not seen during the two years of the International Geophysical Year, and he regarded its existence as doubtful.

Commenting on these contributions, Dr. R. C. Sutcliffe dealt with the ozone distribution and suggested a possible explanation in terms of a thermal circulation. Mr. H. H. Lamb continued with an analysis of upper-air measurements. He pointed out that it is only since 1957 that any general picture of stratospheric circulation over the Antarctic can be constructed, and of the three years in question, it seems fairly certain that 1959 was anomalous in the late winter and spring in regard to winds, temperatures and maximum amounts of ozone in the stratosphere.

Mr. W. H. Bellchambers and Mr. W. R. Piggott described the ionospheric measurements. The Halley Bay observatory, being near the centre of the Weddell Sea geomagnetic anomaly and yet sufficiently outside the auroral zone to avoid the effects of minor corpuscular magnetic or auroral activity, is particularly well placed for the study of the electrified part of the atmosphere. The main conclusions reached are that the $F2$-layer variations are dominated by movements of ionization (which can also be seen near the maximum of the $F1$-layer), and that ionization drift velocities in the E-region reverse with season and are greater in winter than summer. The incidence of 'spread F' is very anomalous, being essentially a magnetically 'quiet day' phenomenon.

In the general discussion, Dr. R. L. Smith-Rose, after paying tribute to the excellent work done by the team, remarked that two features of the results were surprising. In the temperate and auroral latitudes of the northern hemisphere severe 'spread F' is closely correlated with magnetic and auroral activity and is well known as a precursor to the failure of trans-Atlantic radio communication. At Halley Bay, on the other hand, it seems to be associated with relatively quiet conditions. Again, in the northern hemisphere the maxima and minima of $foF2$ are approximately at the same local mean time at most ionospheric stations. This does not suggest the type of movements proposed by the speakers. He asked if there is evidence for any fundamental difference in the behaviour of the layer in the two hemispheres.

Mr. P. M. Brenan and Mr. D. P. Harrison gave an account of the work in radio astronomy. It was found that ionospheric velocities, deduced from the motion of the diffraction pattern on the ground, were approximately towards the west in the first part of the night and towards the east for the remainder of the night and most of the following day, the reversals taking place about 0030 and 1630 L.M.T. The speeds were of the order of 400 m.sec.$^{-1}$ in the evening, falling to about 100 m.sec.$^{-1}$ in the easterly motion. The times of change and the magnitude of the drift speeds agree with measurements of the motions of auroral forms made at Halley Bay by S. Evans (1959) using an all-sky camera.

For radio-echo observations of auroræ and meteors, a low-power equipment working with a rotating aerial on a frequency of $71\cdot3$ mc./s. was used, similar to that at Jodrell Bank. The auroral echoes fit closely the case of specular reflexion for columns of ionization aligned along the local magnetic field at about 100 km.

Commenting on these papers, Dr. J. G. Davies remarked that a clear correlation between the peaks of auroral activity at Halley Bay and the rarer auroral echoes at Jodrell Bank has been demonstrated. The scattering mechanism is clearly specular. He pointed out that in the auroral case, as well as for the work on radio-source scintillations, the fact that the observations appear to be in regions of increased ionization elongated along the direction of the local magnetic field suggests that these may be extensions of the van Allen radiation belts, and may represent the mechanism whereby the radiation zones drain into the atmosphere.

Dr. S. Evans and Dr. G. M. Thomas gave an account of the visual work on aurora. An all-sky camera was used. A plot of the hourly-mean vector movement indicated a systematic diurnal component, reaching a few hundred metres a second in the easterly and westerly directions. Comparison with the horizontal magnetic disturbance vector averaged over the same period was held by Dr. Evans to imply an effective transport of negative charge by aurora.

Dr. Thomas said that a feature of the auroral display at Halley Bay was the almost continuous presence of a quiet arc lying well to the south. There is evidence, supported by observations in other localities, that there is a migration of quiet arcs to higher latitudes at times of maximum sunspot activity.

Mr. J. Paton, discussing these results, speculated whether the small movement in the position of the quiet arcs recorded at Halley Bay between 1956 and 1958, if it is real, is related to changes in the form of the outer van Allen radiation belt during the period between sunspot minimum and maximum. He also asked if the observations now indicate that the phenomena of 'flaming' occur only on the equatorial side of the auroral zones, and that the somewhat surprising rarity of red coloration in the Halley Bay displays indicates the general rule that persistent red diffuse surfaces are very limited in their geographical position, being virtually confined to the middle latitudes.

Sir Graham Sutton, summing up, said that, in his opinion, the Society had been amply justified in its decision to send an expedition to this remote part. The data obtained seemed to be unique in many ways.

The president of the Royal Society, Sir Cyril Hinshelwood, in closing the meeting, paid tribute to all who had taken part, and said he had never had any doubt that the Halley Bay venture would be worth while. From what he had heard, the geophysical services would benefit greatly.

The contributions and a report of the discussion will appear in a forthcoming number of the *Proceedings of the Royal Society*. O. G. Sutton

THE TEACHING OF VETERINARY ANATOMY AS A BRANCH OF BIOLOGY

ITS RELATIONSHIPS TO HUMAN ANATOMY

By Dr. R. A. GREEN

Sub-Department of Veterinary Anatomy, University of Cambridge

EVERYONE has the opportunity of gaining inside knowledge in one only of the sciences—biology. He carries around with him until he dies a living specimen about which he can know something at first hand. This intimate knowledge of vital activity is not only unique, it also carries with it a greater depth of understanding than is possible by the use of the intellect alone. Certain branches of knowledge like mathematics claim to depend on the use of pure reason. Any branch of the natural sciences, however, makes use to some extent of man's knowledge of his own body.

Anatomy is fundamentally a branch of biology but, based historically on cadavers and the descriptive method, it is often thought of as a dead science—in more ways than one. It is also mistakenly considered to be a highly concrete science because it deals with the gross aspects of structure which are not only three-dimensionally solid but which can also be prodded with the fingers. To bring the dead organs to life, an older generation therefore added 'function' as something over and against 'form'. Thus was born one of the many antitheses that used to divide biologists into two warring camps. Nowadays they are mostly too busy being experimentalists to worry about these many unsolved problems, and this is no doubt why words like 'teleological' and 'Lamarckistic' are used less often as epithets of derision.

In fact, as Woodger first remarked[1], the antithesis of form and function is readily resolved in terms of ideas on space/time. A dead organ, far from being one of the most concrete elements in biology, is one of the most abstract. It is a four-dimensional object, from which the dimension of time has been removed. Living structure, by its very nature, has a history. It is changing from moment to moment. Form and function are but two aspects of a single entity—a living organism. To consider any living organism from one only of these two aspects is a highly artificial abstraction from reality. Similarly, because the organism is a structuro-functional whole, considerations in isolation of one of its several organ-systems or of separate organs are still further stages in abstraction, invented by the mind of man. Thus, living structure *is* function.

For some years now in the teaching of human anatomy there has been a tendency to depart from the older descriptive method of dealing with gross structure. Function is introduced in many places, and organs are dealt with in terms of the functions which they are designed to carry out in life. This is occasionally an overtly teleological approach which is all to the good; for, as MacDougall once said[2], there are quite clearly two kinds of causation at large in the world—mechanical and teleological—and, of these, teleological causation is fundamental. Man conceived the idea of inanimate objects pushing each other about because of what he knew at first hand of the results of using his own muscular energy; and, in as much as events happen in the realm of living things *as though* those events were purposive[3]—it does not seem a serious sin to treat them that way if to do so is to further understanding. To hold the opposite view, that in order to be scientific, any statement concerning living things and how they act or are made must be based on a materialistic philosophy, is merely to display a narrow dogmatism that in no way accords with the facts of observation[3].

There was a time when observation played a prime part in the biological sciences. From it was born the descriptive style of anatomy; but like any thought-method indulged in as a specialization this eventually began to defeat itself[4]. The sheer accumulation of descriptive facts began to have an arid effect and became intellectually unsatisfying. Certain details began to be relegated to smaller print, and innovations were made, such as considering the functions of the parts being described.

As well as considering function, attention was also given to those other aspects of the fourth dimension—development and evolution. The embryology of organ-systems has for many years now been a standard part of the background of teaching gross human anatomy and, in most centres, at least some attention is also given to comparative anatomy, by way of emphasizing among other things the specializations involved in man having an upright posture. In some centres a more detailed study is made along almost zoological lines to paint in more of the history of the vertebrate body.

The beginnings of a serious study of the anatomy of domestic animals were made before the already highly developed human anatomy began to break with tradition. It was inevitable, therefore, that the method established in human anatomy was directly imitated. Having, however, to deal with some five different mammals, attempts at a comparative approach, although along purely descriptive lines, were made at the outset. As time passed, many teachers of veterinary anatomy grew aware of the deficiencies of the purely descriptive approach and introduced function and embryology along with a description of parts. But this was seldom a true grafting-on of new material. The current state of development of the teaching of human anatomy gives opportunities for radical changes in approach by veterinary anatomists along avenues less accessible to those that originated them.

Human anatomists are in a difficult situation in the matter of how much descriptive detail to include in their courses. Obviously, their students will need to know the structure of certain parts in considerable detail in their clinical years, and too much cannot be left to the surgeons to teach without a radical alteration being made in medical students' courses. Certain critics maintain that all descriptive anatomy should be applied anatomy and taught alongside surgery. Although this would obviate the difficulties inherent in expecting students to remember structural details with several years gap between pre-clinical anatomy and surgery, it would relegate anatomy to pure technological training. It has more to offer a student than that. But the problem of where to draw the descriptive line is certainly an acute one.

This particular problem is far less pressing in the teaching of veterinary pre-clinical anatomy, for the amount of applied descriptive detail required by even a specialist in surgery is far less. The detail chosen for treatment should, of course, be selected with one eye on its applied value; but even so, the main criterion of choice is its biological value. Which structural details can best be shown as structure-in-action? This is one of the basic yardsticks for selection. Which details can best be treated as examples of adaptation to function against a background of evolutionary and developmental change? Finally, in this choice of what to leave out and what to put in—what other details must be included in order to give a rounded picture of the whole structuro-functional organism rather than merely a pastiche of disconnected parts.

Having, of necessity, to begin with a comparative approach, in order to deal with the structure of odd- and even-toed Ungulates and the Carnivora, among mammals, and of domestic poultry, among birds, it is obviously relevant to include something on reptiles, from which both later classes devolve. In turn, reptiles are only meaningful in matters of structure if their earliest representatives are coupled with early amphibians and treated as the first tetrapods in contrast to fish-like vertebrates. Thus, a more than superficial survey of the vertebrate body is a natural corollary to the teaching of veterinary anatomy. In this way it also joins forces with the dogfish, which the framers of early First M.B. courses in their wisdom included in its syllabus. In human anatomy courses the introduction of much comparative anatomy can be frowned upon as overloading the student. There is no need for a similar criticism in veterinary anatomy courses, where the subject-matter quite naturally demands it.

The embryology of the various organs of the mammalian body falls naturally into place alongside their evolutionary history and their gross form. That is to say, a unified course of all three approaches—not three separate courses. One of the major difficulties here is the absence of appropriate text-books. All the best text-books on mammalian anatomy and embryology are written for medical students. The various adaptations relating to upright posture and the rather more subtle differences due to precocity in development of many organs are not necessarily emphasized by the authors, for their subject-matter is man. For the veterinary student, these differences are a source of confusion, and time has to be consumed in interpreting them in terms of domestic animal anatomy. This very difficulty, however, contains an opportunity. Human anatomists give courses in quadrupedal anatomy. In veterinary anatomy there should be a course of comparative human anatomy. This would not only serve as a guide to existing text-books but would also fulfil two other wider and more valuable purposes—a means of liaison between medical and veterinary professions containing the elements of a common language between the two, and an important part of general education. Comparative medicine is now being given increasing attention; but the foundations of any training are laid in its early years—in this case, in pre-clinical courses. No opportunity should be lost in general education of increasing the spread of knowledge about the human body, and for any student of animal biology a course on this subject should be a constant feature.

As well as having a long-established method of instruction and varied text-books for learning his anatomy, a medical student has another tremendous advantage over a veterinary student. He carries around with him a living text-book. To a non-medical observer, the behaviour of medical students while taking an oral examination is very interesting. All but the weaker candidates will make repeated reference to their own bodies when in the process of answering questions. Their examiners probably barely notice this, except to remark its absence in the poor candidates. It is a method of learning that comes naturally to the student, and all concerned, examiners and examinees, take it for granted. Although it has obvious restrictions, mainly to surface structures, it is nevertheless a means of knowing living anatomy that many a medical man almost certainly makes use of throughout his professional life. He adapts it later by asking patients to carry out various voluntary movements and noting the results, but his unconscious reference point is probably still his own body.

Both the approach and its adaptation would seem to be denied to a veterinary training. The use of living animals for palpation and observation, or the showing of films or cine-radiographs of living structures is never as effective, because full subjective participation on the part of the students is always absent. There is, however, a way around this difficulty. Fortunately, the most generalized of the domestic animals, the dog, differs in only a limited number of structural details from the anatomy of man. The comparative course in human anatomy could stress these differences to the veterinary student. By learning about his own body, which in itself contains an interest drive for any biology student, he can allow for the differences between his own anatomy and that of his subject animals and thereby use his own living text-book in a similar way to a medical student.

Modern anatomy is thus far from being a dead science, but, what of the criticism that it is too time-consuming in this age of specialization to warrant its continuance as a part of pre-clinical training, even in its modern forms ? This criticism can perhaps be levelled even more readily at veterinary than at human anatomy because of the more restricted nature of its descriptive subject-matter. Most anatomists, after making full allowance for the axe they have to grind, are confident of the importance to the students of what they are seeking to do for them, in courses that must remain pre-clinical. The actual putting into words of what is often an instinctive conviction, accumulated through years of teaching, is however sometimes not easy to make. Surely one of the main answers lies in this matter of anatomy being a branch of biology ? In this day and age where machines have invaded the world of biological research, and observation of living animals without interference experiments is a rarity, there is an increasing need to offset this mechanistic trend by laying foundations in the biology of the normal. The changes from the old descriptive method have rendered this possible, and, as technology advances, the importance of emphasizing what can now be taught as living anatomy will increase rather than diminish. By adding to the observations of living subjects the inside knowledge a student can have from his own body, use is made of the insight into a science which belongs to biology alone. Not to develop this insight in a world of advancing technology might well be to lose the very substance of that old but still undeniable claim that medicine, whether human or veterinary, is an art as well as a science.

[1] Woodger, J. H., "Biological Principles" (Kegan Paul, London, 1929).

[2] MacDougall, W., "The Riddle of Life" (Methuen, London, 1938).

[3] Russell, E. S., "The Behaviour of Animals" (Edward Arnold, London, 1938).

[4] Russell, E. S., "Form and Function" (John Murray, London, 1916).

RIBONUCLEIC ACIDS AND THE SYNTHESIS OF CELLULAR PROTEINS*

By Prof. J. BRACHET

Laboratory of Animal Morphology, Faculty of Sciences, University of Brussels

It is hard to believe nowadays how confused the whole field of nucleic acid biochemistry and localization was some thirty years ago: it was thought, for example, that thymonucleic acid was only found in animal cells, while yeast nucleic acid was a specific constituent of vegetal cells. We know now that thymonucleic acid is only one representative of the deoxyribonucleic acids, while yeast nucleic acid is just one of the many ribonucleic acids which are now known to exist in all kinds of cells. Regarding the role of deoxyribonucleic acid, all one could suggest was that it might play the part of an intranuclear *p*H buffer.

Progress and clarification in this field largely came from unexpected quarters, namely, from cytochemical and embryological work: for example, the introduction in the realm of cytochemistry of the specific Feulgen[1] reaction for deoxyribonucleic acid was a major event, since it led to the demonstration of two important facts: deoxyribonucleic acid is strictly localized in the chromatin of cell nuclei, and it is present in the nuclei of all cells, whether they are of animal or vegetal origin.

Work in the thirties by the Needhams[2] and by me[3] on the synthesis of nucleic acid in developing sea urchin eggs also led to important conclusions: it was found that cell multiplication, during embryonic development, is linked with the synthesis of deoxyribonucleic acid and that the site of this synthesis is strictly nuclear. No important reserve of deoxyribonucleic acid, sufficient to allow nuclear multiplication until the larval stages were reached, could be detected in the cytoplasm; the latter, however, already contains large amounts of nucleic acids, in unfertilized eggs. Since this nucleic acid cannot be deoxyribonucleic acid, it must be ribonucleic acid; the latter can therefore no longer be considered as a specific constituent of plant cells. The hypothesis of a conversion of ribo- into deoxyribonucleic acid during cell division was an apparently logical conclusion to draw from all this work. How much of these conclusions remains true nowadays? A good deal, since the universal occurrence of deoxyribonucleic acid in cell nuclei and its synthesis during cell division are now well-established facts; the presence of ribonucleic acid in the cytoplasm of all cells is also generally accepted. The only major flaw in the theory was the hypothesis of the conversion of ribo- into deoxyribo-nucleic acid, which was not on a sufficiently sound basis; but, although such conversion certainly does not occur on a very large scale during egg development, recent biochemical work has shown that many organisms, including embryos, contain enzymes which transform ribonucleosides into their deoxy-counterparts and, ultimately, into deoxyribonucleic acid.

---

* Substance of two Special University Lectures delivered at King's College, University of London, on January 26 and 27.

More progress in our basic knowledge about the role and the localization of ribonucleic acid was to come from other cytochemical studies: a simple staining method, in which two basic dyes (methyl green and pyronine) are combined, allows quick and easy detection of ribonucleic acid in all cells; however, the specificity of the method must be checked by the utilization of control sections which have previously been treated with the enzyme ribonuclease in order to remove the ribonucleic acid they contained (Brachet[4]). Simultaneously, Caspersson[5] worked out a more complicated and more costly method of detection of ribonucleic acid based on the strong ultra-violet absorption of the purine and pyrimidine bases which enter into the constitution of the nucleic acids.

Extensive use of these two methods led, independently and simultaneously, Caspersson[5] and me[4] to the same general conclusion: ribonucleic acid is a universal constituent of all living cells, whether they are of animal, vegetal, or bacterial origin. It is localized in the nucleoli and in the cytoplasm, although variable amounts are found in chromatin as well. Furthermore, there is a remarkable correlation between the ribonucleic acid content of a given cell and its ability to carry out protein synthesis: cells which are metabolically very active, but do not synthesize large amounts of proteins (kidney, heart, muscle cells, for example) have a low ribonucleic acid content. On the other hand, cells which synthesize large quantities of enzymes in the pancreas or the gastric mucosa, as well as the silk-secreting cells of silk worms, contain very large amounts of ribonucleic acid in their cytoplasm and their nucleoli. Finally, when protein synthesis is increased or decreased by experimental means, such as fasting or hormone injection, parallel changes in the ribonucleic acid content of the affected cells can be detected.

More recently, the advent of a new and powerful cytochemical technique, autoradiography, has entirely confirmed these conclusions (Brachet and Ficq[6]): there is an excellent, almost perfect, parallelism between the incorporation of amino-acids into proteins (which is a measure of protein synthesis) and the ribonucleic acid content of all the cells which have been studied.

Quantitative Measurements

Since cytochemical methods do not lend themselves so easily to quantitative work as straight biochemical techniques, it was important to confirm the cytochemical results with quantitative methods: this has been done[7,8] repeatedly, and all that need be said here is that the agreement between the two types of technique is remarkable. We can thus from now on consider the correlation between the ribonucleic acid content and protein synthesis as a well-established fact, and we can draw the conclusion that ribonucleic acid somehow takes a direct role in protein synthesis.

A consequence of this conclusion is that there should also be a correlation between ribonucleic acid content and protein synthesis at the subcellular level: it means that the small particles rich in ribonucleic acid which have been known as microsomes since the work of Claude[9] should be more active in the incorporation of amino-acids into the proteins than the other cell fractions (nuclei, mitochondria, cell sap) which are poorer in ribonucleic acid. The correctness of this prediction has been confirmed many times and, more recently, it has been possible to go one step further and to isolate from the microsomes, by suitable treatment with bile salts, particles which are much smaller and have a still higher ribonucleic acid content than the microsomes: they are the so-called 'ribosomes', which contain as much as 40 per cent ribonucleic acid. It was found, as one would expect, that they are unusually active in the incorporation of labelled amino-acids into proteins[10]. In fact, these ribosomes are now considered by most biochemists as the main site of synthesis of cytoplasmic protein, in bacterial as well as in vegetal and animal cells. Of great interest also is the finding that treatment of microsomes by ribonuclease, in order to destroy the ribonucleic acid they contain, quickly inhibits their ability to synthesize proteins[11]. It can therefore be safely concluded that the above-mentioned relationship between ribonucleic acid content and protein synthesis holds true at the subcellular as well as the cellular or histological level; furthermore, the integrity of ribonucleic acid, in subcellular particles, is necessary if the ability to synthesize protein is to be retained.

But the first clear-cut demonstration of a direct role of ribonucleic acid in protein synthesis came from an entirely different field: the study of the multiplication of plant viruses, especially tobacco mosaic virus. After the demonstration by Markham[12] and by Jeener[13] that the protein part of tobacco mosaic virus (which consists of ribonucleic acid and protein only) is not infective, it was established beyond doubt by Gierer and Schramm[14] and by Fraenkel-Conrat[15] that viral ribonucleic acid, if properly extracted and isolated, is infectious. Treatment of this ribonucleic acid with ribonuclease immediately abolishes the infectivity. A very important point in these experiments is that when viral ribonucleic acid gets into tobacco leaves, it not only reproduces itself but also synthesizes its protein counterpart and produces virus of the strain from which it originates. In other words, ribonucleic acid is the genetic determinant in plant viruses (and in all animal viruses containing ribonucleic acid which have been studied so far) just as deoxyribonucleic acid is in phages and in cells.

But viruses are very simple systems when compared with whole, living cells; for the biologist, it would be of the utmost interest to prove that the integrity of ribonucleic acid is required for protein synthesis in the case of living cells also. Experiments to test this possibility have been going on for several years in my laboratory; the technique is to add ribonuclease to the living cells and to follow such processes as growth, mitotic activity, incorporation of amino-acids into proteins and net protein synthesis. The main results can be summarized as follows[16]: ribonuclease easily penetrates many living cells, where it can accumulate to a large extent. It first breaks down the soluble (cell-sap) ribonucleic acid and then attacks microsomal and nucleolar ribonucleic acid by either breaking it down or building up an inactive enzyme–substrate complex. In any event, protein synthesis, growth and mitotic activity quickly stop, probably as a result of the initial breakdown of soluble ribonucleic acid. But it is a very remarkable fact that the deleterious effects of ribonuclease can be reversed to a large extent (and sometimes even completely) by the external addition of yeast ribonucleic acid. The experimenter can thus control, almost at will, growth and protein synthesis in living cells by playing upon the ribonucleic acid–ribonuclease equilibrium.

After these prolonged cytochemical and biological studies, the problem has finally reached the ultimate stage, the biochemical one: thanks to the work of Hoagland, Zamecnik and their colleagues[17], the mechanism of protein synthesis becomes more and more understandable. This synthesis involves three main stages: first, the amino-acids are activated, in the presence of adenosine triphosphate, by soluble enzymes, and this results in the formation of amino-acyl-adenosinemonophosphate compounds. Secondly, these compounds are incorporated into soluble ribonucleic acid; this step is very sensitive to ribonuclease in the *in vitro* biochemical experiments as well as in our own experiments with onion roots. Finally, the soluble ribonucleic acid, which now carries the amino-acid, is, in turn, incorporated into the ribosomes; there, by a mechanism which remains obscure in many respects, specific proteins, which possess the correct amino-acid sequence, are synthesized. There is no lack of hypotheses about this ultimate step of protein synthesis: the most probable one is that the ribosomal ribonucleic acid carries a 'code', which it has received from nuclear deoxyribonucleic acid; this code would be inscribed, in the ribonucleic acid molecule, in the form of a specific base sequence and it would be translated, in the finished protein, as a corresponding, specific amino-acid sequence.

Role of the Nucleus

Before we can accept such a control mechanism of cellular protein synthesis, we should know more about the role taken by the cell nucleus (which obviously contains all the genetic information) in the synthesis of ribonucleic acid and of protein.

Several methods are available for such investigations; although all of them have some serious drawbacks, it is very encouraging that they all lead to very similar conclusions. The three main methods which have been used so far are the following: (1) investigation of the incorporation of labelled precursors of nucleic acids or proteins into intact cells, by autoradiography methods; (2) comparison of nucleic acid and protein metabolism in nucleate and anucleate fragments of unicellular organisms or eggs; (3) work on homogenates, in which nuclei, mitochondria, microsomes and cell-sap constituents can be recovered by differential centrifugation. The main difficulties with these three types of methods are the following: with the autoradiography techniques, specific activities are often difficult to measure accurately, since usually we do not know exactly the intracellular concentration of the labelled precursor and the chemical composition of the cell organelle which is under study; in the case of anucleate and nucleate fragments of cells, the main limitation is that delicate ultramicromethods are necessary in order to make measurements; with homogenates, it is difficult to be sure that no adsorption or loss of chemical compounds has occurred as a result of a rather drastic procedure. Furthermore, results obtained with 'combined' homogenate fractions (nuclei + microsomes, for example) are always of doubtful significance, since the experimental conditions are too different from those which prevail in a living cell. After these preliminary, but necessary, remarks, I will now discuss briefly the results obtained with the three different types of approach.

Autoradiography work on intact cells has repeatedly emphasized the importance of the nucleolus and perinucleolar chromatin in ribonucleic acid metabolism; these nuclear constituents, in all the cases studied so far, become very quickly labelled when ribonucleic acid precursors such as adenine, orotic acid, cytidine, uridine, etc. are used. It looks as if these precursors could go through the whole of the cytoplasm without being used for the synthesis of ribonucleic acid but, once they reach the nucleus, they incorporate themselves almost immediately in the nucleolus and the surrounding chromatin. Later on, the cytoplasmic ribonucleic acid also becomes labelled to an appreciable extent. All the facts at hand thus suggest that synthesis of ribonucleic acid is extremely active in the nucleus and the adjoining heterochromatic segments; they also strongly suggest that ribonucleic acid which has been synthesized in the nucleus is transferred to the cytoplasm.

The situation is different in the case of protein synthesis: as a rule, nuclei do not incorporate labelled amino-acids at a much faster rate than the cytoplasm; the main exception of this rule is the case of eggs undergoing cleavage, where synthetic processes are practically restricted to the multiplication of the nuclei. These observations obviously suggest that the nucleus is more directly involved in ribonucleic acid than in protein synthesis (see Brachet[18] for a more complete discussion). Experiments recently carried out in my laboratory by Drs. R. Perry and M. Errera entirely confirm this general conclusion: destruction of the nucleolus by an ultra-violet microbeam exerts marked effects on the synthesis of ribonucleic acid in both cytoplasm and chromatin; but, on the other hand, it has relatively little effect on the synthesis of nuclear and cytoplasmic protein.

Nucleate and Anucleate Fragments

I now come to the work done on nucleate and anucleate fragments of unicellular organisms: in *Amoeba*, removal of the nucleus has little effect on the time of survival of the organism; but anucleate fragments quickly become unable to move and to feed: therefore they should be compared with their nucleate counterparts under fasting conditions only. Under these conditions, it is found that removal of the nucleus does not decrease appreciably the oxygen consumption; however, the anucleate halves soon become incapable of utilizing their carbohydrate and fat reserves and, instead, proteins are being broken down[18]. This protein breakdown affects various specific (enzyme) proteins to different extents: whereas protease, adenosine triphosphatase, enolase and amylase remain almost unaffected by removal of the nucleus, dipeptidase undergoes a definite decrease, and acid phosphatase and esterase almost vanish from the anucleate halves. The reason why the nucleus exerts such markedly different effects on the maintenance of a number of enzymes remains uncertain; it may be connected with different intracellular localizations of the various enzymes which have been studied so far; but this point certainly requires additional experimental work before it can be cleared up. Finally, it should be added that the incorporation into proteins of labelled amino-acids, such as methionine or phenylalanine, is markedly reduced after enucleation; this incorporation process, which can be taken as an index of protein synthesis, never stops, however, in anucleate cytoplasm so long as the latter is alive.

The effects of removal of the nucleus are much more drastic, in *Amoeba*, in the case of ribonucleic acid than in that of proteins: the ribonucleic acid content of anucleate fragments decreases quickly and strongly[19]. Ingenious experiments by Goldstein and Plaut[20] have provided direct evidence for the view that the reason for this considerable drop in the ribonucleic acid content of anucleate cytoplasm is that a large proportion of cellular ribonucleic acid is synthesized in the nucleus: grafting the nucleus of an *Amoeba* which had been labelled with phosphorus-32 into a normal *Amoeba*, they found that cytoplasmic ribonucleic acid becomes labelled. On the other hand, the normal nucleus does not take any of the label into its ribonucleic acid, a fact which suggests that ribonucleic acid can move inside the cell in one direction only, namely, from the nucleus towards the cytoplasm.

In accordance with the results which have just been presented and which suggest that the nucleus is the main centre for the synthesis of ribonucleic acid in *Amoeba*, it has been found that enucleation exerts very impressive inhibitory effects on the incorporation of various precursors into cytoplasmic ribonucleic acid. Anucleate fragments seem, however, to be able to carry on, but at a much reduced rate, independent synthesis of cytoplasmic ribonucleic acid. But the whole situation still remains somewhat obscure, since the possibility that the incorporation process might occur in bacteria which have been phagocytized by the *Amoeba* without being killed has not yet been ruled out satisfactorily.

The biochemical activities of anucleate cytoplasm are much greater in the unicellular alga *Acetabularia mediterranea* than in *Amoeba*: it was found by Hämmerling[21] that anucleate halves not only survive for several months, but also that they are even capable of extensive morphogenesis (cap formation); it is therefore not surprising that these anucleate fragments are capable of net protein synthesis, including that of specific enzymes such as aldolase, phosphorylase and fructosidase[22-24]. Although the genes control, as we know, the synthesis of the many enzymes which are present in the cells, removal of the nucleus has nevertheless no immediate effect on enzyme synthesis. It should be said, however, that protein and enzyme synthesis cannot go on for ever in the absence of the nucleus, and that it stops completely after three or four weeks.

The case of *Acetabularia* raises a number of important problems for all those interested in molecular biology: morphogenesis and synthesis of specific proteins can obviously occur, in this case, in the complete absence of the genetic material. There must therefore be an intermediary between deoxyribonucleic acid and the proteins: Could it be that cytoplasmic ribonucleic acid carries the genetic information originating from the genes, and controls, for a certain time in any event, synthesis of specific protein? If so, is this ribonucleic acid of nuclear origin? Is it possible, by experimental means, to suppress the expression of the information which the anucleate cytoplasm has formerly received from the genes? While no clear-cut answer can be given to any of these important questions, recent experiments shed a certain amount of light on them.

Regarding first the behaviour of cytoplasmic ribonucleic acid in anucleate fragments, recent experiments by Dr. Naora and me have led to the following conclusions: there is, in contrast to what happens to protein, no net synthesis of ribonucleic acid in these fragments. On further analysis, however, it is found that a true synthesis of chloroplastic ribonucleic acid occurs in pieces of anucleate *Acetabularia*; this synthesis apparently takes place at the expense of the other cytoplasmic ribonucleic acid fractions (microsomes, cell-sap), which decrease after enucleation. We thus arrive at the following conclusions: chloroplasts show a high degree of independence towards the nucleus and can apparently multiply in its absence; microsomal and soluble ribonucleic acids, in *Acetabularia* as well as in *Amoeba*, lie under much closer nuclear control.

There is good reason for believing that, in *Acetabularia* as in *Amoeba*, part of the cytoplasmic ribonucleic acid is of nuclear origin: incorporation of ribonucleic acid precursors is extremely active in the nucleolus[18] and treatment of the anucleate halves with inhibitors of ribonucleic acid synthesis (ribonuclease, for example[25]) leads to an irreversible loss of regenerating capacity; a similar treatment of nucleate halves produces only a temporary inhibition of regeneration; these facts strongly suggest that the morphogenetic processes, in anucleate fragments, are mediated by ribonucleic acid of nuclear origin. It should, however, be emphasized that anucleate pieces incorporate radioactive precursors into their ribonucleic acid at an almost normal level for many weeks[22,23]: there is thus no doubt that, in this alga, pure cytoplasm is capable of extensive and independent synthesis or turnover of ribonucleic acid.

Regarding finally the expression of the gene-determined morphogenetic character (cap formation) in anucleate fragments, it is interesting to note that it can be easily controlled by modifying the SH—SS equilibrium of the culture medium[23]: by adding —SH-containing substances (β-mercaptoethanol for example), cap formation is completely suppressed. In the presence of its oxidized (—SS-containing) counterpart, dithiodiglycol, caps form earlier and develop faster than in the controls. In other words, the genetic information which the cytoplasm has received from the nucleus (through ribonucleic acid of nuclear origin presumably) is 'forgotten' in the presence of mercaptoethanol and expresses itself better than normally when cytoplasmic —SH groups are oxidized.

Before we close the *Acetabularia* chapter, a last remark should be made: it would be a mistake to believe that nucleo-cytoplasmic interactions always correspond to nuclear control exerted on the cytoplasm; in this alga, a decrease in cytoplasmic energy production, by prolonged cultivation in the absence of light, for example, has far-reaching consequences on both the structure and the ribonucleic acid content of the nucleus and, especially, the nucleolus[16].

The experiments which have been performed on enucleate egg cells and on reticulocytes (see ref. 18 for a more complete review) are in substantial agreement with all that has been said about *Acetabularia*: removal of the nucleus in sea urchin or unfertilized eggs of the newt has no immediate effects on the incorporation of various precursors into ribonucleic acid and proteins; in reticulocytes, the loss of the nucleus is followed by a parallel drop in the ribonucleic acid content and the ability of the cell to incorporate amino-acids into proteins. Nevertheless, synthesis of various enzymes and even of hæmoglobin (the synthesis of which is very clearly genetically controlled) has been reported to occur in these anucleate cells: if this is true, it would be another piece of evidence for the view that genetically controlled synthesis of specific proteins can occur in the complete absence of the genes; here again, one could speculate that cytoplasmic ribonucleic acid of nuclear origin is the carrier of the genetic information.

Work on Homogenates

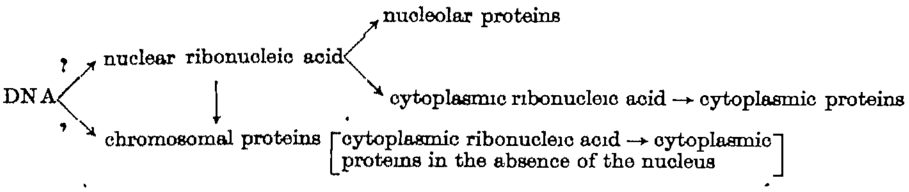
A few words should be said, finally, about the results obtained by biochemists who have been working on fractions recovered by differential centrifugation of homogenates (cf. ref. 18); it has been repeatedly shown, by this method, that the incorporation of ribonucleic acid precursors is always higher in nuclei than in any cytoplasmic fraction; similar experiments made with labelled amino-acids failed to demonstrate a particularly high ability of the nuclei for synthesizing proteins. Thus, we find once more that the nucleus is more directly involved in ribonucleic acid synthesis than in protein synthesis. Mention should be made, in this respect, of the very interesting experiments carried by Allfrey and Mirsky[27] on isolated thymus nuclei: the latter are capable of protein synthesis, and whole deoxyribonucleic acid is required in order to allow them to carry on this process. However, this role of deoxyribonucleic acid is an indirect one, since deoxyribonucleic acid is mainly concerned with energy production in the isolated nuclei. Furthermore, the experiments of Allfrey and Mirsky[27] clearly show that the ribonucleic acid synthesis is a necessary initial step before the isolated nuclei can incorporate amino-acids into their proteins.

General Conclusions

If we compare biological systems so different from each other as *Amoebae*, algae, eggs and reticulocytes, we find big quantitative differences; but they probably are just the result of a secondary factor, namely, the level of energy production in the anucleate cytoplasm. It is not surprising that an anucleate fragment of *Amoeba*, which is unable to feed, cannot be the site of a net protein synthesis; the situation is of course much better for *Acetabularia* (which is capable of active and normal photosynthesis in the absence of the nucleus), for eggs which are full of glycogen, fat and protein reserves, and for reticulocytes which live in such a rich nutrient medium as the blood stream.

Granting these easily understandable quantitative differences, there is no doubt that all the experiments made so far point toward the same general conclusion: the cell nucleus is the main site of synthesis of nucleic acids (deoxy- and ribonucleic acids). Its role in protein synthesis is a less direct one: it apparently controls the synthesis of cytoplasmic protein through the production of nuclear ribonucleic acid. The latter must, ultimately, receive the genetic information from deoxyribonucleic acid; but there is no evidence so far that 'deoxyribonucleic acid makes ribonucleic acid'. Nor is there any experimental evidence for the view that deoxyribonucleic acid could directly 'make' proteins, even chromosomal proteins. Finally, it should not be forgotten that, in the case of *Acetabularia*, independent synthesis of protein and ribonucleic acid (in the chloroplasts at least) is possible in the complete absence of the nucleus and, therefore, of genes and deoxyribonucleic acid.

For these reasons, the common 'slogan': DNA makes RNA, and RNA makes protein, is, in my opinion, an over-simplification which may prove dangerous. The following scheme, although still certainly very simple, is probably somewhat closer to the truth:


DNA
?
nuclear ribonucleic acid
nucleolar proteins
cytoplasmic ribonucleic acid → cytoplasmic proteins
?
chromosomal proteins
cytoplasmic ribonucleic acid → cytoplasmic proteins in the absence of the nucleus

It will be a task for the future to remove the question marks and to increase the number of the arrows present in this still largely hypothetical scheme.

---

[1] Feulgen, R., and Rossenbeck, H., *Z. physiol Chem.*, **135**, 203 (1924).
[2] Needham, J., and Needham, D., *J. Exp. Biol.*, **7**, 317 (1930).
[3] Brachet, J., *Arch. Biol.*, **44**, 519 (1933).
[4] Brachet, J., *Arch. Biol.*, **53**, 207 (1941)
[5] Caspersson, T., *Naturwiss.*, **28**, 33 (1941).
[6] Brachet, J., and Ficq, A., *Arch. Biol.*, **67**, 431 (1956).
[7] Brachet, J., *Enzymologia*, **10**, 87 (1941).
[8] Davidson, J. N., *Cold Spring Harbor Symp. Quant. Biol.*, **12**, 50 (1947).
[9] Claude, A., "Biol. Symposia", **10**, 3 (1943).
[10] Littlefield, W., Keller, E. B., Gross, J., and Zamecnick, P. C., *J. Biol. Chem.*, **217**, 111 (1955).
[11] Allfrey, V. G., Daly, M. M., and Mirsky, A. E., *J. Gen. Physiol.*, **37**, 157 (1953).
[12] Markham, R., "Advances in Virus Research", **1**, 315 (1953).
[13] Jeener, R., Lemoine, P., and Lavand'homme, C., *Biochim. Biophys. Acta*, **14**, 321 (1954).
[14] Gierer, A., and Schramm, G., *Z. Naturforsch.*, **11b**, 138 (1956).
[15] Fraenkel-Conrat, H., *J. Amer. Chem. Soc.*, **78**, 882 (1956).
[16] Brachet, J., *Pubbl. Staz. Zool. Napoli*, **27**, 146 (1955)
[17] Hoagland, M. B., Zamecnik, P. C., and Stephenson, M. L., *Biochim. Biophys. Acta*, **24**, 215 (1957).

[18] Brachet, J., "Biochemical Cytology" (Academic Press, N.Y., 1957).
[19] Brachet, J., *Biochim. Biophys. Acta*, 18, 247 (1955).
[20] Goldstein, L., and Plaut, W., *Proc. U.S. Nat. Acad. Sci.*, 41, 874 (1955).
[21] Hämmerling, J., *Roux' Arch. Entwicklungsmech. Organ.*, 131, 1 (1934).
[22] Brachet, J., Chantrenne, H., and Vanderhaeghe, F., *Biochim. Biophys. Acta*, 18, 544 (1955).
[23] Brachet, J., *Exp. Cell. Res.*, Supp., 6, 78 (1959)
[24] Hämmerling, J., Clauss, H., Keck, K., Richter, G., and Werz, G., *Exp. Cell. Res.*, Supp., 6, 210 (1959).
[25] Stich, H., and Plaut, W., *J. Biophys. Biochem. Cytol.*, 4, 119 (1958).
[26] Stich, H , *Z. Naturforsch.*, 6b, 259, 319 (1951).
[27] Allfrey, V. G., and Mirsky, A. E., *Proc. U.S. Nat. Acad. Sci.*, 43, 589 (1957).

THE AGADIR EARTHQUAKE OF FEBRUARY 29

By ERNEST TILLOTSON

THREE slight earth tremors during the previous week were not considered premonitory of the earthquake which suddenly occurred near Agadir at about 11.40 p.m. on the night of February 29, 1960, since this district had not previously experienced an earthquake of intensity 10 on the ten-degree scale. However, at 23h. 40m. 12s. U.T., after preliminary rumbling, the shock occurred. 90 per cent of the Talborjit quarter where many Moroccans lived in multi-storied apartment buildings, 70 per cent of the new buildings, including the Saada Hotel, built only five years ago, and the Gautier Hotel, and 20 per cent of the industrial buildings collapsed. Agadir, the tourist and economic capital of southern Morocco, where the Atlas Mountains descend to the Atlantic Ocean, was ruined. Some 12,000 people, including 3,000 foreigners, were estimated to have lost their lives, and many thousands besides were injured. A seismic sea wave (tsunami) which reached some 300 yards inland from the coast and then retreated, added to the damage.

There was no electric supply and there were no telephones; sporadic fires occurred as the fires in buildings were scattered about; the sanitary and water systems were utterly destroyed. The headquarters building for the militia collapsed with loss of life, but the police headquarters remained standing. Moreover, there were only a few police in the buildings during this night of Ramadan. An orphanage for about a hundred children was shattered; the hospital was badly damaged, and the maternity ward destroyed. Sailors from the French naval air base some 2½ miles away were quickly on the scene, and their prompt action saved thousands trapped under the ruins.

The ancient Casbah, inhabited by some 500 people, built about the year 1540 on high hills above the port, was destroyed. The shock was felt strongly in Mogador, about 100 miles to the north.

King Mohammed put his son, the Crown Prince Moulay Hassan, in charge of all necessary operations. Total evacuation of the population was ordered, the dead buried, and rescue operations for those trapped were continued. The injured were evacuated to hospitals in other parts of Morocco, and tented camps were erected, a large one being between Agadir and the Moorish town of Inezgane, 7 miles south-east of Agadir, which itself suffered some 30 per cent damage. Many buildings left unstable by the earthquake have been demolished and, since epidemics, especially of typhoid and plague, were feared, a 5-week quarantine was ordered. The ground has been spread where necessary with quicklime and 800 tons of DDT have been sprayed on the area.

At the port of Agadir all cranes collapsed with the falling-in of the quays and jetties, except on the main jetty. The principal cargo sheds were damaged, the harbourmaster killed and both pilots injured.

Evidence of a tremendous submarine upheaval off the coast was obtained from preliminary naval soundings. In one case the depth of water was found to be 45 ft. where previously it was charted at 1,200 ft. In a position about 9 miles from the shore, soundings showed a depth of 1,200 ft. instead of the charted 4,500 ft. An extensive hydrographic survey will thus be required, especially near the harbour, where some dredging was necessary even before the earthquake.

The shock was registered by seismographs at observatories throughout the world (Durham University Observatory, England, *iPz* 23h. 45m. 44s. *D*, *iSE* 23h. 50m. 21s. U.T.), and the United States Coast and Geodetic Survey placed the preliminary epicentre at lat. 30° N., long. 9° W. Small aftershocks have continued to occur, one at about 22·30h. on March 3, one about 00·01h. on March 4, two on March 5 and one on March 6.

The Times reported "an informed source" as stating that the insurance coverage in London for Agadir was expected to be a good deal short of one million pounds, "as North Africa is not regarded as a dangerous area for earthquakes" and as Agadir is basically under French influence and dealt with by French insurance companies. However, any rebuilding which may be undertaken at or near the present site of Agadir must now take earthquake risk into account. Earthquake damage at a given place depends on the properties of the elastic waves arriving there, on the ground at the site shaken, and on the structures involved. The ratio of amplitudes at sites on fairly dry alluvium more than 500 ft. deep to those at sites on crystalline rock is frequently 5 : 1, or more for earthquake waves of period 1–1¼ sec. For waves of period about 0·1 sec. and for waves having periods exceeding 10 sec. (length more than 10 miles) the differences in amplitude are small. Amplitudes of earthquake waves at sites on water-saturated soft ground may be ten times those on crystalline rock. The period of waves giving the maximum ratio decreases to a quarter of a second for places with alluvium about 100 ft. thick. Moreover, at sites on alluvium the length of time of shaking also increases. Ground effects may produce these appreciable differences in duration and amplitude even at localities only a fraction of a mile apart. The importance of choosing crystalline rock or at least dry ground, and of avoiding water-saturated soft ground for foundations of buildings in order to reduce potential earthquake damage, cannot be overemphasized.

OBITUARIES

Dr. W. F. P. McLintock, C.B.

William Francis Porter McLintock, formerly director of the Geological Survey of Great Britain, was born in Edinburgh on February 2, 1887, and was educated at George Heriot's School and the University of Edinburgh. He graduated in 1907, with special distinction in botany, in a remarkable science class of a dozen students which yielded two directors of Geological Surveys (Heron of India was the other), two principals and one professor in Dominion universities, and two heads of departments in the Indian Civil Service.

Following a Civil Service examination in mineralogy, McLintock was appointed assistant curator in the Museum of Practical Geology. Four years later, in 1911, he was promoted to take charge of the geological galleries of the Royal Scottish Museum; and when the Geological Survey and Museum was reorganized in 1920 under the directorship of (Sir) John S. Flett, he returned with Flett from Edinburgh to London, this time as curator. The Museum and Library at 28 Jermyn Street, built in 1851, had long been a reference centre for economic geologists and mining engineers, and a rapid growth of the collections there reflected McLintock's ever-helpful advice to the many that sought it.

In 1927, the Royal Commission on Government Museums recommended the transference of the Museum of Practical Geology to South Kensington, and under Flett's direction McLintock spent the following years in planning the new Museum. His clear-cut and revolutionary ideas on the need for a popularization of geology found small support in a tour of European institutions and met with little encouragement in some academic quarters at home; but a happy co-operation with H.M. Office of Works enabled him to achieve his ideals when the Geological Museum was opened to the public in 1935, at the centenary of the Geological Survey. Nothing in recent years has done more to promote the study of geology in Britain. From an attendance of 18,000 a year in Jermyn Street, the annual number of visitors soon soared to more than 250,000 and to-day exceeds 300,000.

When war came, the Museum was taken over as headquarters of the London Civil Defence Regional Organization, and the collections and library were in part dispersed to the country. McLintock, then deputy director of the Geological Survey, became responsible for the administration of the Survey's war effort, initiating departments dealing with raw materials for atomic energy, exploration geophysics, underground storage of petroleum, and other strategic fields. By 1945, when he succeeded as director, he had plans fully prepared to meet the heavy tasks of re-organizing the Survey on a much-expanded peacetime programme and rapidly restoring the Museum to public service. On completion of this work he resigned in October 1950.

McLintock's publications include a variety of papers on Cornish and Devon minerals, and on the zeolites of Mull; a model account of the Strathmore meteorite, the flight of which he himself observed from an Edinburgh street and which he acquired for the national collections the next morning: a guide to the Geological Museum's collection of gemstones, now in its third edition; and a petrographical study of unusual pseudo-igneous rocks collected by him in Persia, which were shown to be sediments fused in the combustion of oil and gas seepages long since extinguished. In a long and fruitful collaboration with Dr. J. Phemister, he organized and carried out pioneer gravitational and magnetic surveys at many localities in Britain, to demonstrate the usefulness of geophysical methods in geological exploration.

Many will recall the brilliance and pungency of his conversation, the precision of his long memory, the independence of his judgment, and the sharpness with which he devastated all that was hollow and unsound; but perhaps those colleagues who shared with him the long night watches in war-time London appreciated best his unswerving loyalty to the Geological Survey and unselfish devotion to the interests of its staff. He died suddenly in Edinburgh on February 21, following a happy decade of retirement, with his wife, in the Perthshire countryside.

C. F. Davidson

Prof. S. A. Mitchell

Prof. Samuel Alfred Mitchell, formerly director of the Leander McCormick Observatory, died in his eighty-sixth year at Bloomington, Indiana, on February 22. Born at Kingston, Ontario, he graduated at Queen's University, Kingston, in 1894, took a degree at Johns Hopkins University and became instructor and professor of astronomy at Columbia University. In 1912, he was appointed director of the Leander McCormick Observatory, Virginia, a post that he held until his retirement in 1945.

His chief work there was the determination of stellar parallaxes by photographic methods. He was a member of the Commission on Stellar Parallaxes of the International Astronomical Union from its foundation and followed Schlesinger as chairman of the Commission in 1928. He was also a member of the Commissions on Variable Stars, Solar Physics and Solar Eclipses. He was chairman of the last-named Commission from 1935 until 1950 and remained a member of it until 1958.

It is for his work on eclipses and on his speciality throughout, the chromospheric spectrum, that Mitchell will be best remembered. He went on ten eclipse expeditions—four in the United States and one each in Sumatra, Spain, Norway, Niauafoou (or Tin-can Island), Canton Island and Canada; in only three cases were the eclipse observations entirely spoilt by clouds—California in 1923, Norway in 1927 and Canada in 1932. Probably he saw the corona on more occasions than any one else. His book "Eclipses of the Sun" gives an account of his experiences.

Mitchell received the Watson Gold Medal of the U.S. National Academy of Sciences and was elected an associate of the Royal Astronomical Society in 1933, shortly after he had become qualified by naturalization as a citizen of the United States.

Thereto hangs an amusing story. When he married he was still a Canadian, and according to the law of the United States at that time his wife became a Canadian. Later he became naturalized as an American citizen, but the law had meanwhile been altered and the wife's nationality no longer followed her husband's; Mrs. Mitchell remained a Canadian under United States law but became American under British law. Later, wishing to visit her son, who was studying in England, she had to be naturalized as an American citizen in order to get a passport to come to England! F. J. M. STRATTON

Dr. George A. Edwards

GEORGE A. EDWARDS, associate research scientist in micromorphology, at the Division of Laboratories and Research, New York State Department of Health, died in Albany on March 1, at the age of forty-six. Dr. Edwards was a graduate of Tufts University 1939, and received his Ph.D. in biology from Harvard University, 1947. Prior to going to the New York State Department of Health in 1956, Dr. Edwards had been professor of general physiology, co-ordinator of research, and co-founder of the Marine Biological Laboratory, University of São Paulo, Brazil, from 1952; he was a corresponding member of the Brazilian Academy of Sciences.

In the Second World War, Dr. Edwards was aviation physiologist attached to the Air Force in the development of equipment for high-altitude flying and survival techniques for air-sea rescue. Dr. Edwards did extensive research on nerve and muscle physiology, pharmacology, and morphology. His recent publications in electron microscopy included also studies of the ultra-structure of several dimorphic pathogenic fungi and the micromorphology of human bronchogenic carcinomas.

NEWS and VIEWS

Physics at Liverpool: Prof. J. M. Cassels, F.R.S.

PROF. J. M. CASSELS has been appointed to the Lyon Jones chair of physics at the University of Liverpool in succession to Prof. H. W. B. Skinner, who died in January. Prof. Cassels was educated at Rochester House School, Edinburgh, St. Lawrence College, Ramsgate, and Trinity College, Cambridge. Although best known for his many contributions to high-energy physics, his earliest work was performed at the opposite extreme of the energy-scale in nuclear physics when he carried out an elegant and painstaking research in the scattering of very slow neutrons by solids, using the Cavendish Laboratory cyclotron in collaboration with R. Latham. His introduction to high-energy physics was at the Atomic Energy Research Establishment, Harwell, where he worked with the 175-MeV. protons of the synchrocyclotron between 1949 and 1953, producing many papers on nucleon-nucleon scattering and high-energy nuclear interactions. From there he moved to the bigger synchrocyclotron at Liverpool, first as a lecturer and in 1956 as professor of experimental physics. His main research interests were now in pion physics, and he built up a strong group working in this field. He was elected to the Royal Society at the early age of thirty-four. In 1959 he took an appointment at Cornell University with R. R. Wilson, where he has been using the 1·2-GeV. electron synchrotron in electron scattering experiments. He was closely associated with CERN during its earliest days, and has maintained close contacts with high-energy physics at the Atomic Energy Research Establishment and the Rutherford Laboratory.

Metallurgy at Leeds: Prof. J. Nutting

PROF. J. NUTTING, who succeeds Prof. N. J. Petch (see *Nature*, 183, 1643; 1959) in the chair of metallurgy in the University of Leeds, was educated at Mirfield Grammar School, Yorkshire (1935–42), and then at the Department of Metallurgy, University of Leeds (1942–45), where he was awarded the degree of B.Sc. with first-class honours in metallurgy. During the period 1945–48 he worked under the late Prof. Preece on the overheating and burning of steel and was awarded the degree of Ph.D. in 1948. He then went to Cambridge and worked for one year in the Cavendish Laboratory as a scientific officer for the British Iron and Steel Research Association and there joined with Dr. V. E. Cosslett and Prof. E. Orowan on the development of techniques for applying the electron microscope to metallurgical problems. In 1949 he became a demonstrator, and in 1954 a University lecturer, in the Department of Metallurgy, University of Cambridge. For the past twelve years he has worked on problems of phase changes in both ferrous and non-ferrous alloys and on the relation between phase changes and mechanical properties of alloys. He has been particularly interested in electron microscopy and its application to these problems of alloys. He has travelled and lectured widely at scientific conferences and in 1951 was awarded a Nuffield travelling fellowship to visit Canada and the United States.

A New British Computer

ON April 6 there was demonstrated in London the first commercially built British digital differential analyser. This machine, the *Corsair*, has been produced as the result of the joint activities of the Royal Aircraft Establishment, Farnborough, and Semiconductors, Ltd. The differential analyser as such is an old device, but the use of digital circuits to perform the operation of integration has infused it with new life and accuracy. The main attraction of a differential analyser, considered as an analogue device, is that it performs continuous operations such as integration at a much higher rate than is possible with a programmed digital computer. Analogue computing elements are, however, inaccurate, and it is difficult to attain precisions of more than about 1 per cent. The digital differential analyser overcomes this trouble by reducing the integration to digital summation, because this can be performed simply and at very high speed. In digital circuits accuracy is no problem, so that the *Corsair* is able to attain an accuracy of better than 0·01 per cent, which quite outclasses purely analogue devices.

The new computer uses about 2,000 transistors of which nearly 700 are of the surface barrier type, the characteristics of which permit the direct current connexion of various elements with consequent saving of complexity and space. The machine has the rather large number of 50 integrators, which gives it great power and versatility, its physical size is quite small—about 20 c. ft.—and its appearance is attractive and neat. When it is produced in quantity, it should prove an invaluable research tool in universities, colleges of technology and in industry. It is pleasant to see that Britain has now entered this important new field.

Imperial Chemical Industries, Ltd.

A NEW ammonia plant, with a capacity of 100,000 tons a year, and associated plants to make urea and fertilizers is to be built at Imperial Chemical Industries, Ltd., Severnside Works in south Gloucestershire, at a cost of upwards of £10 millions. This plant is expected to start production during 1963. This is the second important project that Imperial Chemical Industries has decided to construct on the new 1,000-acre Severnside site. The first, announced in February, will involve the construction of plants to make ethylene oxide and ethylene glycol, costing £5 millions. Imperial Chemical Industries has also decided to extend the methanol plant at its Heysham Works in Lancashire. A new plant to make 30,000 tons a year began production there only a few months ago. A further extension to make an additional 45,000 tons a year is now to be built, and is expected to be completed during 1962. Methanol is an important raw material for the plastics industry.

Scientific and Technical Services in Rhodesia and Nyasaland

A LIST has recently been published of government and statutory bodies concerned with scientific research and technical services in the Federation of Rhodesia and Nyasaland, giving in brief the history, functions, organization, location and establishment of each (Government Organizations and Statutory Bodies concerned with Scientific Research and Technical Services in the Federation of Rhodesia and Nyasaland, 1959. Pp. 80. Salisbury: Office of the Federal Prime Minister and External Affairs, 1959). Research within the Federation is treated as a "concurrent subject", that is to say, that both the Federal and Territorial Governments have power to legislate in this field. The Federal Government obtained the services of Mr. D. G. Kingwell, of the South African Council for Scientific and Industrial Research, to report on the development of science in the Federation. Mr. Kingwell's recommendations have been adopted, and a Research Act has been brought into operation which is designed to promote scientific and industrial research, including agricultural, veterinary and tsetse research, to establish a research foundation and to provide for the establishment of research councils.

Organization of Medical Care

A REPORT by a World Health Organization Committee on medical care embodies the opinion of a group of experts from several countries, representing public health administration, hospital administration, medical practice, health insurance and voluntary agencies, on measures for "the organization and co-ordination of comprehensive preventive and curative medical care services provided to the individual outside the hospital wards" (World Health Organization. Technical Report Series No. 176: Role of Hospitals in Ambulatory and Domiciliary Medical Care—Second Report of the Expert Committee on Organization of Medical Care. Pp. 32. (Geneva: World Health Organization; London: H.M. Stationery Office, 1959.) 1 Swiss franc; 1*s*. 9*d*.; 0·30 dollar.) The scope of such services is considered to cover ambulatory care in out-patient departments, domiciliary care, after-care and medical rehabilitation. While recognizing that the degree of co-ordination possible will depend on national or local conditions, the Committee considers that the establishment of a central authority with planning and advisory powers would facilitate the rational siting of services and maintain the standards of both the care given and the equipment available. The main out-patient services which would be expected to contribute to a programme of ambulatory and domiciliary medical care are defined, and their functions indicated. They are: dispensaries, polyclinics, out-patient departments, health centres, medical practitioners, industrial medical services, medical rehabilitation centres, and intermediate institutions such as day-hospitals and night hostels. It is emphasized that continuity of care is of the utmost importance; this involves provision for an easy transition from domiciliary and ambulatory to hospital care, and back to the physician first concerned with the case.

The National Research Development Corporation of India

THE fifth annual report and statement of accounts of the National Research Development Corporation of India covers the period ending March 31, 1959, and records sustained progress (pp. 23. New Delhi: National Research Development Corporation of India, 1959). Commercial production from several patents and processes licensed in previous years has already commenced and twenty-four licences were negotiated compared with seventeen in the previous year, and five processes went into production. Development expenditure on projects already sanctioned amounted to Rs. 3.91 lakhs, and gross income from premiums and royalties increased to Rs. 1.66 lakhs. Marketing of 'Hykol' brand activated carbons produced at the Regional Research Laboratory, Hyderabad, commenced, and mica insulating bricks and carbons produced by Corporation licencees have been used in the Bhilai steel plant. During the year 56 inventions were reported for development by 20 research institutions, bringing the total of reported inventions to 503. Projects for the refining of cotton seed oil and the production of copper chlorophyll from indigenous raw materials were completed, and progress is reported in the projects for phthalic anhydride, de-ionization of cane juice, white cement from feldspar, and the fluidized-bed technique for textile processing.

Inventory of Economic Studies in Africa

THE Commission for Technical Co-operation in Africa South of the Sahara has issued an annotated reading list of books, articles and official publications since 1945 dealing with economics in Africa (CSA/CCTA Publication No. 30; Joint Project No. 4: Inventory of Economic Studies concerning Africa South of the Sahara—an Annotated Reading List of Books, Articles and Official Publications. Pp. xi+301. (London: Commission for Technical Co-operation in Africa South of the Sahara, 1960)). The inventory, which has been edited by Miss Peter Ady on the basis of information collected by a panel of national correspondents in economics, is the outcome of the adoption by the Commission in 1957 of the recommendation of a Specialist Committee in Economics. Its 1,377 entries are confined almost entirely to publications dealing specifically with African regions or countries, but it has proved unusually difficult to draw the line between economics and anthropology and between political economy and politics. The entries are arranged alphabetically by author, first, geographically, under Africa General; Belgian Congo; French Republic and Community; Portuguese Africa; Spanish Africa; British Africa; Ghana, Central Africa; and South Africa. Within these sections the entries are classified by subject and there is an author index. Entries and annotations are in English and French.

Museum and Art Gallery, Durban

THE annual report of the Durban Museum and Art Gallery for the municipal year 1958–59 records that curatorial work has mainly centred on the new Marine Hall (pp. 19. Durban: Durban Museum and Art Gallery, 1959). The exhibits of sharks, rays, skates, turtle and Cape sealion have been installed and work on a large exhibit of the major game fishes of the Natal coast is nearly complete. After many experiments plastic has been used to good effect in these recent marine displays. The output of research work on the collections by the staff remains at a high level. Display and storage accommodation at the Old House Museum (which serves as a branch Folk Museum) is now so limited that serious consideration must be given in the relatively near future to the provision of an additional building, either as a separate entity in the grounds or as a wing of the Old House.

Field Studies Council

MEASURED by the quality of the courses conducted, the number of students attending the centres, and the financial outcome of the year's operation, the report of the Field Studies Council for 1958–59 is again one of continued progress. (Pp. 34+4 plates. London: Field Studies Council, 1960.) Over the past nine years the total number of bookings at the Centres has risen from 3,483 to 7,903. Of these, more than half were students of biological subjects, and more than a quarter of geographical and geological subjects. A surprising number of those attending took courses in art and archæology. Well over half the students attending were from grammar schools but, regrettably, the numbers attending from secondary modern schools remained very small; this is a matter to which education authorities should be asked to pay closer attention. Because of the establishment of a new centre at Slapton Ley, the Ministry of Education generously agreed not to carry out its declared intention progressively to reduce the £5,000 annual grant. The reduction will now begin next year and will not lead to much embarrassment. Further information concerning the work of the Council can be obtained from Mrs. F. H. C. Butler, Ravensmead, Keston, Kent.

Reference Books on Mineralogy in the U.S.S.R.

THE Academy of Sciences of the U.S.S.R. is planning to publish in 1959–65 a collection of reference books on mineralogy. The subjects covered by the projected volumes are as follows: Vol. 1, introduction, native elements, intermetallic compounds, arsenides and antimonides, sulphides; Vol. 2, haloids; Vol. 3, silicates (part 1); Vol. 4, silicates (part 2); Vol. 5, niobates and tantalates, carbonates, nitrates, borates, sulphates; Vol. 6, phosphates, arsenates and vanadates, tungstates, molybdates, etc.; Vol. 7, diagrams illustrating phase equilibria important in mineralogy. The size of each volume is estimated to be 500 pages and the price 38–40 roubles. This collection of reference books will be prepared under the auspices of the Institute of the Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, and of the Mineralogical Museum of the Academy of Sciences.

Scientific Bibliography of Latin America

THE Conference of Latin American Scientific Experts convened by the United Nations Educational, Scientific and Cultural Organization at Montevideo in September 1948 requested the preparation of a Latin American biobibliography (Unesco: Centro de Cooperacion Cientifica para America Latina. Scientific Institutions and Scientists in Latin-America. Paraguay (1er Volumen). Pp. ii+93. Chile (2° Volumen). Pp. ii+40. Montevideo: Unesco, Centro de Cooperacion Cientifica para America Latina, 1959). The preparation of this was undertaken by Unesco's Field Science Co-operation Office for Latin America in collaboration with Ibero-American organizations, and Vol. 1 contains a first list of Paraguayan scientists and scientific organizations. Scientists are listed alphabetically, with particulars of their qualifications and experience and publications. Vol. 2 gives similar data for institutions and scientists in Chile.

Ionosphere over Belgium during the International Geophysical Year

THE Royal Meteorological Institute of Belgium has been publishing monthly bulletins of the ionospheric observations taken at the station of Dourbres (lat. 50° 06′ N., long. 04° 36′ E.) during the International Geophysical Year (Royal Meteorological Institute of Belgium, Avenue Circulaire, 3, Uccle, Brussels, 18). An automatic ionosonde of the U.S. National Bureau of Standards type *C*–2 was used; this sweeps over the range of frequencies from 1 to 25 Mc./s. in 30 sec., emitting 30 pulses per sec. of 50 μsec. duration. The peak power transmitted is about 10 kW., from one of two vertical rhombic aerials used for the lower and upper parts of this frequency range (1–4 and 4–25 Mc./sec.). On normal days, soundings are made at about fifteen-minute intervals; but during the Regular World Days and Special World Intervals of the International Geophysical Year, soundings were made every five minutes.

The bulletins of Ionospheric Observations taken during July–October 1958, inclusive, have recently been issued. These are similar in form to those issued for the preceding months of the International Geophysical Year; and contain graphs of the median monthly values of the heights and critical frequencies of the E, $F1$ and $F2$ regions, and also curves showing the percentage of the total time during which the critical frequency of the sporadic Es layer exceeded the limiting values of 3, 5 and 7 Mc./sec. In addition to these graphs, the individual hourly observed values are given for the $F2$, $F1$, E and Es layers. Additional tables give the maximum usable frequencies for radio transmission over a distance of 3,000 km. by the $F2$ and $F1$ layers, and other values relating to the height and critical frequency of the sporadic E region. The symbols used throughout the bulletins conform with the decisions of the Union Radio-Scientifique Internationale/International Geophysical Year sub-committee on Ionospheric Soundings.

Modern Explosives

NUMBER 5 of the Royal Institute of Chemistry "Lectures, Monographs and Reports, 1959" covers the subject of modern explosives (by the late Dr. Wilfrid Taylor. Pp. 63. London: Royal Institute of Chemistry, 1959. 6*s*. net). It is a well-balanced review of modern chemical explosives, written by one of the most distinguished research workers on the subject who, until his death in 1958, was for many years in the Research Department of the Nobel Division of Imperial Chemical Industries, Ltd. It is an excellent introduction for the chemist, physicist or engineer, to the scientific basis of the development of chemical explosives. Dr. Taylor describes in succession the early history of the development of high explosives, the properties sought from explosives, the chemical composition of the more important individual explosives and of the various commercial mixtures developed from them to suit various requirements. He follows with sections on the physical phenomena of detonation (velocity of detonation, temperatures and pressures developed during detonation), and on the precise physical action of explosives in breaking rock and coal. Next is a brief but useful statement of the hydrodynamical theory of detonation, followed by a discussion of modern views of reaction mechanisms in detonation. A special section is devoted to coal-mining explosives, which have to reach the highest possible safety against the danger of ignition of firedamp and coal dust. The whole subject is condensed into sixty very readable pages, with a couple of pages of references carefully selected from among the thousands of original papers on the subject.

A Radiocarbon Dating System using Scintillation Techniques

A PROCEDURE for radiocarbon dating, based on the use of scintillation techniques, is described by C. F. G. Delaney and I. R. McAulay (*Sci. Proc. Roy. Dublin Soc.*, A, 1, No. 1; 1959. 4*s*.). The method involves the conversion of the sample into methyl alcohol, which is then mixed with a liquid scintillator and its radiocarbon activity measured, in a quartz cell, using an arrangement of two photomultipliers in coincidence. The overall yield in the chemical preparation is about 45 per cent, and the purity of the methyl alcohol is checked by gas-phase chromatography. The background counting-rate is reduced by the use of massive screening combined with the application of the technique of pulse-height selection to the outputs of the photomultipliers. In this way, a background of 13·6 c.p.m. is obtained, and the net counting-rate for contemporary material is 20·6 c.p.m. above this value. Thus, when using a counting period of 17 hr., results of significance to 30,000 years are obtainable. The weight of sample required (equivalent to about 15 gm. carbon) is rather large compared with the requirements of most of the methods in current use, nearly all of which are based on proportional gas-counting techniques. However, this method, unlike those based in gas counting, has the advantage that it is not dependent on supplies of liquid air (which is not readily available in Dublin). Moreover, the preparative chemistry is relatively simple, and less steel screening is required than is necessary in most arrangements using proportional counters. The initial dating programme was concerned with the dating of vegetational changes detected by pollen analysis in a peat column from Redbog, Co. Louth, and the results of these measurements are presented.

X-Ray Studies of Some Carbonized Coals

IN a recent paper, R. Diamond has described a notable advance in the X-ray study of carbonaceous materials (*Phil. Trans. Roy. Soc.*, 252, 193; 1959). The paper reviews the author's detailed work with P. B. Hirsch on the X-ray examination of a range of coals carbonized up to 1,000° C., and brings together the analysis of variations in aromatic layer size distribution, mean C—C bond-length and molecular packing in a consistent model of the carbonization process. The approach to the problem of aromatic layer size distribution is particularly interesting not only because it is the first attempt of this kind, but also because of the elegance of the method. The author uses matrix methods in fitting a linear combination of theoretical intensity functions for graphitic layers of various size-groups to the observed X-ray intensities with the minimum total square error. The results are given as histograms showing the percentages by weight of material associated with each size-group. It would seem that this 'resolution' is approaching the limit attainable by X-ray analysis of these complex disordered materials. This is brought out in Diamond's careful discussion of the significance of layer diameter measurements when the structural model is modified to include edge groupings and departures of the aromatic layers from a truly graphitic structure. The structural chemist will want to know more about the nature of the aromatic systems as well as other features which X-ray analysis cannot elucidate, but the facts brought to light in this work should appreciably limit the range for conjecture in a field where it has inevitably been wide.

Culture of Salmon and Trout

IN many parts of North America, the culture of trout and salmon is carried out on a large scale, and a bulletin recently issued by the Department of Fish and Game for the State of California deals briefly with many aspects of hatchery practice (No. 107: Trout and Salmon Culture—(Hatchery Methods). By Earl Leitritz. Pp. 169. Sacramento: Printing Division, Department of Fish and Game, 1959. 2 dollars). The sections on feeding practices and the treatment of disease serve to illustrate how new methods and techniques have been introduced during the past ten or fifteen years. Comprehensive feeding schedules have been developed from actual production records, and in this way the fish are adequately fed with a minimum of waste and the minimum amount of labour. Various anæsthetics have been employed as an aid in tagging, taking of spawn and the transportation of fish. Until recently, urethane (ethyl carbonate) was perhaps the most common anæsthetic used in fishery work. However, tests with mammals have shown that this substance could be carcinogenic after prolonged and repeated exposures. Because of this risk to fishery workers, urethane is no longer used as a fish anæsthetic in California. As an alternative, *MS* 222 (tricaine methane sulphonate) is in common use both in the United States and Europe.

This book was prepared at the request of many of the Department's fish hatchery personnel, and naturally it is concerned mainly with the culture of rainbow trout and certain species of Pacific salmon. However, it contains much useful data and practical information, and would serve as a handy reference for anyone concerned with the rearing and care of salmonids in Britain.

Late Precambrian Fauna in South Australia

In 1947, R. C. Sprigg first described fossilized soft-bodied animals in what were then believed to be lower Cambrian quartzites near the Ediacara mining area, some 380 road miles north of Adelaide, South Australia. In view of its scientific importance, the area was proclaimed a fossil reserve in May 1958, under the control of the Minister of Education and the authorities of the South Australian Museum. In October 1958, M. F. Glaessner and B. Daily visited the area; they have now described its geology and remarkable fauna (*Rec. South Austral. Mus.*, 13; July 1959). It is estimated that eight hundred fossil specimens have been collected from near the top of the Pound Quartzite at Ediacara. Work on this material is not complete; but it is now thought that the fauna consists not only of medusæ believed to represent the Scyphozoa and Hydrozoa, but also Anthozoa (Octacorallia), Annelida, and at least two entirely new types of invertebrates. One or more elements of this fauna show relations with the fauna of the Nama System of South Africa, and one with *Charnia masoni* Ford from Charnwood Forest, England. Glaessner suggests that stratigraphic and palæontological evidence supports the placing of this fauna in the Late Precambrian rather than the Lower Cambrian. The fauna is marine, with both pelagic and benthonic elements, and the lithology suggests shallow water. All the forms appear to have been soft-bodied, and have been preserved as moulds and casts, almost entirely on the undersides of the flaggy quartzite beds.

Evidence of Concurrent Translocation

The problems of translocation in plants remain enigmatic and of perennial interest. In a recent investigation, evidence that different kinds of translocation take place concurrently has been obtained by C. D. Nelson, H. J. Perkins and P. R. Gorham (*Canadian J. Bot.*, 37, No. 6, 1181; 1959). The method used was to trace the pathway of photosynthetically assimilated carbon-14 in the soya bean. They found that when the primary leaf of a soya bean plant was allowed to carry on photosynthesis in labelled carbon dioxide, a small amount of labelled carbon was translocated downward into the root at a velocity of at least 5,040 cm. per hour. This velocity was fifty times greater than the velocity at which sucrose was translocated in the phloem. The rapidly translocated carbon-14 was not moved as carbon dioxide. When the time of translocation was increased from 30 sec. to 10 min. there was an increase in carbon-14 content of the root without any increase in carbon-14 content of the lowest part of the stem. Part of the carbon-14 was translocated through a steam-girdled stem, but under these conditions there was no accumulation in the root. This indicates that the rapid translocation of carbon-14 occurred in both living and dead tissues of the stem. These results were correlated with the localization of carbon-14 in tissue autoradiographs of cross-sections of the stem to show that there were at least three pathways of downward translocation: (*a*) a slow translocation in the phloem; (*b*) a rapid translocation in the xylem; and (*c*) a rapid translocation in either the cortex, the phloem, or the pith.

Grooved Rocks at Apoje, Nigeria

A report of some investigations on grooved rocks at Apoje, near Ijebu-Igbo, Western Nigeria, by William Fagg appeared in the December issue of *Man*. Only a few rocks were studied, but it would appear that there are many more in the region. The grooves, which are deep, wide and rounded, cannot be said to be anything in the way of figures, though circles and ellipses do occur. The problem naturally arises as to the age of these carvings and who made them. They do not recall other rock carvings described by H. Fosbrooke in *Man* during 1952, where it was shown that they were connected with initiation ceremonies. At the same time, these new finds are too carefully made to be merely the result of grinding and polishing stone tools. The modern inhabitants hold them in reverence, and this would suggest a certain antiquity and the probability that they were made by folk who preceded the ancestors of the present population. Maybe when other examples are discovered and studied the answer to these queries will become plain.

Australopithecine Tools

Bone tools at the Kalkbank Middle Stone Age site and the Matapansgat Australopithecine locality, Central Transvaal, are the subject of an article by Prof. R. A. Dart, Dr. Kitching and Revil J. Mason (*Arch. Bull.*, 13, No. 51; Sept. 1958). For some time, Prof. Dart has been studying what kind of bones very early man selected for possible tool-making purposes. Such a selective process would indicate some degree of intelligence. If it can be shown that even the Australopithecine used bone for simple tool-making, and selected certain kinds of bones and perhaps preferred certain animals, then a little more can be suggested as regards the intelligence of these lowly creatures.

Nematology at the Imperial College of Science and Technology

A new Nematology Laboratory for the Imperial College of Science and Technology, London, to be built and equipped at the College Field Station at Silwood Park, near Ascot, Berkshire, at a cost of £30,000, will be the first university laboratory in the Commonwealth specifically staffed and equipped for research and training in this subject at postgraduate level. Shell International Chemical Co. is contributing £15,000 towards the cost of building and equipping the Laboratory which, it is hoped, will be completed in time for the new academic year beginning next October. Under Prof. B. G. Peters, who was appointed to a new chair of parasitology in Imperial College in 1955 (see *Nature*, 176, 145; 1955), work on nematology has been developing, and a full-time one-year course in nematology was started in 1958.

Fritz London Award for Low-Temperature Research

Nominations for the second Fritz London International Award are being solicited from all low-temperature scientists by the selection committee for this award. The first award was made to Dr. Nicholas Kurti, of the Clarendon Laboratory, Oxford, at the fifth International Conference on Low-temperature Physics and Chemistry in Madison, Wisconsin, during August 1957. If a suitable candidate is found the award will be made at the seventh International

Conference on Low-temperature Physics to be held in Toronto during August 29–September 3. Further information can be obtained from Dr. F. G. Brickwedde, College of Chemistry and Physics, Pennsylvania State University, Pennsylvania.

The German Geological Association: Jubilee Meeting

THE Geologische Vereinigung held its jubilee meeting at Würzburg during March 12–14 and it was attended by more than four hundred geologists. The theme considered was orogens. Some thirty authors contributed, their papers being grouped under the headings: time and matter in orogenesis, and structure and distribution of orogens. In the first part the concept of geosynclines was discussed and the sedimentation, metamorphism and the part played by magma within them enlarged upon. In the second, special structures within mountain chains of five continents were described and the differences between those near, or on, the surface and those existing at depth were contrasted. The principal award of the Association, the Steinmann Medal, was made to Prof. H. H. Read, emeritus professor of geology in the University of London, for his outstanding contributions to geological science.

Helminthological Society of Washington Anniversary

THE Helminthological Society of Washington will observe its fiftieth anniversary on October 8. The scientific programme will be held in the University of Maryland, College Park, Maryland. A banquet will be held during the evening at the Naval Officers Club at Bethesda, Maryland. Dr. Chauncey D. Leake, president of the American Association for the Advancement of Science, will be the speaker at a banquet to be held on that day.

Wool Textile Research Conference

THE second Quinquennial Wool Textile Conference is to be held in the United Kingdom during May 18–28. The conference, the theme of which is "Fibre Science", is to be arranged by the U.K. Textile Institute and is to be held at Harrogate. Participants from other countries include: Australia, Belgium, Canada, Germany, Japan, Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland and the United States. Further details can be obtained from the Textile Institute, 10 Blackfriars Street, Manchester 3.

Summer Meeting of the Illuminating Engineering Society

THE Illuminating Engineering Society is holding its biennial summer meeting at Harrogate during May 15–18. Three papers will be presented: "Progress in the Field of Electric Lamps", by H. G. Jenkins (General Electric Co., Ltd.); "Rationally Recommended Illumination Levels", by H. C. Weston; "Plastics, Yesterday, To-day and Tomorrow", by C. L. Child (Imperial Chemical Industries, Ltd.). Further information can be obtained from the Secretary, Illuminating Engineering Society, 32 Victoria Street, London, S.W.1.

Announcements

H.M. THE QUEEN, who is Patron of the Royal Society, will open the tercentenary celebrations of the Society at a meeting in the Royal Albert Hall on the afternoon of July 19 (see *Nature*, March 26, p. 879).

DR. D. H. FOLLETT, keeper of the Department of Electrical Engineering and Communications in the Science Museum, South Kensington, has been appointed director of the Museum in succession to Dr. T. C. S. Morrison-Scott, who is succeeding Sir Gavin de Beer at the British Museum (Natural History) (see *Nature*, March 26, p. 888). Mr. D. Chilton has been appointed keeper of the Department of Electrical Engineering and Communications.

MR. R. C. PALMER, deputy director of research to Griffin and George, Ltd., and associated companies, has been appointed director of research in succession to Dr. A. J. P. Martin, who wishes to concentrate in future primarily on fundamental research. Mr. Palmer was on the staff of the Wool Industries Research Association, Leeds, during 1937–51, after which he was appointed director of research of the South African Wool Industrial Research Institute.

MR. LAWRENCE SUTTON, formerly director of studies at Ashridge College, has been appointed education officer to the Institution of Works Managers, 196 Shaftesbury Avenue, London, W.C.2. As such, he will collaborate with technical colleges running the Institution's two-year training course leading to the certificate in works management, of which more than a hundred were awarded in 1959.

APPLICATIONS are invited for the Bowles Memorial Travel Scholarship. The object of the Scholarship is to enable the holder to travel abroad for the purpose of either collecting plants for introduction to British gardens or studying practical horticulture in other countries. Applicants must be of the male sex, not more than twenty-eight years of age on January 1, 1961, and have some academic connexion with horticulture. Applications should reach the Secretary, Royal Horticultural Society, Vincent Square, London, S.W.1, by September 30.

UNDER the title "Postgraduate Courses 1960–61" the Imperial College of Science and Technology has issued a booklet giving particulars of postgraduate courses available leading to a degree or diploma and of shorter postgraduate courses (mainly lectures) for which, under appropriate conditions, certificates are also given (pp. xii + 113. London: Imperial College of Science and Technology (University of London), 1960). Many of the courses have been accepted by the Department of Scientific and Industrial Research as suitable for the tenure of Advanced Course Studentships, and grants for the courses in agricultural chemistry and nematology are awarded by the Ministry of Agriculture, Fisheries and Food.

THE seventh General Assembly of the International Union for Conservation of Nature and Natural Resources will be held during June 15–24 in Warsaw. The Assembly is to be held jointly with the eighth Technical Meeting; the final sessions will take place in Cracow. Further information can be obtained from the Secretariat of the International Union for Conservation of Nature, 31 rue Vautier, Brussels.

ERRATUM. In the communication entitled "Methods for the Evaluation of the Antibacterial Activity of Surface-Active Compounds" in *Nature* of April 9, p. 132, col. 2, line 47, for "fats" read "fate". The line now reads "The fate of micro-organisms in dishwater was investigated . . ."

THE CARNEGIE INSTITUTION OF WASHINGTON

THE report of the Carnegie Institution of Washington, covering the year ended June 30, 1959, includes the report of the President, those of Departments and Special Studies, to which bibliographies are appended, and the administrative reports*. In reviewing the work of the year, the President directs special attention to the work of the Geophysical Laboratory and the Department of Terrestrial Magnetism and particularly that concerned with the mechanism of formation, the age and composition of Earth minerals. Using special equipment designed to reproduce conditions of temperature and pressure occurring within the Earth's crust, studies of mineralogical changes at pressures up to 50,000 bars (equivalent to a depth of about 150 km.) have shown that orthopyroxene (a calcium–magnesium–iron silicate with manganese) and minerals rich in alumina common in crustal rocks will react under conditions of temperature and pressure found in the mantle to form the magnesian garnet, pyrope. Experimental petrological examinations have been made of pyroxenes, garnets, biotites, amphiboles, spinels and feldspars and investigations of nickel–sulphur binary, iron–arsenic–sulphur and nickel–arsenic–sulphur ternary systems completed. The theory of 'coloured space groups' within crystals was extended and the application of the extended theory to seven mineral compounds of the cubic type of crystal structure was studied. Chemical studies of the highly refractory substance kerogen have been directed at its mode of formation and structure, and pilot experiments indicated that glucose and glycine could be transformed to substances suggesting asphaltine or even kerogen, but of different solubility, by incubating mixtures of them at 100° C. and pH values within the range which might have obtained in sedimentary rocks at the time of kerogen formation.

The techniques of mineral dating by nuclear clocks have been further extended and the ages of two or more co-existing phases in single rocks determined. Work on rocks in the Appalachian complex indicates that major geological events separated by very long intervening periods may be recorded by different minerals in the same rock. Further evidence has been obtained on questions of mountain building and it is now planned to make use of local earthquakes for crustal studies. The first station of a local network for detecting seismic disturbances planned for Peru, Bolivia and Chile was installed near Arequipa during the year. These stations will be equipped with electronically operated seismic recorders requiring the minimum of attention. A study of the mechanisms of heat and electrical conduction of the Earth and their relations concentrated during the year on the photon energy absorption of ferromagnesium silicates showed that the strong ultra-violet absorption of iron-bearing olivines was correlated with the presence of iron in the minerals.

In preliminary studies of all the non-thermal or 'noise-storm' events occurring during the past two years on the Sun no correlation has so far been found between the 'noise-storms' and optical features. The solar observational programme was extensively revised on January 1, 1959, and many older types of observations were discontinued or drastically curtailed to allow systematic examination of the newly discovered weaker magnetic fields which cover much of the solar surface. Observations of Mars with the 200-in. telescope in October 1958 by a guest investigator, Dr. W. N. Sinton, established the presence of three distinct absorption bands near 3·5 microns, chiefly in the dark areas and only very weakly in the bright areas, and in approximately the same positions as are found the reflexion spectra of terrestrial plants, and providing the most suggestive evidence yet to appear for the hypothesis that the dark areas on Mars are caused by some form of plant life which develops seasonally in these areas. Four new supernovæ were discovered during the year, two in nearby galaxies being bright enough for detailed observation. The chemical compositions of a large number of stars have been studied, and the observations and those on colour–magnitude relations are being correlated with data on the generation of nuclear energy and energy transfer from star core to star surface, and it is beginning to appear that the magnitudes and other properties of stars of a given class are affected substantially by the large differences in chemical composition observed. The Committee on Image Tubes for Telescopes has reported thirty-fold reduction in exposure time with two types of image tube, one a single-stage tube, including a photocathode, provisions for electron optics, and a phosphor screen coated on mica, and the other composed of two simple one-stage image tubes cascaded in series, with the phosphor screen of the second stage being photographed, using a fast-relay lens; but both types still have shortcomings.

In the Department of Terrestrial Magnetism the Biophysics Section continues to devote much attention to the study of ribonucleoprotein particles found in bacteria, and striking progress was made during the year in applying quantitative methods to such problems. Improved methods were developed for separating ribosomes of different sedimentation constants by centrifuging through a sucrose density gradient, and by incorporating radioactive tracers in cells for very short periods it was possible to observe nascent protein which is associated with bacterial ribosomes for a short period before it is released as a finished product. Bacterial ribosomes had the same function in protein synthesis as the ribosomes of higher organisms, but the speed of synthesis is about sixty times greater. The new measurements also confirmed the earlier hypothesis as to the nature of ribosome particles and the intricacy of the synthesis of ribosomes. The nucleotide compositions of several classes of ribonucleic acid from *Escherichia coli* were determined by isotope-dilution techniques, using chromatographic and electrophoretic separations, and further information was obtained on the enzyme content of ribosomes, while the mechanism of protein synthesis was also studied through the amino-acid analogue technique, and considerable information was obtained on the mechanism of amino-acid selection by cells.

---

* Carnegie Institution of Washington Year Book No. 58, July 1, 1958–June 30, 1959. Pp. xi+500+15 plates. (Washington, D.C.: Carnegie Institution of Washington, 1959.) 1 dollar, paper bound; 1.50 dollars, cloth bound.

In the Department of Plant Biology it has been demonstrated that simultaneous absorption of light by chlorophyll *a* and chlorophyll *b* both increases the efficiency of light utilization by chlorophyll *a* and raises the initial photosynthetic rate after a dark period markedly over a situation when chlorophyll *a* alone is activated by light. Enhancement effects were also observed from alternate pulsing, in periods of 0·6–15 sec., of light sources of wave-lengths absorbed by chlorophyll *a* on one hand and chlorophyll *b* on the other. Studies continued on the characterization of the different forms of chlorophyll *a* occurring in living plants and additional evidence was sought for the differentiation of the three forms of chlorophyll *a* through fluorescence spectrography, differential bleaching and in other ways. By high-speed centrifugation in a liquid medium of graded density, protochlorophyll holochrome has been obtained relatively free from blue and ultra-violet absorbing contaminants and the transformation from protochlorophyll to chlorophyll was studied by observing the degree of fluorescence of freshly forming chlorophyll. Electron-microscopical studies of etiolated plastids showed that chloroplast lamellæ will form in the absence of protochlorophyll, but the normal aggregation and close pairing of the lamellar disks require the presence of chlorophyll. A bacterial pigment with protochlorophyll-like absorption properties was extracted from a mutant of the purple bacterium, *Rhodopseudomonas spheroides*. The gathering of essential data for the study of range grass hybrids of *Poa* is being concluded, and the investigations have revealed principles relating to the synthesis of new forms in apomictic genera by interspecific hybridization. A study on the genetic structure and evolution of the yarrows, members of the polyploid *Achillea millefolium* complex, is also nearing completion, and studies on rates of photosynthesis and respiration of two altitudinal races of *Mimulus cardinalis*, one from sea-level near the coast of California and the other at middle altitudes in the Sierra Nevada of California, have shown them to differ in the temperature optima and requirements for light saturation when functioning as intact plants. A device has been installed that can regulate, within a narrow range, the carbon dioxide in the air of a small chamber, thus permitting study of the effects of different concentrations of carbon dioxide on plants and simplifying the control of air temperature and relative humidity. In an analysis of the chromosome constitution of races of maize grown in Chile, Bolivia, Ecuador and Venezuela, a relation was found between the knob pattern and the geographical location of the race, which suggests that, under some conditions, a knowledge of the patterns of distribution based on chromosomal-knob constitution may give valuable evidence of the origins and migrations and past history of some early races of Indian corn.

The Department of Genetics has continued to focus attention on the structural and functional properties of genes and chromosomes, and it now appears that the suppressor–mutator system of control of gene expression in maize has some major resemblances to the system controlling flagellar–antigen formation in *Salmonella*. Studies of the effects of deoxyribonuclease on unfixed cells have shown that this enzyme enters the living cell and there brings about marked swelling and deformation of chromosomes, sometimes without appreciable loss of deoxyribonucleic acid. Hybrids have been obtained of *Salmonella typhimurium* and *E. coli*, thus permitting comparison of the homology of their chromosome structure, and the chromosome of the bacteriophage *T2* has been shown to consist of deoxyribonucleic acid, while the mechanisms of replication and recombination of genetic material in bacteriophages has also been investigated.

Studies of the synthesis and interaction of specific macromolecules, in the Department of Embryology, have been specially concerned with tissue specificity, and further experiments in immuno-embryology suggest that there may be two stages in the development of the immune response, which may be experimentally separable. Continued study of immune response of new-born rabbits to injections of chicken liver and spleen homogenates suggests that animals not injected at birth respond strongly to a few major antigenic components, whereas the response of the treated experimental group is eliminated or reduced. A study of the effects of thyroxine upon the metamorphosis of visual pigment of the eyes of the bullfrog tadpole afforded substantial support for the view that thyroxine acts directly on a rate-limiting factor in the eye itself. Encouraging results have been obtained in experiments on the inductive ability of tissue microsomes designed to elucidate inconsistencies in embryonic induction, attributed to a failure of ribonucleic acid or ribonucleoprotein to reach its site of action.

STATUS AND DEVELOPMENT OF THE TEACHING OF CHEMISTRY

AT the Organization for European Economic Co-operation's Summer School for Science Teachers held in 1958 at Tutzing, Germany, the opinion was expressed that chemistry teaching in secondary schools has changed little since 1900 and that the present descriptive approach to the subject involves much memory work on the part of the student, and displays little of the scientific method. It was agreed that it was urgent that chemistry should be taught from the perspective of present-day theory and that so far as possible modern knowledge should be fed back to the school. As a result of these discussions the Organization for European Economic Co-operation's Office for Scientific and Technical Personnel, which works under the direction of Dr. Alexander King, in co-operation with the Irish Department of Education, organized a seminar at Greystones, Co. Wicklow, during February 28–March 10.

The objective of the seminar was to consider at a high level the preconditions and possibilities of: (1) a revision of chemistry teaching based on the knowledge of the atom; (2) pruning of the subject-matter in order to give more time to fundamentals without, however, neglecting adequate experimental work; (3) teaching chemical principles in such a way that they play a part in training the intellect of the pupil. The seminar was asked to come to conclusions concerning the specific steps required to provide the basis for a curriculum more fitted, intellectually and practically, to the needs of modern chemistry.

The following countries were represented at the seminar: Austria, Belgium, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The participants comprised senior secondary school teachers of chemistry, those with official responsibility for chemistry programmes (senior officials of education ministries, inspectors of education), representatives of teacher-training institutes, professors of chemistry.

The proceedings were officially opened by Mr. Rafferty, secretary of the Irish Department of Education. Then followed the 'Keystone Address' of the chairman (Prof. T. S. Wheeler, Dublin). He recapitulated the objectives of the seminar and reviewed the papers to be presented, which were as follows: "Advances in Theoretical Chemistry since 1900" (Prof. K. Grob, Zurich); "The Importance of Molecular Structure in Elementary Chemical Teaching" (Prof. J. Bénard, Paris); "The Requirements for Entry to University Departments of Chemistry" (Prof. W. Cocker, Dublin); "The Requirements for School-leavers entering the Chemical Industry" (Dr. A. K. Mills, Dublin); "The Principles underlying Recent Advances in Practical Chemistry" (Dr. R. J. Magee, Belfast); "The Co-ordination of the Teaching of Chemistry, Physics and Mathematics in Secondary Schools" (Prof. M. Eurin, Paris); "The Teaching of Oxidation-Reduction and Acid-Base Reactions in Relation to the Electronic Atom" (Prof. A. Steiger, Zurich); "The Teaching of Chemistry to Students of 14–16 Years" (Dr. K. Stein, Bad Segeberg); "The Teaching of Chemistry to Students of 16–18 Years" (Dr. B. Borén, Stockholm); "Pruning and Simplification of the Syllabus and the Teaching of Fundamentals" (Prof. L. E. Strong, Richmond, Indiana); "New Materials and Teaching Aids, Text-books, Films, Models" (Prof. J. A. Campbell, Claremont, California).

The discussions were not confined to the set sessions, but were vigorous throughout the period of the seminar. Tuesday and the morning of Wednesday of the second week were devoted to the preparation of reports for transmission to the Organization for European Economic Co-operation. Owing to language difficulties, it was necessary to constitute three working parties (English and German; English and French; English or French, simultaneous interpretation). These parties were asked to make recommendations relating to two chemistry courses, one for students of 14–16 years and the other for those of 16–18. It was assumed that some three hours a week would be available for the study of the subject and that there would be facilities for experimental work.

It was realized that among countries conditions differ much as regards school-leaving age, facilities for practical work, time available for chemistry, and qualifications of teachers. In addition, schools have to cater for those who hope to become chemists and for others who have done with their chemistry when they leave school. Nevertheless it was considered that reports of the type envisaged would be of value to teachers anxious to modernize their courses, who could select to suit their needs.

Each working party had two chairmen (morning and afternoon) who kept in touch with the chairmen of other groups to ensure a measure of unity in the three approaches to the problems under consideration, though it was not thought disadvantageous to have three sets of views on the subjects at issue.

The reports were discussed at two plenary sessions of the seminar. It was agreed that the junior student should have his interest developed early in the constitution and properties of matter. Emphasis should be on observation, and formal definitions kept to a minimum. Methods other than the inductive arguments of Dalton should be used to develop the concept of atoms. The importance of space-filling models at all stages of instruction was stressed. The combustion of coke, the interaction of sulphur and copper, and similar systems can be employed to introduce the notions of chemical reactions, energy change, gaseous, liquid, and plastic systems, chemical equations and structural ideas. It is important that the student understand weight relationships and their correlation to chemical formulæ and equations.

For senior students atomic structure should be the framework of the course and not simply an additional chapter unco-ordinated with the rest of the chemical material presented. The Bohr–Rutherford atom provides a useful introduction; the nature of bonds should be discussed and directional characteristics emphasized. The law of mass action and chemical equilibrium should be treated in terms of reaction kinetics. The Brønsted treatment of acid-base equilibrium is recommended; redox systems can usefully be considered. Reaction mechanisms, thermochemistry and electrochemistry should also be treated in an advanced school course. So far as possible, phenomena should be related to structure; consideration of ion size can be illuminating in the study of crystals. The concept of electronegativity can also be employed to advantage in the discussion of chemical reactions.

Organic chemists should also be taught from the electronic point of view. The nature of single, double and triple bonds should be explained and the reactions of functional groups displayed in relation to their structure. The use of experimental results in the assignment of organic structures provides excellent examples of the application of the scientific method. If time permits, stereoisomerism should be discussed.

In all school courses the collection of a great number of facts about elements and compounds should be avoided. There is no necessity for systematic treatment of elements; examples should be drawn from the chemistry of one or more elements to illustrate a subject, for example redox systems, under discussion. Brief descriptions of technical processes should be introduced where they are of value in illustrating chemical principles. In this connexion reference was made to the tendency for accounts of out-of-date plant to be retained in school text-books. Properly prepared films and film strips can be of great help at all levels of instruction.

The seminar stressed the necessity for providing teaching of physics and mathematics such that the chemistry student has at all stages a knowledge of these ancillary subjects adequate for his needs. Finally, it was suggested that the Organization for European Economic Co-operation bring the recommendations to the notice of the appropriate authorities in the member countries with a request for comments. After an appropriate time small working parties, constituted similarly to the seminar, should meet in Paris to consider such comments as are received and to prepare manuals outlining school courses in chemistry relating to : (*a*) lectures ; (*b*) demonstration experiments by teachers ; (*c*) laboratory work by students. The necessity for devising means for training teachers capable of dealing with these new courses should also be considered.

The participants in the seminar felt that their discussion about a new approach to chemistry had been worth while, and that many concrete ideas of practical value had been elaborated.

T. S. WHEELER

WATER POLLUTION BY TRADE EFFLUENTS

THE last two major Acts in Britain governing the disposal of sewage and industrial effluents were the Public Health (Drainage of Trade Premises) Act of 1937 and the Rivers (Prevention of Pollution) Act of 1951 ; River Boards, which are responsible for controlling the discharge of polluting liquors to rivers, were set up by an Act passed in 1948. During the past few years, some of the provisions of the Acts of 1937 and 1951 have led to much discussion ; a committee, under the chairmanship of Sir Frederick Armer, set up by the Central Advisory Water Committee, after hearing evidence from the many interests concerned with pollution of surface waters, has now reviewed the experience of the past twenty years, and has recommended some important changes in the law*.

The Rivers (Prevention of Pollution) Act differentiated between discharges to streams already being made in 1951, and discharges made after that date. A River Board could control existing effluents in either of two ways : it could bring an action against anyone discharging a "poisonous, noxious, or polluting" liquid, it being left to the Court to decide whether the liquid could be so described, or it could make by-laws (which would require confirmation) covering a stream, or part of a stream, specifying standards of quality with which discharges would have to conform. It had been widely hoped and expected that River Boards would formulate by-laws, at least in industrial areas, since a manufacturer, for example, in designing a plant to treat a polluting liquor, clearly wishes to know the specification of the final effluent he is called on to produce.

It has been found, however, to be very difficult to formulate by-laws, and in fact none has so far been confirmed and come into operation. Since any standards adopted were expected to apply to a considerable length of river, if not to the whole of a river system, the first difficulty was to draw up a specification of permitted effluents which might have to be applied to a wide range of industrial wastes, the composition of which might be unknown, even to the manufacturers, and which might be so complex in composition as to make routine chemical analysis impracticable ; an example would be a liquor arising from the cooling and washing of a town's gas supply. This perhaps could have been overcome by examining liquors of whatever kind by a few comparatively simple tests, each designed to measure the effect of the liquor on some property of a stream. Among those suggested were tests for *p*H value, toxicity to fish, and concentration of suspended solids and oxidizable matter. A greater difficulty is that it is impracticable to treat all polluting liquors, particularly industrial liquors, to give effluents of a common standard of quality—a point which, from internal evidence, was clearly in the minds of those who drew up the Act of 1951.

Control of new or altered discharges brought into use after 1951 was, however, effected in a different way. Here a River Board could impose conditions on the nature and composition, and on the volume, of the discharges, each being considered separately. It was thus possible in each case to draw up a specification appropriate to the liquid to be discharged ; for example, for a liquor from electroplating, the maximum allowable concentrations of toxic metals and of cyanide would be specified. This machinery has worked very well, and since 1951 agreement has been reached on the conditions of discharge of large numbers of new effluents.

The Committee now recommends that River Boards should be empowered (subject to appeal) to deal with all discharges, whether new or existing, by essentially the same procedure. It was recognized that the improvement of the quality of some rivers, particularly the more heavily polluted of them in industrial areas, will have to be a gradual process It is proposed, therefore, that a River Board should have powers to impose standards on effluents which could be reviewed later, and, if necessary, made more stringent.

On the question of discharge of industrial wastes to sewers of a local authority, the chief change recommended is that, except where a contract is in force, the authority should now be empowered to make a charge for the treatment of liquors which have been discharged without major change since before 1937 ; under the Act of 1937 these acquired 'prescriptive rights' and were exempt from payment. All traders would have to furnish information to their local authorities on the volume and nature of effluents discharged to sewers

The Committee took evidence from all the major interests concerned with the purity of streams and, on all but one matter (the private rights of a riparian owner) have produced a unanimous report, which if implemented by legislation should greatly assist River Boards and local authorities in reducing the level of pollution of rivers in Great Britain.

---

* Ministry of Housing and Local Government : Central Advisory Water Committee. Final Report of the Trade Effluents Sub-Committee of the Central Advisory Water Committee. Pp. iv+52. (London : H.M. Stationery Office, 1960.) 3s. 6d. net.

IRIDIUM–PLATINUM ALLOYS

DR. A. S. DARLING has recently published a critical discussion of the constitution and properties of the iridium–platinum alloys*. Until comparatively recently it was generally believed that these metals were completely miscible in each other in both the liquid and solid states—the liquidus curve, lattice parameters, electrical resistivity and micro-structures all suggesting a continuous series of solid solutions. At the same time, there were other facts difficult to reconcile with such a view. As early as 1886 Le Chatelier had observed a thermal abnormality in the 20 per cent iridium alloy around 700° C., and in 1940 Masing, Eckhardt and Kloiber settled the matter by showing that a natural crystal from the Urals had a well-defined two-phase structure.

The true nature of the equilibrium diagram was finally established by Raub and Plate (*Z. Metallkunde*, 47, 688; 1956), who showed that there is a miscibility gap with a maximum at 975° C. and 50 atomic per cent. At 700° C. this gap extends from 7 to 99 atomic per cent of iridium. That earlier workers had failed to appreciate the true state of affairs was due to the extreme sluggishness of the change, annealing periods of the order of a year being required to establish "some semblance of equilibrium" in parts of the two-phase region. The most accurate method of determining this phase-boundary appears to be from measurements of electrical resistance.

The strength and hardness of the alloys increase rapidly with the iridium content, 30 per cent raising the tensile strength from 10 up to 56 tons per sq. in. for the alloy quenched from 1,100° C., the Vickers Pyramid Number increasing seven-fold. Cold-working has an equally marked effect, and the tensile strength of cold-drawn 20 per cent iridium wire may exceed 100 tons per sq. in. Very high hardness values can, as would be expected from the diagram, also be produced by quenching followed by subsequent ageing, the 50 per cent alloy quenched from 1,400° C. and reheated to 700° C. for 15 hr. having a Vickers Pyramid Number around 500. It is not clear, however, whether the fully aged alloys retain sufficient ductility to permit the hardness to be raised still further by cold work.

Alloys containing up to 40 per cent of iridium have been hot-forged and even drawn into wire, and when melted in the argon arc, alloys of still higher iridium contents can be worked with difficulty. The presence of iridium considerably increases the resistance of platinum to corrosion, the 40 per cent alloy being virtually unattacked by boiling aqua regia. The high evaporation losses of these alloys at high temperatures is attributed to the volatility of iridium oxide, a matter of importance in connexion with their use in pyrometry.

Among the more important uses of these alloys Dr. Darling mentions their applications in electrical contacts, precision resistors and potentiometer slide-wires. The 10 per cent iridium alloy used in combination with a 40 per cent palladium–gold wire which generates an electromotive force of 34 millivolts at 600° C. forms a useful thermocouple for moderate temperatures. Bridge wires in electric detonators, fuses and cartridge igniters, the needles used for the initial perforation of diamond wire-drawing dies, suspensions for scientific instruments and hair-springs are other uses to which these alloys have been put.

---

* *Platinum Metals Rev.*, 4, No. 1; Jan. 1960.

DEVELOPMENT OF LEARNING IN THE RHESUS MONKEY

DURING the past five years Harry F. Harlow and his colleagues have conducted an integrated series of researches into the learning capabilities of rhesus monkeys from birth to intellectual maturity*. Control over the monkey's environment has been achieved by separating the infants from their mothers at birth and raising them independently.

Half a decade is too brief a period to establish a definitive programme on the maturation of learning ability in the rhesus monkey, particularly in the later age-ranges. Within this period of time, however, techniques and tests have been developed which demonstrate that such a programme is feasible. The monkey is capable of solving simple learning problems during the first few days of life, and its capability of solving ever-increasingly complex problems matures progressively, probably for four to five years.

Early in life, new learning abilities appear rather suddenly within the space of a few days, but, from late infancy onward, the appearance of new learning powers is characterized by developmental stages during which particular performances progressively improve. There is a time at which increasingly difficult problems can first be solved, and a considerable delayed period before they can be solved with full adult efficiency.

The monkey possesses learning capacities far in excess of those of any infra-human primate, abilities comparable to those of low-level human imbeciles. The monkey's learning capabilities give little or no information concerning human language, and only incomplete information relating to thinking.

These are the generalizable limits of learning research on rhesus monkeys, but they provide an animal with vast research potentialities. There is a wealth of learning problems which the monkey can master, and at present the field is incompletely explored. The maturation of any learning function can be traced, and the nature and mechanisms underlying interproblem and intertask transfer can be assessed. Great research potentialities exist in analysing the fundamental similarities and differences among simple and complex learnings within a single species. The monkey is a subject ideally suited for studies involving neurological, biochemical and pharmacological correlates of behaviour. Rhesus monkeys can be raised under completely controlled conditions throughout a large part and, probably, all of their life-span, and the research of the future will probably correlate the neurophysiological variables, not with the behaviour of the static monkey, but with the behaviour of the monkey in terms of ontogenetic development.

---

* *American Scientist*, 47, No. 4; December 1959.

SCIENTIFIC RESEARCH IN ANTARCTICA

THE Antarctic Treaty signed at Washington on December 1, 1959, by the British Government and by twelve others, all with interests, scientific or otherwise, in the Antarctic, including all seven claimants to the Antarctic's territories, recognized, in a preamble, that it is in the interests of all mankind that Antarctica should continue to be used exclusively for peaceful purposes and should not become the scene or object of international discord. The Treaty also recognized the extreme importance of scientific work and the firm foundation for the continuation of that work resulting from the International Geophysical Year.

In a short debate on the Antarctic in the House of Lords on February 18, opened by Lord Shackleton, who asked when the Government expected the Treaty to be ratified and what its policy was with regard to the future Antarctica, Lord Shackleton stressed the great value of the Antarctic as a source of scientific information. While that scientific interest had led to a remarkable degree of international co-operation, Lord Shackleton was somewhat concerned as to the possibility and effect of development, geologically and in other ways. In particular, he asked what provision had been made for the continuing discussion contemplated under Article 9 of the Treaty and what type of administration the Government had in mind. The Bishop of Norwich, who asked for a Government assurance that the British contribution in Antarctic investigation and research under the Treaty would not be less than that at present existing, also stressed the value of Antarctic research in long-range weather forecasting, geophysics, glaciology and some branches of biology ; and after a tribute to the work done by Great Britain in the past, he emphasized the value of the opportunity for international collaboration in scientific work which the Antarctic offered.

Lord Lansdowne, who replied for the Government, said that it hoped to ratify the Treaty at an early date and that the Government's policy was to promote the basic aims of the Treaty. The Treaty should ensure the use of Antarctica for peaceful purposes only and it was hoped that it had established a firm foundation for scientific co-operation. The Government would have preferred a more comprehensive system of administration, but this could not be achieved at the conference. The question of some form of permanent secretariat was now under discussion. On the exchange of strictly scientific information and the planning of research, which came under Article 3, the Government considered that governments should not attempt to supersede the existing organizations such as the Special Committee on Antarctic Research, which had been working effectively since 1958. This Article, in fact, said: "every encouragement shall be given to the establishment of co-operative working relations with those Specialized Agencies of the United Nations and other international organizations having a scientific or technical interest in Antarctica". He hoped we would continue to make full use of such recently created organization and of the Specialized Agencies of the United Nations. The Government expected the Falkland Islands Dependency Survey, which was a principal contributor to Antarctic research, to continue, and those people most immediately affected by the Treaty, such as observers, exchange scientists and their staffs were, in fact, covered by the juridical and administrative arrangements.

VISUAL PIGMENT OF THE HORSESHOE CRAB, *LIMULUS POLYPHEMUS*

By DR. RUTH HUBBARD and PROF. GEORGE WALD

Biological Laboratories, Harvard University, Cambridge, Mass.

OWING mainly to the work of Hartline, the eye of the horseshoe crab, *Limulus*, has long been a classic object for electrophysiological investigation. This was the first eye in which electrical responses were recorded from single visual receptors[1]. The large size of these units and the relative simplicity of their nervous connexions have permitted a degree of analysis not achieved with other types of visual element[2]. This growing body of electrophysiological information lends special interest to the chemistry of the underlying processes.

We have now extracted the visual pigment of *Limulus*. This is the fourth arthropod visual pigment to be examined and the first such pigment obtained from an arachnoid. Two visual pigments have been extracted earlier from crustaceans, one from a euphausiid[3], the other from a decapod, the lobster[4] ; and a visual pigment has also been obtained from an insect, the honey-bee[5].

The principal results of our experiments are summarized in Fig. 1. From a fraction of the eye tissues which we believe consisted largely of fragments of rhabdomeres, we have extracted a photosensitive pigment with $\lambda_{max.}$ 520 mμ. The chromophore of this pigment is retinene$_1$. We therefore consider it to be a rhodopsin. On exposure to light it bleaches to a mixture of retinene and opsin. This behaviour, characteristic of vertebrate rhodopsins, distinguishes the *Limulus* pigment sharply from certain other invertebrate rhodopsins—squid, octopus, cuttlefish, lobster—which under physiological conditions do not bleach but yield in the light relatively stable red-orange metarhodopsins, in which retinene remains attached as chromophore to opsin[4,6].

The curve shown in Fig. 1 is a difference spectrum measured in the presence of hydroxylamine. This reagent combines with retinene$_1$ to form retinene$_1$

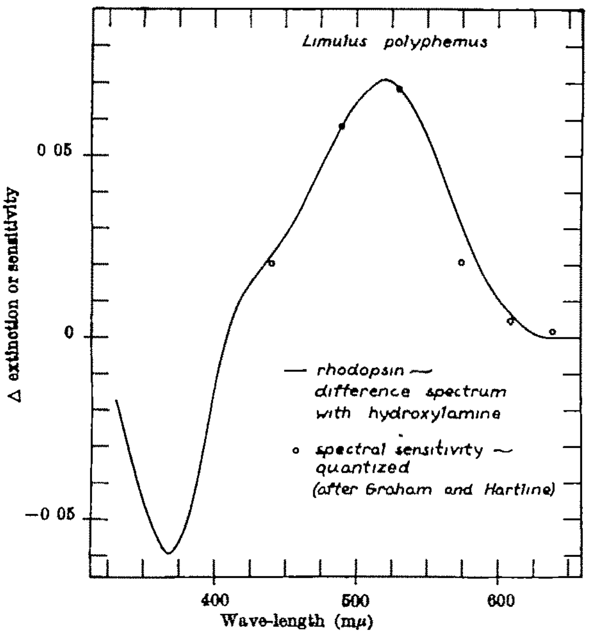


Fig. 1. Absorption spectrum of *Limulus* rhodopsin, compared with the spectral sensitivity of the photoreceptors *in vivo*. The difference spectrum, measured in the presence of hydroxylamine, shows the changes in absorption caused by exposure to light. The positive changes (λ_{max} 520 mμ) represent the bleaching of the visual pigment, and are equivalent to its true absorption spectrum at wave-lengths longer than 450 mμ. The negative changes represent the formation of retinene$_1$ oxime ($\lambda_{max.}$ 367 mμ) as a product of bleaching. The absorption spectrum of the visual pigment in solution agrees with the spectral sensitivity of the eye measured electrophysiologically by Graham and Hartline

oxime, with $\lambda_{max.}$ at 367 mμ, which appears as a minimum in this figure. The use of hydroxylamine identifies the product of bleaching unequivocally as retinene$_1$, and also makes the difference spectrum equivalent to the true absorption spectrum at wave-lengths longer than 450 mμ (ref. 7).

The points in Fig. 1 show the measurements by Graham and Hartline of the spectral sensitivity of photoreceptors in the eye of *Limulus*[8]. They are in good agreement with our absorption spectrum.

Our first attempt to find a visual pigment in the *Limulus* eye involved large, sexually mature animals (about 12–15 cm. across the carapace), collected on the beaches while mating. The eyes of these animals were highly sclerotic, and in most cases the corneas were virtually opaque, frequently heavily encrusted with algae, and sometimes perforated. On extracting these eyes, we found no photosensitive pigment or retinene, but obtained only a small amount of chlorophyll, presumably from the algae, and some carotenoid.

We therefore began working with young *Limulus*, 3–5 cm. across the carapace, having pliable, amber-coloured shells, and transparent corneas. The animals were dark-adapted over-night and all procedures carried out in dim red light. A cut was made around the cornea, and the eye was lifted off. The eyes were collected on dry ice and stored at −15° C.

In an earlier preparation of rhodopsin from lobster eyes[4] it had proved advantageous to isolate the structures containing the visual pigment—presumably the rhabdomeres—by using the methods ordinarily employed to isolate the outer segments of vertebrate rods and cones. We hoped in the same way to separate the rhabdomeres of the *Limulus* eye from the remaining tissues and black screening pigment.

In one of our first experiments, the eyes from 44 animals were thawed and ground thoroughly in a mortar with 8 ml. of 45 per cent sucrose in neutral $M/15$ phosphate buffer. This suspension was layered over in a centrifuge tube with neutral phosphate buffer and spun in a Spinco preparative ultracentrifuge at 40,000 r.p.m. for 10 min. A fine layer of tissue fragments, presumably including the rhabdomeres, collected at the interface between the sucrose and buffer solutions, the remaining tissues and black pigment forming a sediment at the bottom of the tube. The interfacial material was drawn off with a syringe and the sediment was reground and fractionated as before. The interfacial material from both these flotations was pooled, diluted with buffer, and sedimented by centrifuging at 40,000 r.p.m. for 15 min. The faintly straw-coloured supernatant was discarded and the tissue was extracted with 0·6 ml. of 2 per cent aqueous digitonin for 1 hr. at 5° C. After clearing this extract by centrifuging, its absorption spectrum was recorded in a Cary spectrophotometer. On exposure of this solution to light, a just perceptible bleaching occurred in the visible spectrum, accompanied by a small rise of extinction in the near ultra-violet, suggesting the bleaching of a visual pigment to retinene. However, the changes were much too small to yield a reliable record.

We first thought that our isolation procedure had possibly lost most of the visual pigment, and decided therefore to see whether retinene could be obtained from whole eyes and in what quantity. The eyes of 51 animals were ground in a mortar with about three times their volume of anhydrous sodium sulphate. The dry product was pre-extracted with petroleum ether in the dark. The extract contained a yellow carotenoid, epiphasic on partition between petroleum ether and 90 per cent methanol, both before and after saponification. It possessed absorption bands in hexane at about 425, 449, and 476 mμ and was apparently β-carotene. No vitamin A or retinene was found in this extract.

The tissue was then extracted exhaustively in the light with acetone containing a few per cent ethanol and water. The light should have bleached any visual pigment that was present, the acetone-ethanol should have destroyed it by denaturation. The extract, transferred to 2 ml. hexane, was pale yellow, owing to a small residue of carotene. The direct spectrum showed little but general absorption rising steeply into the near ultra-violet. The extract was transferred to 0·3 ml. chloroform, and 0·25 ml. of this solution was mixed with 1 drop of acetic anhydride and 0·5 ml. of saturated antimony trichloride in chloroform. The absorption spectrum, recorded immediately, is shown in Fig. 2, curve 1. It displays the absorption band characteristic of the antimony chloride product of retinene, with $\lambda_{max.}$ 667 mμ, distorted by a second band at shorter wavelengths ($\lambda_{max.}$ about 600 mμ) caused by some unidentified contaminant. The latter band faded rapidly, so that a second spectrum, recorded a few minutes later, displayed the retinene band alone (curve 2). From curve 2 one can calculate that this extract from 102 eyes contained about 4×10^{-4} μmole retinene, that is, about 4×10^{-6} μmole per eye. This amount of retinene from the whole eye is in reasonable agreement with the amount of rhodopsin we had extracted from the tissue isolated by flotation in the previous experiment. There was no reason to doubt, therefore, that we had isolated the correct tissue ; but

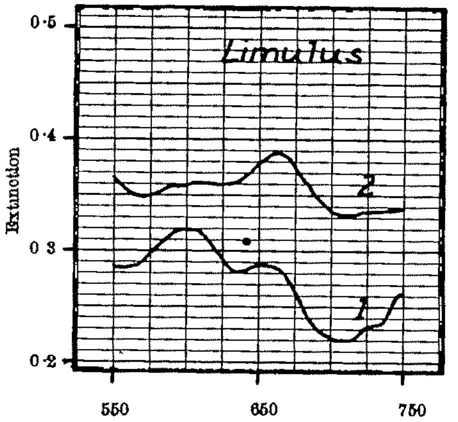


Fig. 2. Absorption spectrum of the product of the antimony chloride reaction with an extract of *Limulus* eyes. The spectrum, measured immediately after mixing the reagents (curve 1), displayed the absorption maximum characteristic of retinene$_1$ in this reaction ($\lambda_{max.}$ 667 mμ), distorted by another maximum at about 600 mμ, due to an unidentified contaminant. The latter faded rapidly, so that the spectrum, re-measured a few minutes later, displayed the retinene band alone (curve 2)

the small amount of photosensitive pigment in the *Limulus* eye introduced special difficulties.

We next isolated the rhabdomere tissue from 378 eyes of young animals, by the flotation procedure described above. This time the isolated tissue was frozen-dried, and pre-extracted exhaustively with petroleum ether. The extract contained β-carotene, about one-third as much as had been obtained from whole eyes.

The residual tissue was extracted with 0·6 ml. of 2 per cent digitonin. The extract was cleared by centrifuging and divided between two micro-absorption cells. Spectra were measured in the Cary model 11 recording spectrophotometer, with a 0–0·1 slide wire that magnifies the extinction 10 times. The results of these measurements are shown in Fig. 3.

The two halves of the extract were first balanced against each other to yield a base line (curve 1). One sample was then irradiated for 2 min. with orange light and the spectrum recorded (curve 2). The record made in these circumstances is a difference spectrum, the difference in absorption between the dark and irradiated solutions. Changes above the base-line represent bleaching due to light, changes below represent the formation of new absorbing material. Curve 2 shows bleaching maximal at about 530 mμ, with the simultaneous formation of a product absorbing maximally at about 370 mμ. This extract was then re-irradiated for 7 min., and allowed to stand in the dark for about 15 min., before recording curve 3. The maximum had now moved to about 520 mμ, an indication that *Limulus* rhodopsin, like that from other species, bleaches over orange-red intermediates such as metarhodopsin, which disappear slowly and thus distort the early difference spectrum. As with vertebrate rhodopsins, however, these distortions are abolished by using hydroxylamine (cf. Fig. 1).

To the remaining portion of the extract, kept in darkness until this point, neutral hydroxylamine was added to a final concentration of 0·04 *M*. Its spectrum was balanced in the spectrophotometer against that of the previously bleached solution, so as to yield a base line. Then this extract was irradiated for 2 min. with white light and left for half an hour in the dark until entirely stable. The result was the difference spectrum shown in Fig. 1, with $\lambda_{max.}$ 520 mμ, and with a minimum at 367 mμ, the absorption maximum of retinene$_1$ oxime.

From the spectrum shown in Fig. 1 one can estimate that we had extracted about 3×10^{-6} μmole of rhodopsin per eye, if one assumes that *Limulus* rhodopsin, like that of other animals, has a molar extinction of about 40,000[7]. This assumption is supported by the fact that bleaching *Limulus* rhodopsin yields about the same extinction of retinene oxime as is obtained from cattle rhodopsin[7]. The quantity of extracted pigment is in reasonable agreement with the amount of retinene we found in whole eyes (4×10^{-6} μmole per eye).

From these results one can estimate roughly the extinction of visual pigment *in situ*. It is generally assumed that in compound eyes the visual pigment is restricted to the rhabdomeres of the retinula cells. The rhabdom of *Limulus* takes the form of a central hub, filled by the dendrite of the eccentric cell, from which radiate fins, usually 10 in number, each formed by the fusion of two rhabdomeres at the surface of contact between adjacent retinula cells[9]. In animals of the size we used, the rhabdom is estimated to be about 100μ long, the fins being about 1·5μ wide (0·75μ contributed by each of the two adjacent rhabdomeres which fuse) and projecting about 10μ from the centre. The entire volume of rhabdomere material, therefore, is about $1{\cdot}5 \times 10^4\mu^3$ (that is, $10 \times 100 \times 1{\cdot}5 \times 10$). Animals of this size have 800–1,200 ommatidia. The volume of rhabdom per eye is therefore of the order of $1{\cdot}5 \times 10^7\mu^3$

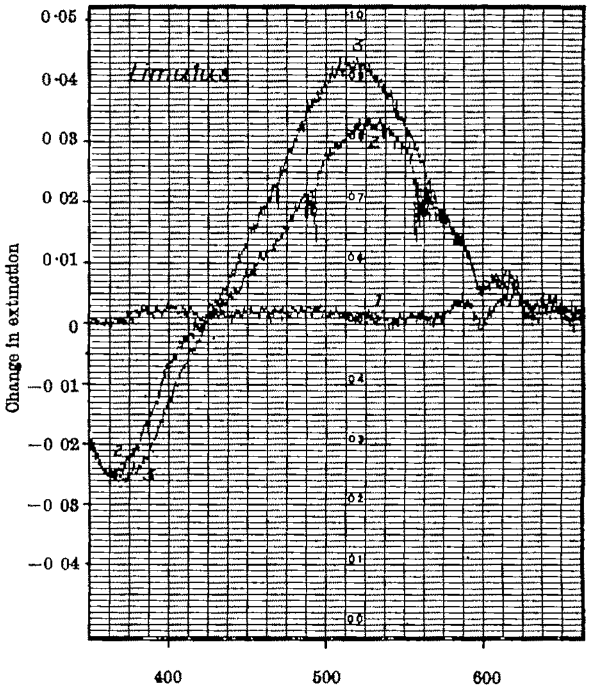


Fig. 3. Difference spectra of *Limulus* rhodopsin in aqueous solution, recorded with a Cary spectrophotometer using a 0–0·1 slide-wire that amplifies the extinction scale ten times. Two portions of the extract were balanced against each other to yield a base-line (1). Then one portion was exposed to light for 2 min.; the difference spectrum (2) shows bleaching maximal at about 530 mμ, and the simultaneous formation of a product with $\lambda_{max.}$ about 370 mμ (retinene$_1$). After a second irradiation and a period in darkness, the solution had become stable (3); $\lambda_{max.}$ now lay at 520 mμ

(ref. 10). If one assumes that *Limulus* rhodopsin has an extinction of about 40,000, 4×10^{-6} μmole of rhodopsin distributed evenly over this volume would have an extinction at 520 mμ of 0·07 in a layer 100μ deep, corresponding to the length of the rhabdom. This extinction is equivalent to an absorption of about 15 per cent. It is interesting that this absorption is of about the same order as occurs in the rods of a number of vertebrate eyes[11].

The only previous report of the extraction of a photo-pigment from the *Limulus* eye is contained in a single sentence and a figure in a paper by Bliss, dealing primarily with squid rhodopsin[12]. According to Bliss, the *Limulus* pigment bleached in the light only after treatment with formaldehyde. The difference spectrum he measured had a maximal extinction of 0·004, lower therefore than one can ordinarily measure accurately; yet the eyes would have had to contain about seven times as much pigment as we find, to yield this extinction under the conditions of his experiment ("15 retinas from 4 cm. wide animals, dissolved in 3 cc."). The $\lambda_{\max.}$ of this pigment was at about 480 mμ. This description, therefore, differs on all counts from the present observations.

This investigation was supported in part by funds from the Division of Neurological Diseases and Blindness of the U.S. Public Health Service (grant *B*-568 *C*-5), the Office of Naval Research, and the Rockefeller Foundation. We are grateful to Dr. H. K. Hartline for advice, and to him and Dr. Miller for information concerning the dimensions of the *Limulus* photoreceptors.

[1] Hartline, H. K., and Graham, C. H., *J. Cell. Comp. Physiol.*, 1, 277 (1932).

[2] For reviews, see Hartline, H. K., Wagner, H. G., and MacNichol, jun., E. F., *Cold Spring Harbor Symp.*, 17, 125 (1952). Fuortes, M. G. F., *Amer. J. Ophth.*, 46, No. 5, Part 2, 210 (1958).

[3] Kampa, E. M., *Nature*, 175, 996 (1955).

[4] Wald, G., and Hubbard, R., *Nature*, 180, 278 (1957).

[5] Goldsmith, T. H., *Proc. U.S. Nat. Acad. Sci.*, 44, 123 (1958).

[6] Hubbard, R., and St. George, R. C. C., *J. Gen. Physiol.*, 41, 501 (1957–58). Brown, P. K., and Brown, P. S., *Nature*, 182, 1288 (1958). Kropf, A., Brown, P. K., and Hubbard, R., *Nature*, 183, 446 (1959).

[7] Wald, G., and Brown, P. K., *J. Gen. Physiol.*, 37, 189 (1953–54).

[8] Graham, C. H., and Hartline, H. K., *J. Gen. Physiol.*, 18, 917 (1934–35).

[9] Miller, W. H., *J. Biophys. Biochem. Cytol.*, 3, 421 (1957).

[10] Miller, W. H., and Hartline, H. K. (personal communication).

[11] Hubbard, R., *J. Gen. Physiol.*, 37, 381 (1953–54). Wald, G., and Brown, P. K., *Science*, 127, 222 (1958).

[12] Bliss, A. F., *J. Gen. Physiol.*, 26, 361 (1942–43).

FRACTIONATION OF TWO METABOLICALLY DISTINCT CLASSES OF RIBONUCLEIC ACIDS IN ANIMAL CELLS AND ITS BEARINGS ON CANCER

By Prof. A. SIBATANI, K. YAMANA, K. KIMURA and T. TAKAHASHI*

Cytochemistry Laboratory, Yamaguti Medical School, Ube, and the Department of Biology,
Faculty of Science, Kyushu University, Fukuoka, Japan

RECENTLY we have shown[1] that the treatment of suspensions or homogenates of normal and malignant animal cells with aqueous phenol may lead to a fractionation of their ribonucleic acids into two components differing markedly in the nucleotide composition and the rate of uptake of phosphorus-32.

The procedure we are employing for such studies may be summarized as follows. A part of the material labelled *in vivo* or *in vitro* with phosphorus-32-orthophosphate (1–2·5 hr.) was fractionated by the Schmidt–Thannhauser method[2] to obtain the total ribo- and deoxyribo-nucleic acids. The rest of the material was treated with 90 per cent phenol[3], and the ribonucleic acid released into the aqueous phase (fraction *P*) was dialysed against water and hydrolysed with alkali[2]. The phenol layer was treated with ethanol and the precipitated protein material was fractionated by the Schmidt–Thannhauser method to recover the residual ribonucleic acid (fraction *R*). The nucleotide composition of various ribonucleic acids was determined by 'Dowex-1' (formate) chromatography[2]. The separated nucleotides were purified by charcoal adsorption[1], and uridylic acid was further paper-chromatographed in *n*-propanol–ammonia–water (60 : 30 : 10)[4]. Alternatively, the alkaline hydrolysates of ribonucleic acids were first adsorbed on charcoal[4] and then the eluted mixed nucleotides paper-chromatographed as above. Deoxyribonucleic acid was usually extracted with hot dodecyl sulphate[5] from the acid-precipitated residue of the Schmidt–Thannhauser method. The specific activity of ribonucleic acid was calculated as the weighted mean of those of the separated nucleotides, or approximated by determining that of combined adenylic, cytidylic and uridylic acids in the eluate from the unresolved single spot on the paper[4]. The specific activity of deoxyribonucleic acid was determined directly.

The fraction *P* ribonucleic acid had a high guanylic acid content and a low specific radioactivity, while the fraction *R* showed a low guanylic acid content and a markedly high specific radioactivity[1]. The proportion of the fraction *P* in total ribonucleic acid was about 70 per cent in rabbit lymphatic cells and the appendix, about 85 per cent in the rat liver and 90–95 per cent in the mouse Ehrlich ascites carcinoma and rat ascites hepatoma *AH*-7974. The nucleotide composition of various fractions is listed in Table 1. In some instances, especially in tumours, cytidylic acid content was also appreciably lower in fraction *R*.

The most remarkable point of these findings is the fact that the specific activity of the fraction *P* was usually very close to that of deoxyribonucleic acid in various tissues differing markedly in the rate of deoxyribonucleic acid synthesis. Also it must be stressed that, by Kirby's method[3] of ribonucleic acid extraction with phenol which is now extensively employed, one may very well be discarding the bulk of ribonucleic acid with high turnover rate.

---

* Permanent address: Department of Internal Medicine, Kyushu University Medical School, Fukuoka.

Table 1. NUCLEOTIDE COMPOSITION OF RIBONUCLEIC ACIDS

Material	Ribonucleic acid fraction	Molar ratio (adenylic acid = 10)			E_{260} recovery (per cent)
		Guanylic acid	Uridylic acid	Cytidylic acid	
Lymphatic cells of rabbit appendix	Total	17·5	10·1	15·3	96·5
	P	20·2	10·6	16·2	101
Rabbit appendix	*P–A*	16·1	10·3	13·0	80·0
	P–B	18·9	10·4	14·6	92·8
	R	15·9	10·0	12·8	95·0
Rat liver	Total	18·0	9·0	16·7	88·2
	P	19·6	10·1	16·0	82·0
	R	14·5	9·0	15·3	79·9
Mouse Ehrlich ascites tumour (7 days)	Total	17·9	10·8	15·1	92·2
	P	19·8	11·1	15·4	98·1
	R	12·1	9·9	11·2	104
Rat ascites hepatoma *AH*-7974 (7 days)	Total	17·4	7·9	15·0	99·2
	P	18·4	11·7	15·1	93·3
	R	11·7	10·0	11·5	100

Table 2. *In vivo* INCORPORATION OF PHOSPHORUS-32 INTO FRACTIONS OF RIBONUCLEIC ACIDS OF SOME ASCITES TUMOUR CELLS

	Mouse Ehrlich ascites carcinoma			Rat ascites hepatoma *AH*-7974
Age of tumour (day)	10	7	7	12
Duration of incorporation experiment (hr.)	2·5	2	2	2
Ribonucleic acid fraction	Specific activity (counts/min./μgm. P)			
Total	15·7	35·0	10·1	9·30
P	6·78	15·0	2·78	4·42
R	65·2	191	48·7	73·6
(Deoxyribonucleic acid)	6·70	17·0	10·1	15·4

The specific activity of the fraction *P* may further be reduced a little by a fractionation utilizing the solubility difference in molar sodium chloride solution. A small amount of soluble ribonucleic acid (fraction *P–A*) with a relatively high specific activity may be removed from the bulk of ribonucleic acid which is precipitated in this salt solution (fraction *P–B*). Such a finding corroborates that of Brown *et al.*[6]. Whether or not the fraction *P–A* is a mixture of the fraction *P–B* and fraction *R* is not clear at the moment.

The simplest interpretation of the above observations would be to postulate the occurrence in animal cells of two principal classes of ribonucleic acids differing in composition, metabolic activity, and mode of linkage with proteins which may serve as the basis of fractionation with phenol. We will call such classes of ribonucleic acids class I and class II, the former being released by phenol and the latter remaining in the residue in typical experiments. It should be emphasized here that the terms fraction *P* and *R* pertain to the extraction procedure using phenol no matter what their chemical or metabolic properties, while the designations 'class I' and 'class II' ribonucleic acids represent partially hypothetical entities.

It is suggested from the specific activity determination that class I ribonucleic acid is duplicated only once during the mitotic cycle like deoxyribonucleic acid, so far as the composition of the cell is kept constant. Because deoxyribonucleic acid is believed to be metabolically rather inert[7], the specific activity of any phosphate compound of cells incorporating radiophosphate, even in the absence of turnover, cannot be appreciably lower than that into deoxyribonucleic acid in the steady state. It can be inferred, therefore, that class I ribonucleic acid may be conserved without turnover in proliferating or non-proliferating cells of fixed composition. The fraction *P* probably contains class I ribonucleic acid in a relatively pure form, being free from contamination by class II ribonucleic acid, which would significantly raise the specific activity of the fraction *P* over that of deoxyribonucleic acid. Whether the fraction *R* represents more or less pure class II ribonucleic acid cannot be determined at the moment.

The close agreement of the specific activities of deoxyribonucleic acid and of fraction *P* ribonucleic acid may not be realized in systems changing their composition. In regenerating rat liver the synthesis of class I ribonucleic acid seems to be enhanced prior to that of deoxyribonucleic acid[1]. In ascites tumour also, the specific activity of fraction *P* ribonucleic acid was sometimes found to be lower than that of deoxyribonucleic acid (Table 2). Indeed, a continuous decrease in ribonucleic acid content per cell during the growth of the Landschütz ascites tumour of the mouse has been reported[8].

The hypothesis of the occurrence of cellular ribonucleic acids in two classes can be tested by studies on ribonucleic acids in subcellular components. However, results so far obtained have been mostly erratic for the reason suggested below, so that we are still not in a position to discuss the matter at full length. To mention some positive results (Table 3), both nuclei and cytoplasm of the rabbit appendix yielded the two fractions which would represent classes I and II. It is noted that the proportion of the fraction *R* was much higher in nuclei the ribonucleic acid of which resembles the class II ribonucleic acid in guanylic acid content and the turnover rate[2]. Also free cytoplasmic ribonucleoprotein particles (ribosomes) of the rabbit appendix gave fractions with properties in line with the results on whole cells.

In earlier experiments consistent results were obtained by an indiscriminate use of commercial phenol, but it was soon found that the use of different batches of phenol might result in a marked change in the efficiency of fractionation. The use of redistilled phenol made the results even worse. Prob-

Table 3. RIBONUCLEIC ACIDS OF SOME SUBCELLULAR COMPONENTS OF RABBIT APPENDIX LABELLED WITH PHOSPHORUS-32 *in vivo*

Ribonucleic acid fraction	Relative amount (per cent of total)			Guanylic acid content (adenylic acid = 10)			Specific activity (counts/min./μgm. P)		
	Nucleus	Cytoplasm	Ribosome	Nucleus	Cytoplasm	Ribosome	Nucleus	Cytoplasm	Ribosome
P–A	1·0	3·0	1·3	—	—	—	—	4·03	—
P–B	43·1	75·6	79·1	17·7	16·4	17·1	7·34	2·24	0·79
R	55·9	21·4	19·6	13·0	12·1	15·0	27·4	5·91	17·5
(Deoxyribonucleic acid)							6·53	2·02	6·31

Nuclei and cytoplasm were separated according to Osawa *et al.* (ref. 2). Ribosomes (free ribonucleoprotein particles) were sedimented at 105,000*g* for 90 min. from a 0·25 *M* sucrose homogenate after removing larger particles by centrifuging at 44,000*g* for 30 min. Values for individual subcellular components were obtained in separate experiments lasting 2 hr.

ably some impurities in the commercial phenol may be of critical importance, and the use of reagents of lower degree of purity generally resulted in a consistent and clear-cut fractionation. The critical factor(s) may also be provided by the tissues. Thus, the rabbit liver gave a relatively 'good' fractionation with re-distilled phenol, while the appendix and kidney yielded a 'poor' fractionation with the same phenol. Some monovalent and divalent cations such as sodium or calcium ions were effective in improving the extent of fractionation, and the addition of ethylenediamine tetraacetate affected the fractionation, while magnesium ions were without effect. Temperature (0–37°) does not seem to be very critical, while the *p*H of the medium (before addition of phenol) is obviously of great importance, the best fractionation so far being obtained at *p*H 6–7. Unless such factors are carefully controlled, isolated subcellular components tend to yield a poor fractionation, and the specific activity of the fraction *P* may no longer be close to that of deoxyribonucleic acid and vary considerably among different subcellular fractions[9].

Several authors[10] have reported a remarkably high guanylic acid content of neoplastic ribonucleic acids. This would suggest a depletion of class II ribonucleic acid in tumour cells, and our observation confirmed it. Extensive uptake of labelled precursors by ribonucleic acid of tumour cells, in spite of the deficiency of class II ribonucleic acid with high turnover rate, may partly be explained by an active net synthesis of class I ribonucleic acid.

It was also reported that the bulk of ribonucleic acid of tumour cells showed little turnover[11]. This fact would again be a reflexion of the marked preponderance in tumour cells of class I ribonucleic acid which appears to be metabolically rather inert. In this connexion it is of interest that the acid ribonuclease activity per unit amount of ribonucleic acid is much lower in tumour cells than in normal cells[12]. However, whether this fact has some bearings on the metabolic stability of the bulk of ribonucleic acid in cancer cells is not clear.

Thus, the relationship between the synthesis of class I ribonucleic acid and that of deoxyribonucleic acid, and the role of two classes of ribonucleic acids in the transfer of genetic information and in protein synthesis may become attractive problems in cell physiology and cancer research.

This work was aided in part by a grant from the Ministry of Education. We express our thanks to Dr. Waro Nakahara, director of the Cancer Institute, Tokyo, for his encouragement and interest in this work. We are further indebted to Prof. S. Nakamura and Prof. S. Shibata, Yamaguti Medical School, for the use of instruments in their laboratories, and to Prof. I. Kawakami, Kyushu University, Dr. S. Osawa, Nagoya University, and Dr. Y. Sugino, Kyoto University, for their advice and discussion.

[1] Sibatani, A., Yamana, K., Kimura, K., and Okagaki, H., *Biochim. Biophys. Acta*, 33, 590 (1959). Yamana, K., *Gann*, 50, 201 (1959).

[2] Osawa, S., Takata, K., and Hotta, Y., *Biochim. Biophys. Acta*, 28, 271 (1958).

[3] Kirby, K. S., *Biochem. J.*, 64, 405 (1956)

[4] Ledig, M., Weill, J. D., and Mandel, P., *Bull. Soc. Chim. Biol.*, 40, 599 (1958).

[5] Sibatani, A., *Exp. Cell. Res.*, 17, 131 (1959).

[6] Brown, R. A., Davies, M. C., Colter, J. S., Logan, J. B., and Kritchevsky, D., *Proc. U.S. Nat. Acad. Sci.*, 43, 857 (1957).

[7] Kihara, H. K., Amano, M., and Sibatani, A., *Biochim. Biophys. Acta*, 21, 489 (1956). Swick, R. W., Koch, A. L., and Handa, D. R., *Arch. Biochem. Biophys.*, 63, 226 (1956)

[8] Ledoux, L., and Revell, S. H., *Biochim. Biophys. Acta*, 18, 416 (1955)

[9] Takanami, M., *J. Histochem. Cytochem.*, 7, 126 (1959).

[10] de Lamirande, G., Allard, C., and Cantero, A., *Cancer Res.*, 15, 329 (1955). Chargaff, E., Magasanik, B., Vischer, E., Green, C., Doniger, R., and Elson, D., *J. Biol. Chem.*, 186, 51 (1950). Miura, Y., *Saisin Igaku*, 13, 2466 (1958) (in Japanese).

[11] Révész, L., Forssberg, A., and Klein, G., *J. Nat. Cancer Inst.*, 17, 37 (1956). Scott, J. F., and Taft, E. B., *Biochim. Biophys. Acta*, 28, 45 (1958).

[12] Ledoux, L., Pileri, A., Vanderhaeghe, F., and Brändli, S., *Nature*, 180, 1048 (1957). Ledoux, L., *Arch. Intern. Physiol. Biochim.*, 66, 124 (1958).

CHLOROPHYLL CONTENT OF GIBBERELLIN-TREATED WHEAT SEEDLINGS

By Prof. FREDERICK T. WOLF* and Dr. ALAN H. HABER

Biology Division, Oak Ridge National Laboratory†, Oak Ridge, Tennessee

INCREASED plant growth stimulated by gibberellic acid is generally accompanied by a paling of the leaves[1–3]. In a recent review, Brian summarized the situation as follows: "The leaves formed after treatment are noticeably paler in colour than usual. This is a general response to gibberellic acid; it can be to a considerable extent reduced by ensuring that mineral nutrients, especially nitrogen, are not limiting, but even under the best nutrient conditions some chlorosis is usually visible. It is not known whether the chlorosis is due to a destruction of pigment, reduced rate of synthesis of pigment, to a failure of pigment synthesis to keep in step with the increased cell extension, or to change in pigment composition"[4]. In this article we present the results of an investigation of the relation between the effects of gibberellic acid treatment on growth and on pigment content.

'Gibrel' (potassium salt of gibberellic acid) was kindly given by Merck and Co. Wheat grains were germinated and the seedlings grown in Petri dishes containing water or 3×10^{-4} *M* gibberellic acid ($\sim$ 115 p.p.m.), as described previously[5], under 400–500 ft.-candles of white light during 16-hr. days. Chlorophylls *a* and *b* were analysed according to "Official Methods of Analysis" of the Association of Official Agricultural Chemists[6] or by Robbelen's method[7]; total carotenoids were estimated by the latter method. Twelve to sixteen seedlings were used in each determination.

Results of a typical experiment are given in Table 1. Six days after sowing, the height of plants treated with gibberellic acid had increased at least 60 per cent more than the controls and the leaves were indeed paler. But the chlorophyll content was not

---

* Oak Ridge Institute of Nuclear Studies research participant summer of 1959. Present address: Department of Biology, Vanderbilt University, Nashville, Tennessee.

† Operated by Union Carbide Corporation for the United States Atomic Energy Commission.

Table 1. INFLUENCE OF GIBBERELLIC ACID ON THE GROWTH AND CHLOROPHYLL CONTENT OF WHEAT SEEDLINGS

Treatment	Age 6 days	12 days	18 days*	24 days*	30 days*
			Height (mm.)		
Control	59·5	100·8	140·1	249·0	294·8
Gibberellic acid	98·8	176·1	258·7	356·3	404·5
			Fresh weight (mgm.)		
Control	38·9	75·7	124·3	340·5	544·4
Gibberellic acid	42·2	80·1	131·4	309·3	420·8
			Total chlorophyll (μgm.)		
Control	26·8	56·7	126·0	381·2	583·8
Gibberellic acid	26·1	46·2	81·2	248·6	370·8

* Plants removed from Petri dishes and transplanted to pots of soil after 12 days.

significantly different in treated and untreated plants. After 12 days, the chlorophyll content of the treated plants was about 20 per cent less than in the controls. Total carotenoid values were 12·5 μgm. per plant for the controls and 10·4 μgm. for treated plants. Hence the reductions in amounts of chlorophyll and carotenoid in treated plants were about the same. The difference in chlorophyll content between the treated plants and controls increases with time.

Twenty determinations of the chlorophyll *a* : chlorophyll *b* ratio in each of the two series of plants showed 75·6 per cent of the total chlorophyll consisted of chlorophyll *a* in the controls and 75·5 per cent in the plants grown in gibberellic acid. Obviously, the difference between the appearances of the two groups of plants cannot be related to a change in the proportion of the two chlorophylls.

Leaves of etiolated seedlings grown for 8 days in water in darkness were excised, placed in vials containing water or gibberellic acid, and exposed to 1,000 ft.-candles of light from a water-cooled source similar to that described by Withrow and Elstad[8]. Measurements of chlorophyll content during the subsequent 48 hr. (Fig. 1) showed no significant difference in rate of chlorophyll synthesis during greening, and therefore no difference in chlorophyll anabolism from gibberellic acid treatment.

Five-day-old seedlings grown in water were placed in 3 × 10^{-4} *M* gibberellic acid and at the same time transferred to continuous darkness. The disappearance of chlorophyll in dark-grown plants and in plants similarly treated in all respects except for treatment with gibberellic acid were compared. The acid had no effect on chlorophyll disappearance, and therefore no effect on chlorophyll catabolism (Fig. 2), even though the plants responded to the gibberellic acid in darkness. The average heights of the treated and control plants after the seven days in darkness were 180·4 and 132·6 mm., respectively.

The findings with young plants (5–8 days old) indicate that gibberellic acid can exert a pronounced effect on growth without affecting the total content, anabolism, or catabolism of chlorophyll. The paler appearance of six-day-old treated plants therefore results solely from pigment dilution. Since the pigment content does not differ significantly in these treated and control plants, there is no real chlorosis. The chlorophyll content of older treated plants (12 days or more) is less than in the untreated controls. But since gibberellic acid promotes growth without affecting the content, synthesis, or destruction of chlorophyll in young plants, its influence on chlorophylls and other pigments in older plants is probably an indirect result of its growth stimulation. These results support the suggestion that 'chlorosis' induced by gibberellic acid is in part related to nutritional deficiencies[3,4]. The acid does not influence the pigment content of the very young seedlings adequately supplied with nutriment from the grain, but does reduce the pigment content of older plants. This may be correlated with the growth results in Table 1, which indicate that the untreated plants eventually surpass the treated seedlings in growth-rate.

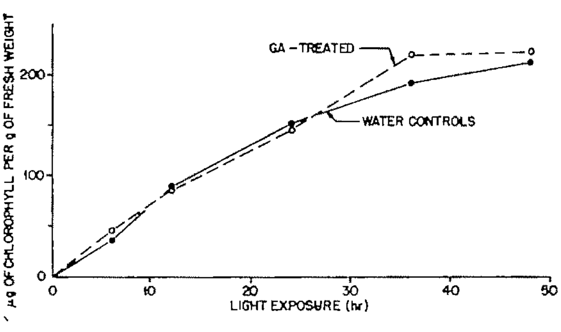


Fig. 1. Effect of gibberellic acid on greening of 8-day-old detached etiolated wheat leaves

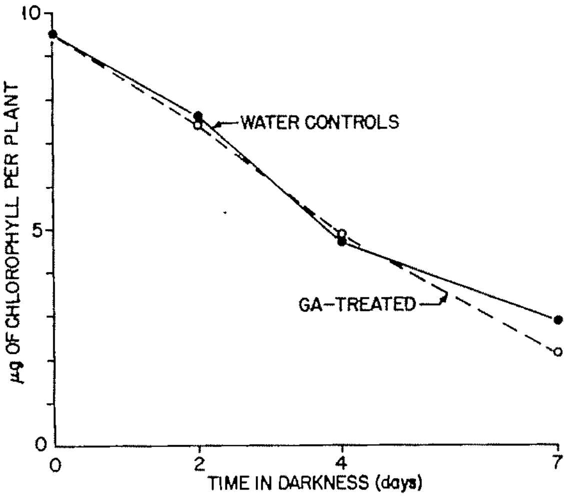


Fig. 2. Effect of gibberellic acid on disappearance of chlorophyll after transferring 5-day-old wheat seedlings to continuous darkness

These results demonstrate that (*a*) chlorosis does not necessarily accompany growth stimulated by gibberellic acid and (*b*) the paling in very young seedlings results solely from a failure of chlorophyll synthesis to keep pace with the increased cell expansion[5]. Besides the simple dilution of chlorophyll, the apparent chlorosis in older plants must also result from delayed effects of malnutrition, not to direct action of the acid on formation or destruction of chlorophyll. Stimulation of growth by gibberellic acid without direct effect on chlorophyll metabolism is consistent with the finding that the acid does not directly affect photosynthesis[9].

We wish to thank Mrs. Helen Luippold, Mrs. Dora Furr, and Mr. Joe White for help in caring for the plants and for assistance in the experiments.

[1] Brian, P. W., Elson, G. W., Hemming, H. G., and Radley, M., *J. Sci. Food and Agric.*, 1954, 602 (1954).
[2] Brian, P. W., and Hemming, H. G., *Ann. App. Biol.*, 45, 489 (1957).
[3] Wittwer, S. H., and Bukovac, M. J., *Econ. Bot.*, 12, 213 (1958).
[4] Brian, P. W., *Biol. Rev. Cambridge Phil. Soc.*, 34, 37 (1959).
[5] Haber, A. H., and Luippold, H. J., *Amer. J. Bot.*, 47, 140 (1960).
[6] Association of Official Agricultural Chemists, "Official Methods of Analysis", seventh ed., 112 (1950).
[7] Robbelen, G., *Ztschr. Indukt. Abstamm.-u. Vererbungslehre*, 88, 189 (1957).
[8] Withrow, R. B., and Elstad, V., *Plant Physiol.*, 28, 334 (1953).
[9] Haber, A. H., and Tolbert, N. E., *Plant Physiol.*, 32, 152 (1957).

PROTEIN COMPONENTS FROM TURNIP YELLOW MOSAIC VIRUS

By Dr. J. M. KAPER

Department of Biochemistry, University of Leyden

RECENTLY we reported a degradation method[1] with which soluble protein fragments were obtained from a purified preparation of turnip yellow mosaic virus. Evidence was presented that the alkaline treatment involved had not affected the peptide bonds of the protein. Under the electron-microscope the preparation showed spherical particles of a certain minimal diameter and also larger aggregates of variable size, all of which were much smaller than the virus particles, however.

Since then I have started to investigate the products of the alkaline treatment of the virus by means of electrophoresis and the ultracentrifuge.

Turnip yellow mosaic virus purified by the butanol–chloroform procedure[2] was treated with 0·13 *M* dipotassium hydrogen phosphate–sodium hydroxide buffer of *p*H 11·2 (virus concentration in mixture was 1 per cent). During this treatment, extending over a period of approximately 2½ days at room temperature, the *p*H of the reaction mixture dropped from 11·2 to 11·0. After the reaction, part of the mixture was set aside while the rest was subjected to ultracentrifugation in the Spinco model *L* ultracentrifuge for 2 hr. at 40,000 rev./min. After termination of the run, the resulting pellet and supernatant fractions were separated. The supernatant was set aside, the pellet was re-suspended in distilled water and again ultracentrifuged for 2 hr. at 40,000 rev./min. This washing and ultracentrifugation procedure was repeated once more, after which the pellet was taken up in distilled water. The three solutions (total mixture, pellet, and supernatant fraction) thus obtained were dialysed against 0·1μ *p*H = 7 buffer[3] for 2 days at 5° C. with three additional buffer changes to equilibrate for electrophoretic and sedimentation analysis.

Electrophoresis was performed at room temperature in the Kern *LK*30 micro-electrophoresis apparatus equipped with Jamin interference optics. Sedimentation analysis was carried out at 20° C. in the Spinco ultracentrifuge model *E* with schlieren optics.

Fig. 1 shows the electrophoretic pattern of the reaction mixture after 29 min. of electrophoresis at 53 V. and 3·8 m.amp. The upper limb in the picture represents the mixture of components ascending towards the anode. The presence of three main components with different mobilities is evident, although in the upper limb most of the fastest-moving gradient has left the cell already.

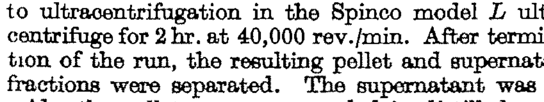


Fig. 1. Electrophoresis pattern of the reaction mixture after treatment of turnip yellow mosaic virus at *p*H 11·2–11·0. Buffer: 0·1μ, *p*H 7, room temperature

(a), Polynucleotide gradient; (b) gradient of pellet fraction; (c), soluble protein gradient

Through analysis of the supernatant fraction (which can be shown to contain the soluble protein[1] and polynucleotide material) and the pellet fraction, gradient (*a*) in Fig. 1 could be identified with polynucleotide material which had been liberated from the virus and which was not dialysable; gradients (*c*) and (*b*) represented the soluble protein and the pellet fraction respectively. Control analysis of intact turnip yellow mosaic virus under the same experimental conditions showed that the pellet fraction and the virus had identical electrophoretic mobilities; this was further corroborated by mixing the two substances and analysing them at *p*H 7·0, 8·3 and 9·5, under which conditions they behaved as one component in electrophoresis. The ultra-violet spectrum of the pellet fraction was predominantly of protein character (maximum 270 mμ, minimum 250 mμ and shoulder at 290 mμ), although it was evident that small amounts of nucleic acid in one form or another were present in the fraction.

Fig. 2*A* shows the sedimentation pattern of the reaction mixture in the ultracentrifuge 5 min. after reaching the desired speed of 59,780 rev./min. Here again we observe three main components and a small amount of a fourth. The identification of the various boundaries with the fractions obtained in the preparative procedure was carried out by separate runs, as in the electrophoresis. In Fig. 2*A* the gradients are designated accordingly. The sedimentation coefficient (uncorr.) of (*b*) was determined from this run and found to be 47 *S*. In separate runs of the pellet fraction at 33,450 rev./min. and at dilutions as much as 0·005 per cent we found sedimentation coefficients of 52–53 *S*. As is evident from Fig. 2*B*, the pellet fraction gives a sharp and symmetrical boundary and is only contaminated by a small amount of substance with sedimentation-rate of approximately 80 *S*. Gradient (*c*) in Fig. 2*A* shows a pronounced polydispersity and represents the soluble protein which we described earlier[1]; (*a*) is the polynucleotide material resulting from the degradation of the virus-nucleic acid. Figs. 2*C* and 2*D* represent the sedimentation patterns of reaction mixtures of turnip yellow mosaic virus treated at *p*H 12·1–11·9 and *p*H 10·8–10·5 (the two *p*H-values indicate the *p*H at the beginning and at the end of the reaction).

The pellet fractions of both mixtures analysed separately had sedimentation coefficients of 52–53 *S* again. The fraction containing the soluble protein from the *p*H 12·1–11·9 treatment (Fig. 2*C*) showed much less polydispersity and the sedimentation

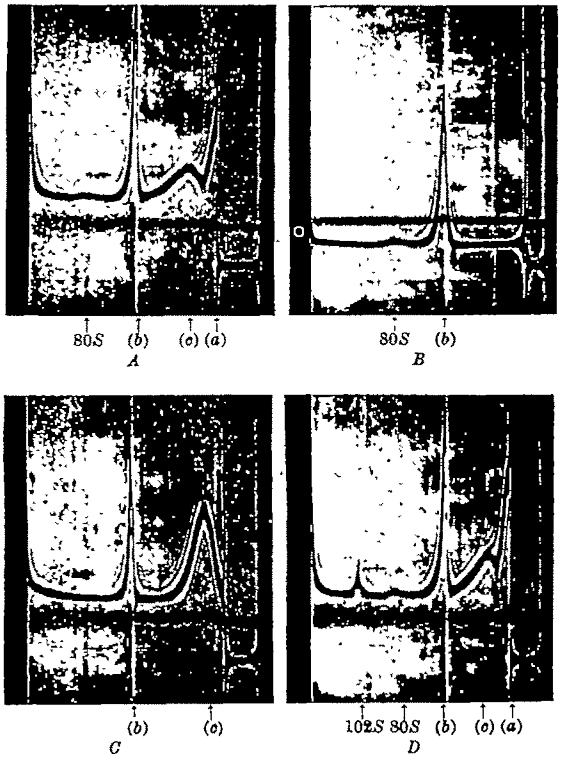


Fig. 2. Sedimentation patterns of degradation products of turnip yellow mosaic virus. Buffers: 0·1μ *p*H 7; temperature, 20° C. (The horizontal streak which is visible on all our schlieren diagrams is not caused by irregularities in the systems under measurement, but could, according to the Spinco field engineer, be attributed to dust particles which had accumulated on the mercury lamp just in front of the slit)

A, reaction mixture from degradation at *p*H 11·2–11 0; 5 min. after reaching speed of 59,780 rev./min.

B, pellet fraction (conc. 0·25 per cent) obtained from degradation at *p*H 11·2–11 0; 26 min. after reaching speed of 33,450 rev./min.

C, reaction mixture from degradation at *p*H 12 1–11·9; 5 min. after reaching speed of 59,780 rev./min.

D, reaction mixture from degradation at *p*H 10 8–10 5; 3 min. after reaching desired speed of 59,780 rev./min.

(*a*) polynucleotide gradient; (*b*) gradient of pellet fraction; (*c*) soluble protein gradient

coefficient determined from the 'peak' of (*c*) was about 11 *S*. Electrophoresis of the reaction mixture of *p*H 12·1–11·9 showed that no change had occurred in the relative mobilities of both components, but that the relative concentrations had changed in favour of the soluble protein. Polynucleotide material could no longer be detected, as apparently the nucleic acid had broken down to dialysable nucleotides. The ultra-violet spectrum of the pellet fraction (Fig. 3) obtained at this *p*H had more protein character; this might be attributed to the absence of the 80 *S*-contamination.

The reaction mixture at *p*H 10·8–10·5 showed quite the opposite picture (Fig. 2*D*) which, of course, could be anticipated. Gradient (*a*), representing the polynucleotides, is again present, gradient (*c*) shows very much polydispersity and, in addition to the 80 *S*-component, there is an appreciable amount of fast-moving substance with a sedimentation coefficient of 102 *S*, which probably represents residual virus. Electrophoresis showed again the gradients (*a*), (*b*) and (*c*) with the same relative mobilities as in the other experiments.

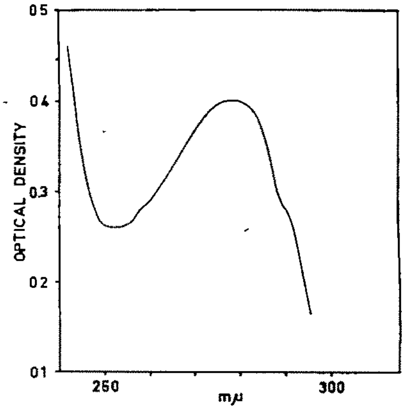


Fig. 3. Ultra-violet spectrum of pellet fraction isolated from treatment of turnip yellow mosaic virus at *p*H 12·1–11·9. Buffer, 0·1μ, *p*H 7

One main conclusion emerges from the experiments described. Through alkaline treatment of turnip yellow mosaic virus it is possible to penetrate the virus and affect the imbedded nucleic acid in such a way that it starts to leak out in (poly) nucleotide fragments of variable size, depending on the *p*H of the reaction. After the (poly) nucleotides have leaked out, they leave an empty or virtually empty protein shell. This material can be isolated by a simple differential centrifugation procedure. That the protein shell has probably remained intact seems evident when the identical electrophoretic mobilities of both virus and protein are considered and when its sedimentation coefficient, 53 *S*, is compared with those of Markham[4] (48·8 *S*) and of Lyttleton *et al.*[5] (50 *S*) for turnip yellow mosaic virus top component. In addition to this, we have compared the 'natural' virus plus top-component system, isolated by the procedure described by Cosentino *et al.*[6], with a 'reconstructed' system, obtained by mixing the virus (without top component) and the 53 *S* component in approximately the same concentration ratio. The sedimentation patterns thus obtained, with sedimentation coefficients of 52 *S* and 109·5 *S* (virus) for the 'natural' system and 53·5 *S* and 109 *S* for the 'reconstructed' system, were virtually identical.

Besides the full-size protein, fragments of smaller size are obtained[1]. We do not know as yet what is the exact sequence of events during the alkaline treatment; but the experiments described suggest that first the intact protein shells are formed, and they then dissociate into particles of smaller size.

This sequence of events, as well as other aspects of the reaction, are being studied in detail, and I also hope to carry out a complete characterization of both proteins described.

I am indebted to Prof. H. Veldstra for his interest and encouragement, to Miss C. Houwing for her assistance and to the Rheumathology Department and the Medical Chemistry Department of the University Hospital for putting their Spinco model *E* ultracentrifuge and the micro-electrophoresis apparatus at my disposal.

[1] Kaper, J. M., and Steere, R. L., *Virology*, **8**, 527 (1959).
[2] Steere, R. L., *Phytopath.*, **46**, 60 (1956).
[3] Miller, G. L., and Golder, R. H., *Arch. Biochem. Biophys.*, **29**, 420 (1950).
[4] Markham, R., *Disc. Faraday Soc.*, **11**, 221 (1951).
[5] Lyttleton, G. W., and Matthews, R. E. F., *Virology*, **6**, 470 (1958).
[6] Cosentino, V., Paigen, K., and Steere, R. L., *Virology*, **2**, 139 (1956).

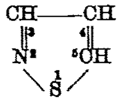
SULPHASOMIZOLE (5-*p*-AMINOBENZENESULPHONAMIDO-3-METHYL*ISO*THIAZOLE): A NEW ANTIBACTERIAL SULPHONAMIDE

By A. ADAMS, W. A. FREEMAN, A. HOLLAND, D. HOSSACK, J. INGLIS,
MISS J. PARKINSON, H. W. READING, K. RIVETT, R. SLACK,
R. SUTHERLAND and R. WIEN

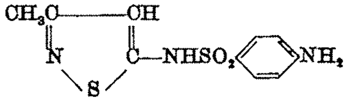
Research Laboratories, May and Baker, Ltd., Dagenham, Essex

THE development of a controlled antibiotic policy, primarily to curb the spread of resistant strains of *Staphylococcus aureus*[1], has led to a renewed interest in sulphonamide therapy. Additional stimulus has also been provided by the introduction of the 'long-acting' sulphonamides, the main advantage of which is probably convenience of administration. The prolonged action of these new products may be attributable to differences in metabolic pathways brought about by differences in substitution in the heterocyclic moieties attached to the N^1 position of the classical structural types. The compounds of this class that have been used clinically during the past few years have all conformed to a traditional chemical pattern, their duration of action and rate of excretion being varied by variation of substituents in known heterocyclic nuclei.

Against this background, it is pertinent to report a new departure in sulphonamide research, in which a hitherto unknown heterocyclic nucleus—*iso*thiazole (I)—has been introduced. The full consequences of this development remain to be worked out, but sufficient work has been completed to show that this new sulphonamide, 5-*p*-aminobenzenesulphonamido-3-methyl*iso*thiazole (the name sulphasomizole has been approved by the British Pharmacopœia Commission), is of considerable interest.



(I)

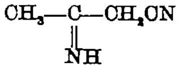


Sulphasomizole

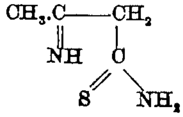
When our work began, we had no experimental evidence that the *iso*thiazole nucleus (I) could exist, but the system had long been of theoretical interest to us because of the similarity between —S— and —CH = CH— in aromatic structures. Thus, the new parent compound should resemble pyridine in many of its chemical properties[2].

We have synthesized mononuclear *iso*thiazoles by two distinct routes. The first involved the oxidation of 5-aminobenz-1,2-*iso*thiazole to *iso*thiazole-4,5-dicarboxylic acid[3], from which 4-*p*-aminobenzenesulphonamido*iso*thiazole was eventually prepared. This compound showed high activity against streptococcal and staphylococcal infections in mice, and the results stimulated us to devise a simpler synthesis of a related 5-sulphonamide.

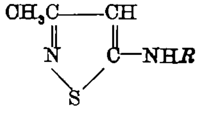
Treatment of β-imino-*n*-butyronitrile (II) with hydrogen sulphide gave β-iminothio-*n*-butyramide (III)[4], which was oxidized by a variety of reagents to 5-amino-3-methyl*iso*thiazole (IV : R = H)[5].



(II)



(III)



(IV)

The amine is a valuable intermediate for the preparation of many mononuclear *iso*thiazoles, and more than fifty derivatives of *iso*thiazole have been made[6]. One of the most interesting from the biological point of view is 5-*p*-aminobenzenesulphonamido-3-methyl*iso*thiazole (IV : $R = SO_2.C_6H_4.NH_2$-*p*)[5], a sulphonamide of high solubility in water (*p*H 6·0, 248 mgm./100 ml.; *p*H 7·0, 2,260 mgm./100 ml.) from which almost neutral, concentrated (more than 50 per cent w/v) aqueous solutions of the corresponding sodium salt can easily be made.

The antibacterial properties of sulphasomizole have been determined by carrying out *in vitro* tests in a synthetic medium similar to that described by Wilson[7]. Aqueous solutions of sodium sulphasomizole were used for these tests. After infection of the medium with a standardized inoculum and incubation at 37° C. for 24 hr., the minimal inhibitory concentrations were recorded.

The organisms included the following: *Staphylococcus aureus* (5 strains), *Streptococcus pyogenes* (2 strains), *Str. agalactiae*, *Str. dysgalactiae*, *Str. uberis*, *Str. pneumoniae*, *Str. equi*, *Str. viridans*, *Str. faecalis* (2 strains), *Alkaligenes faecalis*, *Aerobacter aerogenes* (2 strains), *Escherichia coli* (7 strains), *Klebsiella pneumoniae*, *Proteus vulgaris* (2 strains), *Pseudomonas pyocyanea* (2 strains), *Shigella flexneri*, *Shig. sonnei* (2 strains), *Salmonella typhi* (Rawlings), *S. paratyphi* B, *S. gallinarum*, *S. pullorum*, *S. typhi-murium*, *S. cholerae-suis*, *S. abortus-equi*, *Corynebacterium pyogenes*, *Haemophilus gallinarum*, *Pasteurella septica*

and *Brucella abortus*. Sulphasomizole was active against most of this wide range of Gram-positive and -negative organisms, with the exception of one strain of each of the following organisms: *Str. faecalis*, *Aerobacter aerogenes*, *Shigella sonnei*, *Pasteurella septica*, and two strains of *Escherichia coli*; but other reference sulphonamides, tested under the same conditions, also did not show any activity against these particular strains.

Experiments were carried out in mice infected intraperitoneally with either *Str. pyogenes*, *Str. pneumoniae*, *Staph. aureus*, or *E. coli*. Sulphasomizole was given either by stomach tube at 1, 5, 24, 48 and 72 hr., or graded concentrations were mixed in the diet and fed from one day before to three days after infection. Interpretation of the results was based on two criteria: (1) determination of the median effective dose, from the survival-rates, and (2) the mean effective blood concentration (the concentration of the sulphonamide in the blood necessary for 50 per cent protection of infected mice)[8,9]. Sulphasomizole showed good activity against these experimental infections, and in general appeared as active as the sulphonamides in current use.

The absorption of sulphasomizole into the blood and cerebrospinal fluid, its distribution in the tissues and excretion in the urine were determined in several species. Estimations of the sulphonamide were made by the Bratton–Marshall method[10]. The sulphonamide was given orally or subcutaneously (as the sodium salt). After oral administration to mice, rats and rabbits, it was well absorbed in doses up to 0·5 gm./kgm., and high concentrations of unconjugated drug were produced within half to 1 hr. (It should be emphasized that the term 'unconjugated' refers to the diazotizable material detected by the Bratton–Marshall method before hydrolysis, whereas the term 'conjugated' refers to the extra diazotizable material found after acid hydrolysis. Koechlin, Kern and Engelberg[11] prefer the terms 'directly' and 'indirectly' reacting.) The pattern of the blood concentration curves showed that the drug did not disappear rapidly from the circulation, appreciable amounts being present up to 24 hr. after administration; about 35 per cent was conjugated in the blood.

The sulphonamide was freely distributed in the tissues in rabbits. After an oral dose of 0·5 gm./kgm., maximum concentrations were found in the liver, lung, and spleen within about 2 hr., and at about 4 hr. in the kidney. In pregnant rabbits, sulphasomizole passed freely into the fœtus, and in lactating rabbits, into the milk.

Some information on the blood concentrations in man was obtained from three male volunteers and two patients. A single oral dose of 1 gm. in volunteers produced a maximum blood concentration of about 7·5 mgm./100 ml. within 4 hr., which fell only slightly by 6 hr. and had fallen to 2·0 mgm./100 ml. by 24 hr. About 40–50 per cent of the dose was recovered from the urine in 24 hr. In two patients each given 2 gm. of the sodium salt intramuscularly, the blood concentrations were 11·25 and 20·5 mgm./100 ml. (unconjugated and conjugated drug, respectively) in one patient after 9 hr., and in the other patient 15·7 and 27·2 mgm./100 ml. after 12 hr. These levels were amply maintained by repeated doses of 1 gm. at 12-hourly intervals.

In rats, after a single oral dose of 0·5 gm./kgm., about 25 per cent (of which 70 per cent was in the unconjugated form) was excreted in the urine during the first 24 hr. Excretion from rabbits was a little more rapid, about 35 per cent (of which 50 per cent was unconjugated) being found in the urine during the same period after an oral dose of 0·5 gm./kgm.

Sulphasomizole appeared in the cerebrospinal fluid of rabbits after oral administration of 0·5 gm./kgm. and the concentrations, relative to those found in the blood, were about 10 per cent. Intravenous injection of 0·2 gm./kgm., as a solution of the sodium salt, produced relatively high concentrations in the cerebrospinal fluid, about 85 per cent of the concentration in the blood. The difference between these two results is not fully understood.

Up to the present, we have only examined the concentration of free sulphonamide in the cerebrospinal fluid of one human patient suffering from meningococcal meningitis (James, E., Shiel, M., and Ardley, D. G., personal communication). 9 hr. after 2·0 gm. given intramuscularly as the sodium salt, the concentration in the cerebrospinal fluid was 1·85 mgm./100 ml. (16·5 per cent of the blood concentration). Two days later, after another four intramuscular injections, each of 1 gm., had been given, the concentration in the cerebrospinal fluid was 3·25 mgm./100 ml. 5 hr. after the last dose (17·2 per cent of the blood concentration).

In toxicity experiments, no deleterious effects were observed on the growth-rate of young rats or on the blood picture of guinea pigs, after daily oral doses of 0·5 gm./kgm. for several weeks. There was no significant crystalluria, even though the acetyl derivative of sulphasomizole is only sparingly soluble in water. Metabolic studies are being made to determine the nature of the urinary excretion products, and we have obtained some indication, in rats, that there is a marked increase in excretion of glycuronic acid, and a smaller increase in excretion of ethereal sulphate after continued administration of the sulphonamide.

Intramuscular injections of aqueous solutions of the sodium salt in concentrations as high as 20 per cent w/v are well tolerated in rats; 5 per cent w/v solutions have no deleterious effect when instilled into the conjunctival sac of the rabbit's eye.

To sum up, this new sulphonamide has the attributes of a useful therapeutic agent. It possesses a good all-round antibacterial spectrum and is well absorbed and distributed in the body. It is readily excreted in the urine and animal experiments indicate that it does not produce crystalluria even in high dosage. The sodium salt is highly soluble in water and well tolerated on injection. Further experimental information will be published elsewhere.

Clinical studies of the new sulphonamide are in progress.

We wish to thank Drs. E. James and M. Shiel of the Rush Green Hospital for the opportunity of estimating blood concentrations of this new sulphonamide in two patients.

[1] Barber, M., Dutton, A. A. C., Beard, M. A., Elmes, P. C., and Williams, R., *Brit. Med. J.*, 11 (1950).

[2] Adams, A., and Slack, R., *J. Chem. Soc.*, 3061 (1959).

[3] Adams, A., and Slack, R., *Chem. and Indust.*, 1232 (1956).

[4] British Provisional Patent Application No. 32801/56.

[5] British Provisional Patent Application No. 32259/57.

[6] British Provisional Patent Application No. 21628/56; 32802/56.

[7] Wilson, A. T., *J. Lab. Clin. Med.*, 43, 230 (1954).

[8] Litchfield, jun., J. T., and Wilcoxon, F., *J. Pharmacol.*, 96, 99 (1949).

[9] White, H. J., Wadsworth, B. C., Redin, G. S., and Gentile, A. J., *Antibiotics and Chemotherapy*, 2, 659 (1952).

[10] Bratton, C., and Marshall, jun., E. C., *J. Biol. Chem.*, 128, 537 (1939).

[11] Koechlin, B. A., Kern, W., and Engelberg, R., *Antibiot. Med.*, 6, Supp. p. 22 (1959).

LETTERS TO THE EDITORS

PHYSICS

Detection of Recently Produced Fission Products in the Atmosphere

We have been investigating in some detail the trend in fission product-levels of surface air sampled at our laboratory site at Sutton, Surrey, since May 1959. Recently, we detected a sharp increase in the levels of activity, and evidence is presented here which suggests that this was due to the first nuclear weapon test in the Sahara.

The levels of atmospheric radioactivity have been studied by measurements made on dust collected from the air by three systems: (1) a small electrostatic precipitator; (2) a large electrostatic precipitator; (3) a membrane filter assembly. The results of some of our counting measurements are shown in Fig. 1. It will be seen that the increase in activity was pronounced, but transitory, occurring some time during February 28–March 1, 1960.

The activities of the small electrostatic precipitator and the membrane filter assembly samples were measured by β-counting and in Fig. 2 the decay of small electrostatic precipitator sample 83 (February 24–March 1, 1960) is shown. The initial rapid decay is due to daughter nuclei of naturally occurring radon and thoron. After this initial decay, a half-life of 9–12 days is observed for the next 6 days, after which the curve tends to flatten out.

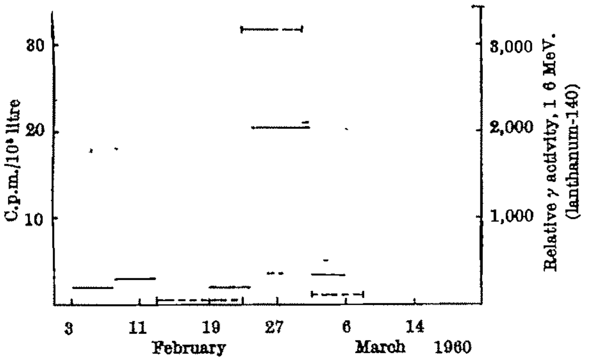


Fig. 1. Counting-rate from three sets of dust samples showing rise between February 28 and March 1, 1960. Horizontal lines indicate period of collection. Membrane filter, ... (left-hand scale); small electrostatic precipitator, ——— (left-hand scale); large electrostatic precipitator, — — · (right-hand scale)

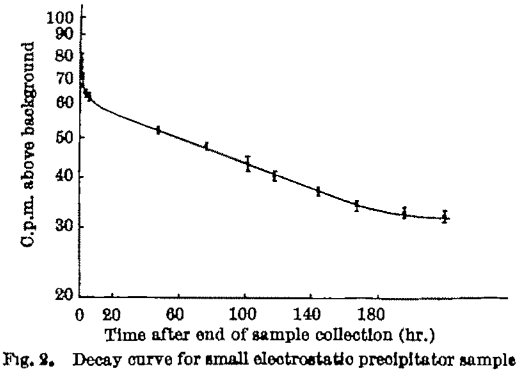


Fig. 2. Decay curve for small electrostatic precipitator sample 83

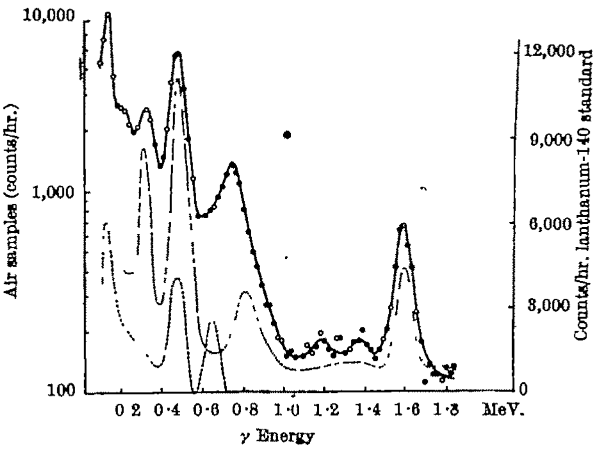


Fig. 3. Gamma-scintillation spectra showing large electrostatic precipitator samples 11(– – – –) and 12 (—○—○) compared with the spectrum of lanthanum-140 (. . . . .)

Fig. 3 shows a γ-spectrum of large electrostatic precipitator sample 12, collected over the period of increased activity, together with a spectrum of large electrostatic precipitator sample 11 taken during the preceding 10 days. The spectrum of a standard source of barium-140 plus lanthanum-140 is also shown. It will be seen that the spectrum of our standard has four prominent peaks[1] and that three of these appear in the spectrum of sample 12. The peak at about 750 keV. is probably due to zirconium-95 plus niobium-95 which would mask the lanthanum-140 line at 815 keV.

If this material is assumed to have come from the nuclear test on February 13, 1960, this would mean that our first measurements were made 20 days after fission. The principal fission products at that time are barium-140, lanthanum-140 and praesodymium-143, which decay with half-lives around 13 days, and cerium-141, with a half-life of 32 days[2]. The decay curve shown in Fig. 2 is very close to that to be expected from such a mixture of activities. Further, the principal γ-lines above 200 keV. will be those due to lanthanum-140, zirconium-95 and ruthenium-103. Energies corresponding to the first two of these nuclides are present in the spectrum of sample 12. The lines of ruthenium-103 would be masked by those of the lanthanum-140 spectrum. These two main lines of evidence combine to demonstrate the occurrence of recently produced fission products in the atmosphere, and it appears likely that these were derived from the French nuclear test.

The concentration of lanthanum-140 in the air was estimated to be 2×10^{-16} c./litre, averaged over the two-day period during which the increase in activity occurred (maximum permissible concentration for a life-time irradiation of occupationally exposed workers, 5×10^{-11} c./litre)[3]. From the known fission yields[2], the concentration of other nuclides can then be estimated. For example, the iodine-131 level would be about 1×10^{-16} c./litre on the same date. There are in all about ten nuclides with activity of the same order of magnitude at this time, so that the total activity would not be expected to exceed 2×10^{-15} c./litre. It is apparent that though detectable, at this site, none of the nuclides was present at a level having biological significance.

We wish to express our thanks to Prof. W. V. Mayneord, in whose Department the work was carried out, for his help and guidance.

W. Anderson
R. E. Bentley
L. K. Burton
C. A. Greatorex

Physics Department,
Institute of Cancer Research,
Royal Cancer Hospital,
Fulham Road, London, S.W.3.

[1] Strominger, D., Hollander, J. M., and Seaborg, G. T., *Rev. Mod. Phys.*, **30**, 585 (1958).

[2] Low, K., and Björnstedt, R., *Arkiv Fysik*, **13**, 85 (1957).

[3] National Bureau of Standards, Handbook No. 69.

Radioactivity of the Atmosphere due to Distant Nuclear Test Explosions

The programme at Harwell of rain-water collection and analysis for nuclear debris has been reported by Stewart *et al.*[1-3] and by Crooks *et al.*[4]. In conjunction with this programme, samples of radioactive dust are collected from the atmosphere using aircraft of the Royal Air Force. Similar sampling programmes using aircraft have been reported[5] from the United States, Norway and Sweden.

The dust samples are collected in filters of esparto fibre mounted in holders such that forward movement of the aircraft forces air through the filter. Measurements have been made of the concentration in air of fission-product activities at an altitude of 47,000 ft. in the lower stratosphere and in a composite sample taken between 1,700 and 18,000 ft. in the troposphere.

The filters are analysed for cæsium-137 (30-year) and zirconium-95 (65-day) by a γ-ray spectrometer using a crystal of sodium iodide (3 in. by 3 in. diameter), adequate shielding and a multi-channel pulse analyser. The uncertainty in a single analysis is usually less than 10 per cent provided that, in the case of cæsium-137, the ratio zirconium-95/cæsium-137 is less than 1. If necessary, the samples are allowed to decay before the final determination of cæsium-137.

The stratospheric samples are collected with disk filters (area 45 cm.^{2}) through which the air-flow is measured by an orifice plate assembly and pressure gauges. Typically, about 20 kgm. of air passes through the filter during a flight of 1 hr. between latitudes 50° N. and 56° N. above the United Kingdom. The results of sampling at 47,000 ft. between 1957 and 1959 are expressed in Fig. 1 as the concentration of cæsium-137 in μμc./kgm. of air and also as the ratio of concentrations, zirconium-95/cæsium-137. The collection efficiency of the filters measured at this altitude is nearly 100 per cent. The separate analyses of samples (about 6 per month) are combined to provide a mean monthly concentration.

The concentration of activity in the troposphere is much lower, in accordance with the steep gradient of fission product activity in the atmosphere[1]. In this case samples are collected in cylindrical filters (area 300 cm.^{2}) through which the airflow is measured indirectly. About 1,600 kgm. of air passes through the filter in a flight of 9 hr. along a track over the eastern Atlantic between latitudes 42° N. and 65° N. The flight plan produces a composite tropospheric sample of effective altitude ~4,000 ft. The results are presented in Fig. 2. The activity on the filter is corrected by the collection efficiency, measured in these conditions to be 85 per cent. The monthly concentration plotted is the mean of samples from about twenty sorties.

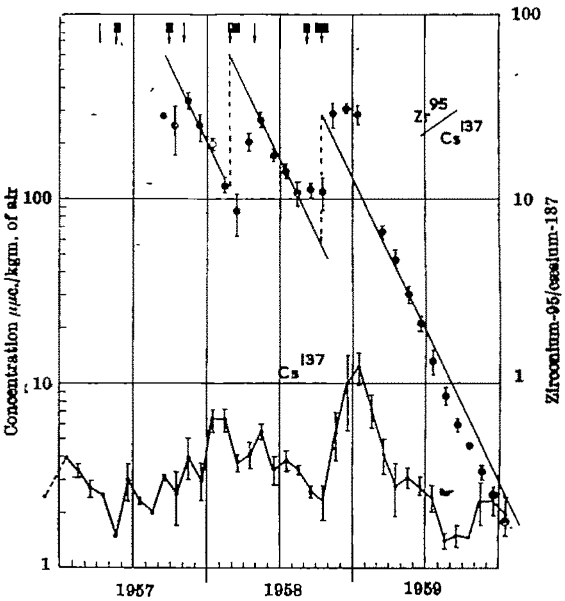


Fig. 1. Concentration of cæsium-137 and zirconium-95 in the lower stratosphere (altitude 47,000 ft.)

A simple calendar of nuclear test explosions has been fitted to both figures. This has been drawn mainly from results published by Harris[6] and is restricted to explosions of high yield (megaton). It should be recognized that explosions of low yield (kilotons) occurred frequently at other times.

The following observations are based upon deductions from the evidence of Figs. 1 and 2.

The concentration of cæsium-137 in the troposphere follows a seasonal variation, exhibiting peaks in the spring, about May, and troughs in the autumn. This is similar to the effect observed in rain-water by

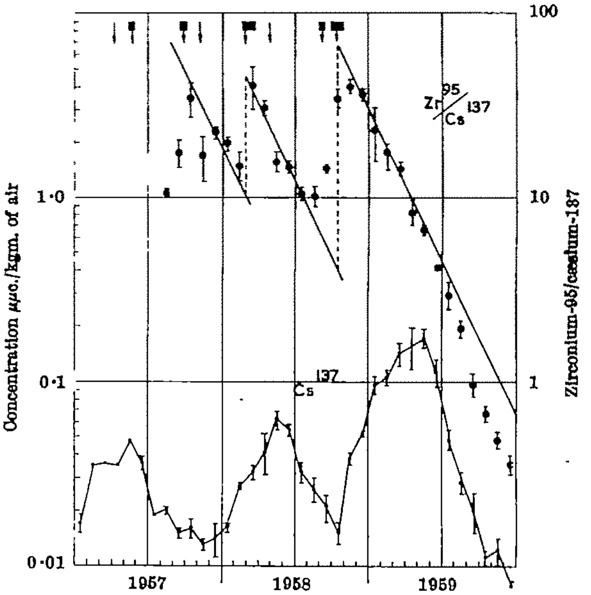


Fig. 2. Concentration of cæsium-137 and zirconium-95 in the troposphere (effective altitude ~ 4,000 ft.)

Stewart *et al.*[2,3]. On the other hand, the record of cæsium-137 concentration in the lower stratosphere (Fig. 1) does not follow the same seasonal variation. During 1957–59 a peak appears in January that may represent a seasonal movement of debris injected in the preceding months.

The ratio zirconium-95/cæsium-137 is a useful index of the age or origin of the mixture of fission products. Within a few months after a new series of test explosions the disturbed conditions are followed by a 'settled period' during which this ratio decays fairly regularly. In some settled periods this decay-rate corresponds to the radioactive half-life of zirconium-95 (65 days), as drawn in the diagrams. Such correspondence implies good mixing, in the regions of sampling, of new fission products from the recent explosions with those from previous explosions, that is, samples are taken from a source of radioactive material that is supplied in constant proportions from the 'reservoirs' of new and old debris.

The proportion of new activity may be calculated from the isotope ratios. For example, during January–June 1959 the proportion of activity in the troposphere due to explosions of autumn 1958 was about 45 per cent. This estimate is to be compared with ~60 per cent derived from the ratios strontium-89/strontium-90 in rain-water at Milford Haven[4] and with 40–50 per cent calculated by Ambrosen[7] for rain-water in Denmark. Departure of the plotted ratios zirconium-95/cæsium-137 after mid-1959 from the earlier line of decay (Fig. 2) corresponds to a reduction in this proportion, that is, to a relative increase in the rate of supply of old debris.

The debris sampled in the lower stratosphere after the autumn 1958 explosions shows evidence (Fig. 1) of good mixing in the second half of 1959. Previously in 1959 the behaviour of the zirconium-95/cæsium-137 ratios is again consistent with a relative increase in the rate of supply of old radioactivity.

Differences between the troposphere and lower stratosphere in the durations of the settled periods and the values of zirconium-95/cæsium-137 are significant. The explosions of autumn 1958 have in the latitudes of the United Kingdom produced a proportionately larger increase in the activity in the troposphere than in the lower stratosphere. This is contrary to the situation in the summer of 1958. In the latitudes of the United Kingdom the two regions of the atmosphere have maintained separate identities, as defined by the ratio zirconium-95/cæsium-137 during 1959.

A fuller account and discussion of the concentration of activity in air and rain-water will be published later.

D. H. Peirson
R. N. Crooks
E. M. R. Fisher

Health Physics Division,
Atomic Energy Research Establishment,
Harwell. Feb. 24.

[1] Stewart, N. G., Crooks, R. N., and Fisher, Miss E. M. R., A.E.R.E. Report *HP/R* 2017 (H.M.S.O., 1957).

[2] Stewart, N. G., Osmond, R. G. D., Crooks, R. N., and Fisher, Miss E. M. R., A.E.R.E., Report *HP/R* 2354 (H.M.S.O., 1958).

[3] Stewart, N. G., Osmond, R. G. D., Crooks, R. N., Fisher, Miss E. M. R., and Owers, M. J., A.E.R.E. Report *HP/R* 2790 (H.M.S.O.. 1959).

[4] Crooks, R. N., Osmond, R. G. D., Owers, M. J., and Fisher, Miss E. M. R., A.E.R.E. Report *R* 3094 (H.M.S.O., 1959).

[5] "Fallout from Nuclear Weapons Tests", U.S. Congressional Hearings, May 5–8, 1959, 1, 742 and 763 (U.S. Government Printing Office, Washington, 1959).

[6] Harris, D. L., "Recent Advances in Atmospheric Electricity", edit. by Smith, L. G., 241 (Pergamon Press, 1958).

[7] Ambrosen, J., *Nature*, 185, 301 (1960).

Isotopic Composition of Potassium

Recent measurements[1–6] of the natural isotopic composition of potassium have yielded values for the potassium-39/potassium-41 ratio ranging from 13·48 ± 0·07 (Nier) to 13·96 ± 0·05 (Omura and Morito). These results are not inconsistent with the presence of variations of 1 or 2 per cent in the potassium-39/potassium-41 ratio for different samples. Earlier measurements, many of which have been summarized by Reuterswärd[3], cover an even wider range, and include numerous reports[7–12] of differences of 1 per cent or more between the potassium-39/potassium-41 ratios of minerals, normal and cancerous human tissues, and other biological samples. More recently, Voshage and Hintenberger[13] have shown that potassium of abnormal isotopic composition can be produced naturally as a result of the action of cosmic rays on iron meteorites.

The ratio potassium-41/potassium-40 was measured by Nier[1] for a sample of mineral origin and found to be 578 ± 6. Subsequent measurements on other mineral samples have agreed with this figure within 1 or 2 per cent. Fenn *et al.*[14] have reported a difference of approximately 2 per cent in the specific radioactivity of potassium salts from mineral and biological sources. This implies a corresponding difference in the relative isotopic abundance of the radioactive isotope potassium-40. However, other workers[15,16] using a similar technique have found no significant differences between the specific radioactivities of potassium salts separated from various mineral and biological materials.

This communication describes a survey of the isotopic composition of potassium in natural samples. The survey was carried out in two parts. In the first, fifty potassium-39/potassium-41 analyses were made on twenty-seven different samples; in the second, twenty potassium-41/potassium-40 analyses were made on fifteen different samples. Each group of samples included minerals (among them two microclines giving anomalous potassium–argon ages), normal and cancerous human tissues, embryonic tissue, Indian Ocean sea water, two tektites (australites) and one plant sample (*Scaevola spinescens*). Extensive tests were carried out to eliminate sources of experimental error and to establish accurately the probable errors due to the remaining random effects.

Isotopic analyses were carried out with a 60-degree, first-order single-focusing mass spectrometer with a 14-cm. ion path radius. Features of the instrument were the use of a new type of single-filament ion source[17] allowing accurate comparison of isotope ratios, use of dual ion-current collectors and amplifiers[18], and the stabilization of potassium-39 ion currents to allow more accurate measurement of the potassium-40 ion currents[19]. A rotating source assembly allowed rapid interchange of ion sources without changing the vacuum conditions or the adjustment of the ion gun. Chemical separation of the potassium as the tetraphenylboron salt was carried out for each sample, this being converted to the nitrate before analysis.

The repeatability of the results was obtained by repeated analysis of samples from a homogeneous standard material (potassium nitrate, the potassium originating from the Stassfurt sylvine deposit). The probable error for any single analysis was close to 0·3 per cent for potassium-39/potassium-41 ratios, and 0·7 per cent for potassium-41/potassium-40 ratios.

Investigations were carried out on the effects of gas scatter, non-linearity and temperature sensitivity of the measuring circuits, secondary electron emission from the collectors, ion reflexion from the collectors, stray magnetic fields in the source region, and other factors. In no case did the necessary correction to the potassium-39/potassium-41 ratio exceed 1 part in 1,000.

Tests to determine the effects of impurities in the sample materials showed that, if analyses had been carried out without any chemical purification of the samples, the potassium-39/potassium-41 ratios would have been subject to systematic errors ranging up to 3 per cent. Errors of this magnitude were associated with sample solutions in which only a few per cent of the total number of cations in each sample were potassium ions. A somewhat similar effect has been reported by Reutersward[3]. The mechanism of the effect has not yet been definitely established.

Tests to establish the degree to which samples were contaminated by 'normal' potassium were carried out using synthetic control samples of anomalous potassium-39/potassium-41 ratio. Contamination effects were proved to be negligible in all stages of the chemical treatments and in the actual isotopic analysis.

The overall distributions of results for both groups of samples were similar to the random distributions obtained by repeated analysis of the standard KNO_3. None of the samples showed a significant difference in either potassium-39/potassium-41 or potassium-41/potassium-40 ratio relative to the standard. It follows that the assumption of constant potassium-40 relative abundance, widely employed in the application of the potassium–argon dating method, is probably valid within very small limits, at least in the case of terrestrial samples. The normal isotopic composition of the australites shows that there is no significant age difference between the potassium from these and terrestrial sources. The normal potassium-39/potassium-41 and potassium-41/potassium-40 ratios obtained for human tissue suggest that claims of abnormal radioactivity of potassium from organic sources may be due to the presence of impurities in the sample materials.

The systematic errors which can apparently arise from the analysis by solid source techniques of samples containing large quantities of impurities may explain many of the previous reports of significant variations in the potassium-39/potassium-41 ratio of natural potassium.

The values obtained for the mean ratios potassium-39/potassium-41 and potassium-41/potassium-40 in the ion beams reaching the mass spectrometer ion collectors from the standard samples were 13·77 ± 0·03 and 576 ± 3 respectively. The quoted errors are probable errors.

It must be noted that mean ion current ratios, although usually assumed equal to the ratios in the sample material, are not absolute ratios. They include the effects of all systematic errors occurring up to the time of arrival of the ions at the collectors. Such errors can only be definitely established by calibrating the instrument with a sample of known isotopic composition. To eliminate all possible sources of error, the calibration sample must be in the same chemical form and of almost the same isotopic composition as the sample materials. No mass spectrometer appears to have been calibrated for potassium in this way, although a calibration with a synthetic argon isotope mixture has been made by Nier[1].

The availability and cost of separated potassium isotopes of high purity are now such that there must be several laboratories in a position to attempt absolute determinations of the isotopic composition of potassium. Existing instruments could be calibrated with accurately prepared gravimetric mixtures of separated isotopes in approximately normal proportions and used to obtain the absolute isotopic abundance ratios. Laboratory potassium salts, in view of the apparent constancy of the isotopic composition of potassium, could then be generally used for the calibration of mass spectrometers and for the measurement of absolute values of isotopic fractionation effects in the various types of ion sources. Such measurements could be expected to contribute substantially towards a better understanding of surface ionization phenomena.

Thanks are due to the many persons who assisted with the collection, identification and preparation of the samples. Prof. C. J. Birkett Clews and Dr. P. M. Jeffery are thanked for their guidance and encouragement. The work was supported by the New South Wales State Cancer Council, Dr. K. W. Starr, the University of Western Australia Research Grants Committee and the Australian Atomic Energy Commission, to which I am also indebted for a Postgraduate Research Studentship.

B. R. F. KENDALL*

Department of Physics,
University of Western Australia,
Nedlands.

* At present with the Electron Physics Group, Radio and Electrical Engineering Division, National Research Council of Canada, Ottawa.

[1] Nier, A. O., *Phys. Rev.*, **77**, 789 (1950).

[2] White, J. R., and Cameron, A. E , *Phys. Rev.*, **74**, 991 (1948).

[3] Reutersward, C., *Arkiv Fysik*, **11**, 1 (1956).

[4] White, F. A., Collins, T. L., and Rourke, F. M., *Phys. Rev.*, **101**, 1786 (1956).

[5] Greenewalt, D., U.S. Atomic Energy Comm., Report *NYO*-3936 (1956).

[6] Omura, I., and Morito, N., *J. Phys. Soc. Japan*, **13**, 659 (1958).

[7] Brewer, A. K., *J. Amer. Chem. Soc.*, **58**, 365 (1936).

[8] Brewer, A. K., *J. Chem. Phys.*, **4**, 350 (1936).

[9] Brewer, A. K., *J. Amer. Chem Soc.*, **59**, 869 (1937).

[10] Lasnitzki, A., and Brewer, A. K., *Biochem. J.*, **35**, 144 (1941).

[11] Lasnitzki, A , and Brewer, A. K., *Cancer Res.*, **1**, 776 (1941).

[12] Lasnitzki, A., and Brewer, A. K., *Cancer Res.*, **2**, 494 (1942).

[13] Voshage, H., and Hintenberger, H., *Z. Naturforsch.*, **14,a**, 194 (1959).

[14] Fenn, W. O , Bale, W. F., and Mullins, L. J., *J. Gen. Physiol.*, **25**, 345 (1942).

[15] Lasnitzki, A., *Amer. J. Cancer*, **35**, 225 (1939).

[16] Mullins, L. J., and Zerahn, K., *J. Biol. Chem.*, **174**, 107 (1948).

[17] Kendall, B. R. F., *Rev. Sci. Instr.*, **29**, 1089 (1958).

[18] Kendall, B. R. F., *Nuclear Instr.*, **3**, 73 (1958).

[19] Kendall, B. R. F., *Rev. Sci. Instr.*, **29**, 851 (1958).

Electron Spin Resonance in Hydrogen Peroxide – Water Solutions at 90° K. irradiated with Ultra-Violet Light

ELECTRON spin resonance measurements have been made on ultra-violet irradiated hydrogen peroxide – water solutions. The electron spin resonance spectrometer works at 9·35 kMc./s. and uses a conventional phase-sensitive detector system, with a field modulation frequency of 280 c./s.

The hydrogen peroxide – water solutions were frozen at 90° K. in quartz tubes. Solutions of concentrations 46–87 per cent w/w hydrogen peroxide

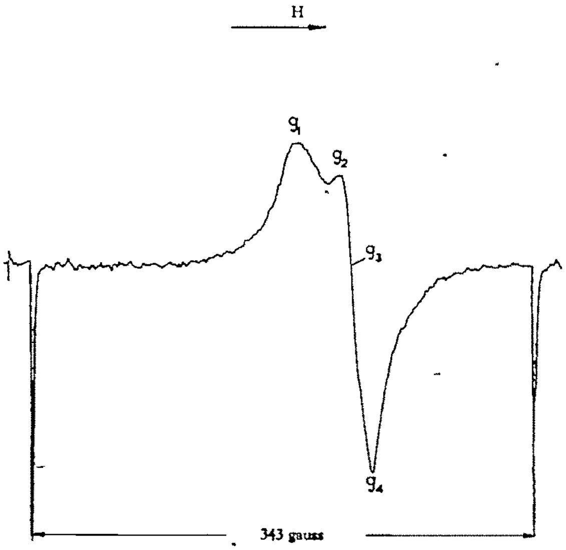


Fig. 1. Primary radical produced by ultra-violet on 87 per cent hydrogen peroxide at 90° K.

formed transparent glasses without much cracking. They were then irradiated for several hours using a Hanovia mercury vapour lamp. The ultra-violet light was filtered by the 'Pyrex' glass Dewar holding the frozen samples so that only wave-lengths longer than approximately 3000 Å. were transmitted.

The samples were quickly transferred to the spectrometer cavity (also at 90° K.) so that no warm-up took place. They then gave the spectrum shown in Fig. 1. The shape of the spectrum is very nearly the same for all the solution concentrations tested —46, 61, 78 and 87 per cent w/w. The g-values for the various points of the spectrum of this 'primary' free radical are given in Table 1. The samples were then warmed up by transferring them to a copper block maintained at a given temperature, storing them there for 5 min., and then returning them to the cavity, which was kept at 90° K. This process was repeated many times for the same samples, raising the temperature of the copper block between each step. On warming to temperatures above 130° K., the primary free radical is converted to another 'secondary' free radical. The spectrum for this radical is shown in Fig. 2. The conversion of the primary radical to this secondary radical is shown in Fig. 3, where $\frac{n_2}{n_1+n_2}$ and n_1+n_2 are plotted against warm-up temperature (n_1 is number of radicals of primary species and n_2 is number of radicals of secondary species). The ratios $\frac{n_2}{n_1+n_2}$ were calculated from the relative heights of the peaks g_1 and g_2 in the various spectra. It is seen from Fig. 3 that radical destruction takes place over the same range of temperature as that in which primary radicals are converted to secondary radicals. Measurements of the temperature for $\frac{n_2}{n_1+n_2} = 0·5$ show that this is 130 ± 5° K. for the four solution concentrations tested. The g-values of the various points of the secondary radical are also given in Table 1. The spectrum of the secondary radical shows the g-value anisotropic shape predicted by Searl *et al.*[1] for a polycrystalline sample containing axially symmetric crystals, and which identifies g_1 as $g_{\parallel}$ and g_4 as $g_{\perp}$. The spectrum also shows hyperfine splitting of amount 11 ± 2 gauss on the g_1 and g_4 peaks.

Table 1

Species	g_1	g_2	g_3	g_4
Primary	2·0375 ± 0·0008	2·0165 ± 0·0004	2·0105 ± 0·0004	2·0007 ± 0·0004
Secondary	2·0295 ± 0·0010	2·0128 ± 0·0004	2·0096 ± 0·0004	2·0084 ± 0·0004

The occurrence of two separate radicals under these conditions does not appear to have been reported before. Electron spin resonance spectra have been recorded by Kaitmazov *et al.*[2] from ultra-violet irradiation of hydrogen peroxide – water solutions at 77° K. without warming the sample above this temperature. They found a spectrum which showed

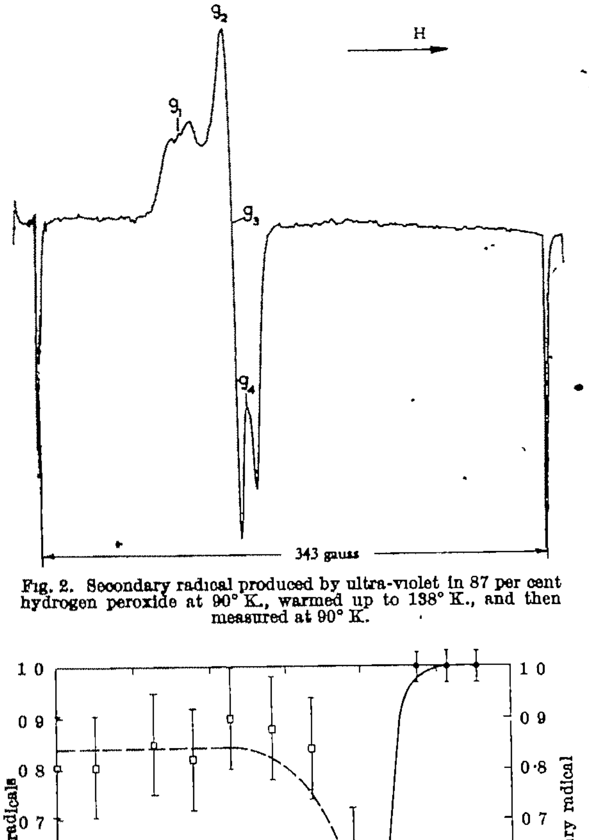


Fig. 2. Secondary radical produced by ultra-violet in 87 per cent hydrogen peroxide at 90° K., warmed up to 138° K., and then measured at 90° K.

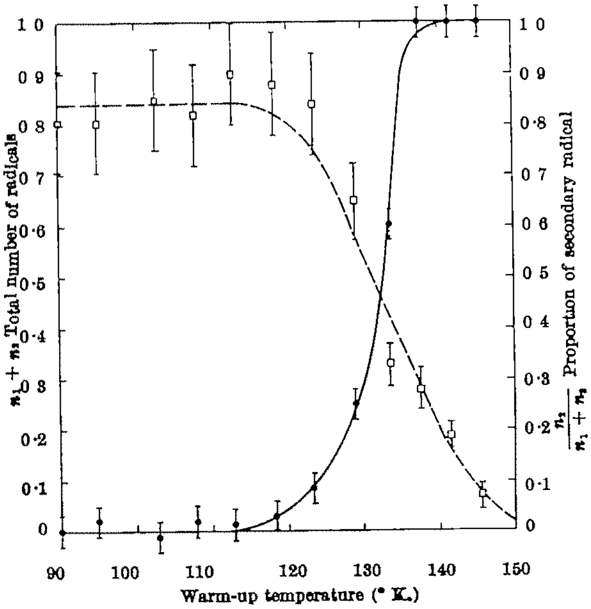


Fig. 3. Plot of $\frac{n_2}{n_1+n_2}$ (●) and $n_1 + n_2$ (□) against temperature of warm-up for 87 per cent hydrogen peroxide

the same g-values as the primary radical above, but which also showed a hyperfine splitting of 12 gauss on the g_4 peak. It therefore appears that their samples contained a mixture of the primary and secondary radicals with the primary radical predominating. The discrepancy between their spectrum and that of Fig. 1 might be explained if Kaitmazov *et al.* used ultra-violet wave-lengths shorter than 3000 Å. Hodgson *et al.*[3] also performed electron spin resonance measurements on a 40 per cent solution irradiated at 77° K. with 2537 Å. ultra-violet; but the resolution obtained was not good enough for comparison with the above measurements. It is also quite likely that the spectrum for the primary radical (Fig. 1) contains a small amount of secondary radical spectrum, and this might account for the g_2 shoulder. The secondary radical spectrum has been reported before by Gorbanev *et al.*[4] and also by Ghormley *et al.*[5], using the method of dissociation of hydrogen peroxide and water in an electrical discharge and freezing the products at 77° K. The spectrum shown in Fig. 2 is in agreement with these measurements; in particular Ghormley *et al.* quote $g_1 = 2{\cdot}027$, $g_2 = 2{\cdot}0085$, which agree within experimental error with the values given in Table 1. We have also performed similar discharge experiments and obtained agreement with the secondary radical.

Further experiments are now being performed in order to obtain more information on these two radicals, and the results of these measurements will be published in due course. It is hoped that this information will be sufficient to identify the radicals.

The hydrogen peroxide for these measurements was kindly supplied to us by Laporte Chemicals, Ltd. We wish also to acknowledge grants for apparatus and for one of us (R. C. S.) from the British Empire Cancer Campaign.

ROBERT C. SMITH
S. J. WYARD

Department of Physics,
Guy's Hospital Medical School,
London.

---

[1] Searl, J. W., Smith, R. C., and Wyard, S. J., *Proc. Phys. Soc.*, **74**, 491 (1959).

[2] Kaitmazov, S. D., and Prokhorov, A. M., *Zhur. Ekspt. i. Teoret. Fiz.*, **36**, 1331 (1959).

[3] Hodgson, W. G., Ingram, D. J. E., Parker, C. A., and Rees, W. T., *Nature*, **176**, 1227 (1955).

[4] Gorbanev, A. I., Kaitmazov, S. D., Prokhorov, A. M., and Tsentsiper, A. B., *Zhur. Fiz. Khim.*, **31**, 515 (1957).

[5] Ghormley, J., Livingston, R., and Zeldes, H., *J. Chem. Phys.*, **24**, 483 (1956).

RADIOPHYSICS

Ionospheric Effects associated with the Solar Flare of July 10, 1959

ON July 10, 1959, the Sydney Observatory reported a class 3+ solar flare lasting from 0210 to 0410 U.T. The Cable and Wireless, Ltd., Receiving Station at Singapore also experienced a sudden fade-out of all radio circuits at 0210 U.T., the circuits not being re-established until between 0415 and 0430 U.T.

Ionospheric changes associated with the flare were observed at the Department of Scientific and Industrial Research Radio Research Substation at Singapore by using an automatic ionosonde[1]. Fig. 1 shows measured values of f_0F2 and of the lowest frequency on which reflexions were obtained from the E or the F layer (f min.), together with median values for the same parameters for control days (July 1–20). A large change in f min. occurred between 0200 and 0230 U.T., and this is in agreement with the reported time of occurrence of the flare. The changes may be compared with those observed during the solar flare of February 23, 1956[2,3].

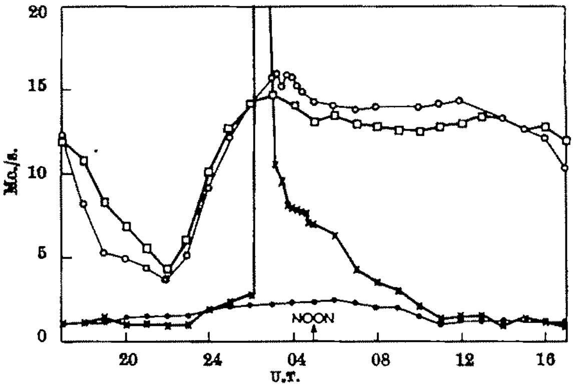


Fig. 1. Ionospheric characteristics observed on July 10, 1959, and control days. ○—○, Measured values f_0F2; ×—×, measured values f min.; □—□, median values f_0F2 for control days; ●—●, median values f min. for control days

An approximation to the increase in the electron density in the D layer has been computed from measurements of f min. and is presented in Fig. 2 as a ratio:

$$B/B_0 = (f1 + fL)^2/(f2 + fL)^2$$

where fL is the gyrofrequency around the vertical component of the geomagnetic field, $f1$ is f min. on July 10, 1959, $f2$ is f min. on control days (median).

A pulse in the measured values of f_0F2 was also observed immediately after the period of very high absorption. This pulse is similar to that studied by Minnis and Bazzard[3] and the same technique has been used to form an estimate of the amplitude of the pulse. On this occasion the best measured value of f_0F2

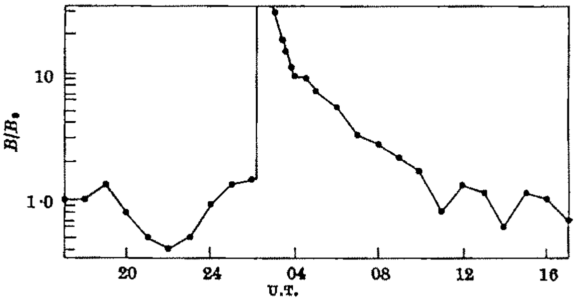


Fig. 2. Ratio of D-layer ionization on July 10, 1959, to median value of that observed on control days

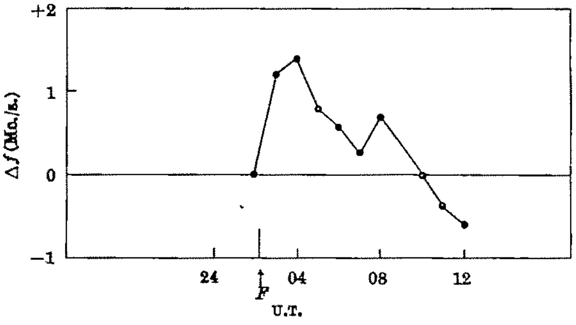


Fig. 3. Difference between measured and probable values of f_0F2 on July 10, 1959, and control days. F, Time of commencement of flare

prior to the disturbance was at 0200 U.T., and the most probable values for subsequent hours have been derived from this value and results recorded on the control days. The differences, Δf, between the measured and probable values of f_0F2 at each hour are shown in Fig. 3. The pulse reached its maximum amplitude between 0300 and 0400 U.T., the time of day in July when f_0F2 normally reaches its maximum value at Singapore.

Differences between the measured and probable values for all hours between 0200 and 1200 U.T. on each day in July have therefore been examined for similar pulses but none was found. The enhanced ionization of the $F2$ layer on July 10 can therefore reasonably be attributed to the effects of the solar flare.

The work described was carried out as part of the programme of the Radio Research Board. The work is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

V. A. W. HARRISON

Radio Research Station,
Department of Scientific and
Industrial Research,
Slough.

---

[1] Clarke, C., and Shearman, E. D. R., *Wireless Eng.*, 30, 211 (1953).

[2] Minnis, C. M., Bazzard, G. H., and Bevan, H. C., *J. Atmos. Terr. Phys.*, 9, 233 (1956).

[3] Minnis, C. M., and Bazzard, G. H., *Nature*, 181, 690 (1958).

Observations of Atmospheric Radio Noise

RECENT observations of radio noise from the upper atmosphere mainly at a frequency of 5 kc./s. have shown that it appears frequently to come from sources of limited geographical size. For example, records of the noise amplitude at places only 1,000 km. apart differ considerably in their time variations, while directional measurements of the apparent noise sources have suggested that they are sometimes as small as 500 km. in extent[1-3].

Yet, although the illumination of the Earth by this radiation in the Australian area appears to be both patchy and sporadic, its occurrence is clearly associated with world-wide disturbances of the geomagnetic field. It is therefore of some interest to examine any evidence for a world-wide noise pattern. Aarons, Gustafsson and Egeland[4] have reported observations of radio noise in the kilocycle region at Kiruna, Sweden. They detected the radiation mainly in two bands centred at about 750 c./s. and 2 5 kc./s. between the hours 0600 and 1900 G.M.T. on December 5, 1958.

Examination of routine records of radiation amplitude in the band 4 kc./s.–6 kc./s. obtained at Camden, New South Wales, has shown that following a geomagnetic sudden commencement (S.S.C.) at 0035 G.M.T., December 4, 1958, a noise storm began suddenly at 1250 G.M.T. on the same day and lasted until 2200 G.M.T. on December 5, 1958. As found on many other occasions at Camden its beginning coincided with a bay-like variation in the magnetic record. Fig. 1 shows a comparison of the Kiruna and Camden geomagnetic and noise records. The early part of the noise storm was apparently not recorded at Kiruna although this could have been due to the different recording technique used at the two places.

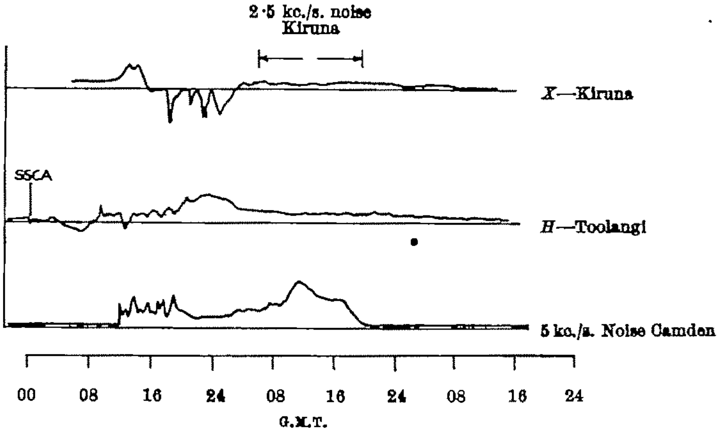


Fig. 1. Comparison of geomagnetic and very-low-frequency noise records (December 4, 1958) from Kiruna, Sweden, and Camden, New South Wales

It therefore appears likely that there is a world-wide pattern of noise illumination during geomagnetic disturbances, although more examples will be needed to confirm this. The study of this pattern may be of considerable importance because of the possibility that it represents an image of the disturbed regions of the outer atmosphere which are the sources of auroral particles. Investigations of whistling atmospherics have led to the belief that they are guided by ionization ducts in the outer atmosphere, probably lying along the geomagnetic field lines[5]. These magneto-ionic ducts will also guide any radiations in the kilocycle frequency band which are generated in the outer atmosphere and will thus project an image of the radiation sources on to the ionosphere. The radiation itself is likely to be caused by emission from fast charged particles traversing the plasma of the outer atmosphere.

Future studies of the world image at 5 kc./s. may be made either with a network of ground receivers or with satellite receivers. For an instantaneous picture, ground receivers would be necessary since a satellite takes 24 hr. to scan the whole Earth, whereas the average duration of noise bursts is only about 3 hr. Also, the geographical spacing between successive orbits is considerably greater than the scale of the fine structure of the image so far established[3]. Satellite and ground-based techniques are thus complementary and it is planned at this laboratory to make use of both.

The geomagnetic records of Toolangi Geomagnetic Observatory were supplied by the Commonwealth Bureau of Mineral Resources.

G. R. A. ELLIS

Upper Atmosphere Section,
Commonwealth Scientific and Industrial Research
Organization,
Camden,
New South Wales.

---

[1] Ellis, G. R. A., *Planet. Space Sci.*, 1, 253 (1959).

[2] Ellis, G. R. A., Cartwright, D. G , and Groves, J. R., *Nature*, 184, Supp. No. 18 (1959).

[3] Ellis, G. R. A., *J. Geophys. Res.* (in the press)

[4] Aarons, J., Gustafsson, G., and Egeland, A., *Nature*, 185, 148 (1960).

[5] Helliwell, R. A., 'Agard' Symposium on the Upper Atmosphere, Paris, May 1959.

Correlation of Occurrence of Whistlers with Geomagnetic Activities

In order to study the correlation of geomagnetic activities with the frequency of occurrences of whistlers, I have investigated the I.G.Y. and I.G.C. data for 2 years, that is, July 1, 1957–June 30, 1959, at the stations Toyokawa (geogr. co-ord. 34° 50′ N., 137° 22′ E.; geomag. co-ord. 24·5°, 203·5°) and Wakkanai (geogr. co-ord. 45° 22′ N., 141° 41′ E.; geomag. co-ord. 35·3°, 206·0°) and the 3-hr. range *K* indices of Kakioka Magnetic Observatory.

To show most effectively the geomagnetically disturbed days, I have defined as 'effective *K* index' the sum of products of the *K*-indices 5, 6·5 (for 6 or 7) and 8 (for > 8) and their number of occurrences per day; the indices 5, 6 or 7 and > 8 mean moderate storm, moderate severe storm and severe storm, respectively. At first I drew a diagram showing the correlation between my 'effective *K* index' and the number of occurrences of whistlers, and found that they can be classified fairly distinctly into two groups: one belongs to the winter group, October (or November)–March (or April), where many whistlers are found every month; the other to the summer group, May–September, where smaller numbers are found. It seems that it is difficult to find a single law applicable both to winter and to summer groups.

It may be deduced that the frequency of occurrences of whistlers has a definite seasonal variation depending on thunderstorm activities, distributions of electron density and geomagnetic intensity in the exosphere and in the ionosphere due to solar activities and other yet unknown cosmic phenomena; daily variations due to effective *K* index are superposed upon this general seasonal variation. Therefore I investigated the correlation of the effective *K* index with the frequency of occurrences of whistlers observed at Wakkanai in most frequent periods, that is, during September and December 1957, January, February, March and December 1958, January, February and March 1959; Wakkanai was selected owing to remarkable occurrences of whistlers there.

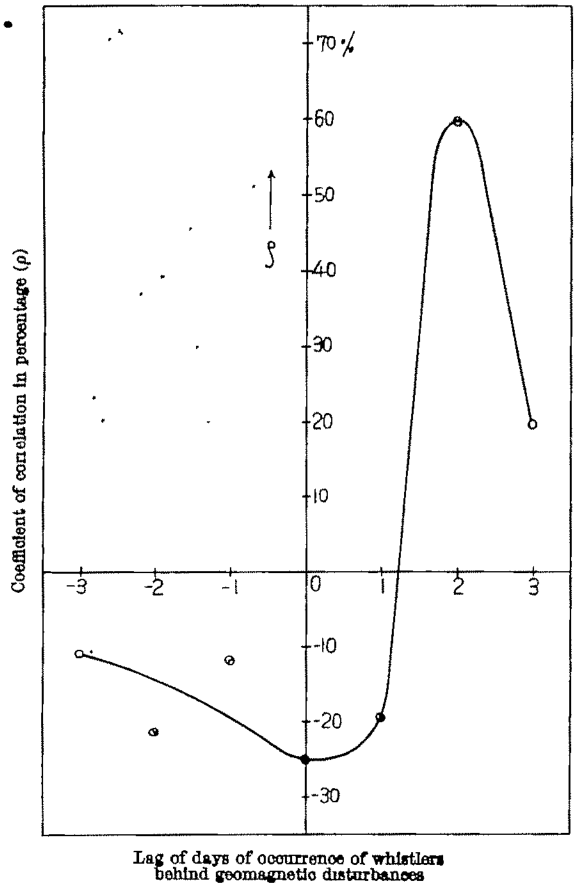


Fig. 1. Correlation between lag of occurrence of whistlers and geomagnetic disturbance

Table 1. Correlation between Lag of Occurrences of Whistlers and Geomagnetic Disturbances

Lag of days of occurrences of whistlers behind geomagnetic disturbances	−3	−2	−1	0	1	2	3
Coefficient of correlation	−0·11	−0·21	−0·12	−0·25	−0·19	+0·60	+0·20

Taking as reference disturbed days where effective *K* indices are more than 6, I investigated the correlation with the frequency of occurrences of whistlers, and found that it was most remarkable on the second day after geomagnetic disturbances; really the correlation coefficient on the second day was 0·60, as shown in Table 1, and in Fig. 1, from which I conclude that whistlers occur most frequently on the day which lags two days after geomagnetic disturbances. In the summer group the same correlation as that in the winter was not found.

Atsushi Kimpara

Research Institute of Atmospherics,
Nagoya University,
Toyokawa-shi, Aichi-ken.
Feb. 24.

GEOCHEMISTRY

Origin of Chondrules and Chondritic Meteorites

More than 90 per cent of all stony meteorites are classified as chondrites, because of the presence of chondrules—spheroidal aggregates of one or more silicates, commonly olivine and orthopyroxene. In form, texture and structure chondrules are not like any spheroidal bodies observed in terrestrial rocks, and their origin has been argued by investigators of meteorites for more than a century, without a generally accepted solution being reached. Roy[1] has recently provided an admirable summary of the hypotheses of origin. Most of these hypotheses imply that chondrules were derived originally from the crystallization of a silicate melt. These hypotheses are often linked with the generally accepted belief that these meteorites are fragments of a disrupted body of asteroidal or planetary dimensions.

I would suggest an alternative hypothesis, that the structure of chondritic meteorites is the result of reaction and recrystallization of pre-existing material essentially in the solid state, and that many, if not all, chondritic meteorites, instead of being fragments of a disrupted planet or asteroid, have always been independent and individual objects.

The pre-existing material I believe is represented by the carbonaceous chondrites, a small group (19 out of a total of about 800 chondrites), quite distinct from all other meteorites in chemical composition (they contain carbon, organic compounds, water-soluble compounds, and much combined water) and in mineralogical composition (the silicate material is largely chlorite, a hydrated magnesium–iron silicate). Chlorite decomposes on heating above about 600° C. to give olivine and orthopyroxene; if carbon is present, a natural smelting will take place, reducing some of the combined iron to metallic iron, and thereby increasing the magnesium content of the silicates. The reactions can be represented as follows:

$$\underset{\text{chlorite}}{Mg_4Fe_2Si_4O_{10}(OH)_8} \rightarrow \underset{\text{olivine}}{2(Mg,Fe)_2SiO_4} + \underset{\text{orthopyroxene}}{2(Mg,Fe)SiO_3} + 4H_2O$$

$$\big\downarrow {+2C}$$

$$4MgSiO_3 + 2Fe + 2CO_2$$

These reactions will produce the mineralogical composition of the usual chondritic meteorites, an aggregate of olivine and/or orthopyroxene, with some metallic iron. This relationship between carbonaceous chondrites and the other chondritic meteorites was pointed out by Wiik[2], who stated: "This is intended only to give a picture of the chemical relations between the subgroups, and not intended to suggest the genesis". I believe this is not only a chemical relationship but also a genetic one.

The texture and structure of the chondritic meteorites is quite remarkable if they have originated in any body with a considerable gravitational field. Many of them are very porous and friable, so much so that they can be crumbled in the hand, indicating they were not consolidated under pressure. They generally contain nickel–iron in amounts ranging from 5 to 25 per cent, this metal being intimately mixed with the low-density silicate minerals and showing no sign of gravitational segregation. Both these features are readily explicable if these meteorites are the product of chemical reconstitution of carbonaceous chondrites triggered off by heating to 600° C. or higher. A possible explanation is that carbonaceous chondrites represent aggregates of primitive cosmic dust, and that most of them have, during the course of geological time, approached sufficiently close to the Sun to be heated enough to set off the reactions converting them to olivine–pyroxene chondrites.

Suggestive evidence in favour of such an explanation is provided by the age data on chondrites. Gerling and Rik[3] have measured the ages of several chondrites by the potassium–argon method, and found them to differ one from another, ranging from 720×10^6 years up to $3,000 \times 10^6$ years. Different ages for different chondrites are to be expected on the hypothesis outlined here, since the potassium–argon age will give the time since recrystallization.

The hypothesis outlined here can be tested if we can devise methods for determining the temperature of crystallization of the minerals making up the chondrites. A few clues are already available. The St. Marks stone contains quartz, and hence its temperature of crystallization (at zero pressure) cannot have exceeded 867° C. The Indarch stone contains tridymite, which, if it crystallized within the field of stability of this mineral, implies a temperature of crystallization between 867° and 1,470° C. Other geochemical thermometers which should be investigated are: (*a*) composition relationships between olivine and co-existing pyroxene; (*b*) the nature of the plagioclase feldspar (present in small amount in most stone meteorites), whether low-temperature or high-temperature; (*c*) the nature of the nickel–iron phases—both kamacite and tænite are present in many stony meteorites, but usually as individual grains, not in Widmanstätten intergrowths. Investigations along these lines are proceeding in this Museum.

If the origin of the chondritic meteorites is that outlined above, the other meteorite types—achondrites, pallasites, and siderites—can be explained as the products of gravitational differentiation of a planetary or asteroidal body formed by the aggregation of chondrites. Such a body would probably pass through a molten stage as a result of the heat produced by aggregation, chemical reactions, and nuclear disintegrations. Given a moderate gravitational field, this would produce a silicate mantle overlying a metallic core. Subsequent disintegration would give rise to the essentially metal-free achondrites, and the silicate-free siderites, the few pallasites coming from a transition zone. In this connexion it should be noted that diamonds have been found only in siderites and achondrites, indicating that only these meteorites crystallized under sufficiently high pressures.

BRIAN MASON

American Museum of Natural History,
New York 24, N.Y.

---

[1] Roy, S. K. Fieldiana, *Geology*, 10, No. 31 (1957).

[2] Wiik, H. B., *Geochim. Cosmochim. Acta*, 9, 279 (1956).

[3] Gerling, E. K., and Rik, K. G., *Meteoritika*, 10, 37 (1952).

CHEMISTRY

Pentafluoropyridine

In two recent communications[1,2], a general method for the preparation of perfluoro-aromatic compounds was described. It involved the defluorination of saturated[2] and unsaturated[1] cyclic fluorocarbons over a metal surface at 400–600°, when the corresponding aromatic fluorocarbons were produced. For example, hexafluorobenzene was obtained[1] from octafluoro*cyclo*hexa-1 : 3- or -1 : 4-diene, and octafluoronaphthalene[2] from perfluorodecalin; several other examples were also described[2].

We now report the first synthesis of an unsaturated perfluoro-heterocyclic compound by a similar process. The starting material was undecafluoropiperidine, which was prepared by known routes—the electrochemical fluorination of either piperidine[3] or pyridine[3,4]. When passed through a heated nickel tube (2 ft. 6 in. long × 1 in. diameter) packed with nickel gauze, this gave pentafluoropyridine in moderate but significant yields. In a typical experiment, undecafluoropiperidine (3·4 gm.) was passed through the tube at 560° with a nitrogen flow-rate of 4·0 litres/hr. Gas-liquid chromatographic analysis (dinonyl phthalate/kieselguhr : nitrogen carrier gas) of the pyrolysate (2·1 gm.) showed that at least four components were present in addition to some unchanged starting material. The component with the highest retention time was separated from several combined pyrolysates (5·0 gm.) by preparative-scale gas-liquid chromatography[5] and was distilled *in vacuo* from phosphorus pentoxide to give pentafluoropyridine

(0·55 gm.), boiling point 84°, n_D^{20} 1·3834 (found: C, 35·6; C_5F_5N requires C, 35·5 per cent): mass-spectrometry, principal mass peaks: 169, C_5F_5N; 150, C_5F_4N; 138, C_4F_4N; 124, C_4F_4. The compound had $\lambda_{max.}$ at 254 mμ (ε, 2,700 in ethanol). The presence of strong bands in the infra-red spectrum at 1,650, 1,537, and 1,505 cm.$^{-1}$ was also consistent[6] with a pyridine structure, and the absence of strong bands at frequencies higher than 1,650 cm.$^{-1}$ showed that no olefinic bonds were present.

The other three components from the pyrolysis have not yet been identified, but are believed to be unsaturated.

Pentafluoropyridine is a colourless and almost odourless liquid. It is immiscible with water but miscible with organic solvents. We have been unable to detect any basic properties of the compound. A potentiometric titration in aqueous ethanol against *N*/20 acid showed no end-point. Hydrogen chloride in dry ether gave no hydrochloride, and no picrate was formed in ethanol solution. This behaviour is different from that of the primary amine pentafluoroaniline[7], which was weakly basic and formed an easily hydrolysable hydrochloride in ethereal solution. It is noteworthy that pyridine is a stronger base than aniline.

We thank Dr. J. R. Major for the mass-spectrometric results.

J. BURDON
D. J. GILMAN
C. R. PATRICK
M. STACEY
J. C. TATLOW

Chemistry Department,
The University,
Edgbaston,
Birmingham, 15.

[1] Gething, B., Patrick, C. R., Tatlow, J. C., Banks, R. E., Barbou , A. K., and Tipping, A. E., *Nature*, **183**, 586 (1959).

[2] Gething, B., Patrick, C. R., Stacey, M., and Tatlow, J. C., *Nature*, **183**, 588 (1959).

[3] Simons, J. H., U.S. Pat. 2,490,098 (1949).

[4] Simmons, T. C., Hoffmann, F. W., *et al.*, *J. Amer. Chem. Soc.*, **79**, 3429 (1957).

[5] Evans, D. E. M., and Tatlow, J. C., *J. Chem. Soc.*, 1184 (1955).

[6] Bellamy, L. J., "The Infrared Spectra of Complex Molecules", 277 (Methuen and Co., Ltd., London, 1958).

[7] Forbes, E. J., Richardson, R. D., and Tatlow, J. C., *Chem. and Indust*, 630 (1958) (and unpublished work).

A Modification for washing the Benzidine Sulphate Precipitate in the Determination of Sulphate

AMONG the numerous procedures that have been developed for determining sulphate with benzidine, that reported by Kent and Whitehouse[1] is most commonly employed as a micromethod. The reliability of the method has also been confirmed by me.

In this, as in all the other procedures, difficulty is experienced in removing the excess of benzidine from the benzidine sulphate precipitate without losing any of the latter. The difficulty was previously overcome by collecting the benzidine sulphate precipitate in a porous glass filter crucible and washing the unreacted soluble benzidine thoroughly. The method yields accurate and reproducible results provided that the filter is of standard porosity and the filtering time is held constant. Owing to the difficulties associated with the use of the filter crucible, the method is, however, time-consuming.

I have developed the following procedure for washing the benzidine sulphate after its precipitation by the method of Kent and Whitehouse. The contents of the precipitation tube are transferred to a centrifuge tube of about 10-ml. capacity which tapers to a sharp point. One drop of an aqueous suspension of barium sulphate which has been carefully rinsed free of excess barium or sulphate ions is then added and it is centrifuged for 5 min. at 3,000 r.p.m. Two more drops of the barium sulphate suspension are added, and the tube centrifuged for a further 15–20 min. The upper clear layer is then removed and the mouth of the tube dried with cellulose tissue. About 9 ml. of an alcohol–acetone (1 : 1) mixture is added to the tube, and the precipitate is broken up with a stiff steel wire. The tube is centrifuged about 5 min., two drops of the barium sulphate suspension are added, and the centrifugation continued for about 10 min. It should be noted that the total amount of barium sulphate added forms a cone 1–1·5 mm. high at the bottom of the tube when tightly packed. The upper clear layer is decanted, about 9 ml. of the alcohol–acetone mixture is added and the tube is centrifuged for about 10 min. After the supernatant has again been removed, 3 ml. of *N* hydrochloric acid is added to dissolve benzidine sulphate precipitate, which is broken up with a steel wire. After ½ hr., 2 ml. of water is added to the tube, and the latter is centrifuged for 5 min. The solution containing the benzidine is transferred to another tube for diazotization by the method of Kent and Whitehouse.

The microprecipitate of benzidine sulphate is always enclosed between two tightly packed layers of barium sulphate during the decantations. After the first centrifuged precipitate has been broken up, the benzidine adsorbed on the barium sulphate is removed by washing with the alcohol–acetone mixture. After the centrifuged precipitate has been broken up a second time, the pure benzidine sulphate is dissolved in the hydrochloric acid. The solubility of barium sulphate is so slight that it cannot cause any significant error.

In spite of its apparent complexity, the method can be readily employed in routine analyses. One hundred analyses can be performed daily with a centrifuge that takes 50 tubes and a larger throughput can be achieved by using a larger centrifuge. The accuracy of the method is about the same as reported by Kent and Whitehouse. The absorbance reading for the blank is 0 020 when a Beckman *DU* spectrophotometer is employed.

I. P. T. HAKKINEN

Department of Physiology,
University of Turku,
Finland.

[1] Kent, P. W., and Whitehouse, M. W., *Analyst*, **80**, 630 (1955).

Freezing-Point Depressions of Hoagland's 'Carbowax' Systems

SOLUTIONS of various osmotic pressures have been widely used in biology. Sugars and their derivatives, commonly used to maintain osmotic pressures, have the drawback that many, if not all, of these compounds can be metabolized by the test tissue or organism. McClenden and Blinks[1] described the use of 'Carbowax 4000' (polyethylene glycol) in maintaining various osmotic concentrations in a study of the Hill reaction. Excellent results were reported. This

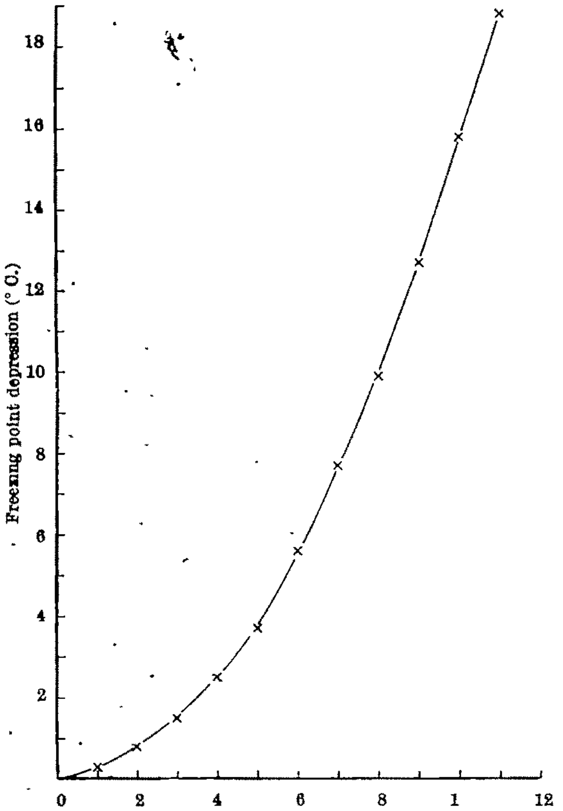


Fig. 1

laboratory has successfully used 'Carbowax 4000' in a study of water uptake by bush beans, *Phaseolus vulgaris*. We believe our results on freezing point depressions of complete Hoagland's solutions containing various concentrations of 'Carbowax 4000' may be of value to other investigators.

'Carbowax 4000' was dissolved in Hoagland's complete nutrient solution[2]. The freezing point depression was routinely checked about 24 hr. later. Solutions could be kept a week at room temperature without any effect on freezing-point depression. This lack of ageing effect agrees with the results of Couper and Eley[3]. Beckmann freezing-point apparatus was used for all determinations. For solutions containing 0–60 per cent (w/v) 'Carbowax 4000', a brine solution (−10° C.) was used to lower the temperature; for solutions containing 60–100 per cent (w/v) 'Carbowax 4000', chilled acetone (−20° C.) was used; for solutions containing 100–110 per cent (w/v) 'Carbowax 4000', acetone-dry ice (held at −30° C.) was used. The overlap between freezing solutions was used to maintain continuity.

No difference could be detected in freezing-point depressions of solutions determined in two different freezing mixtures. The results are presented in Fig. 1. It can be seen that the curve, while smooth, deviates from van't Hoff's law. The points on this curve are the result of a single run. The complete sequence was determined several times, however. The greatest deviation from the results presented here was 0·2 deg. C. From results presented here osmotic concentrations can readily be calculated. Couper and Eley[3] give results for freezing-point depressions of 'Carbowax 4000' in water.

This work was financed in part by Medical and Biological Research Funds, Initiative 171, State of Washington.

Howard G. Applegate

Division of Industrial Research,
Washington State University,
Pullman, Washington.

---

[1] McClenden, J., and Blinks, L., *Nature*, 170, 577 (1952).

[2] Hoagland, D., and Arnon, D., Univ. Calif. Agric. Exp. Sta. Circ., 347 (1938).

[3] Couper, A., and Eley, D., *J. Polymer Sci.*, 3, 345 (1948).

Some New Complexes of Rhenium

No complexes with oxygen or acetylenic ligands of rhenium have been previously reported, and the only known olefin complex was prepared indirectly[1]. We have prepared acetylacetone (rhenium acetylacetonates containing other ligands have been prepared, Nyholm, R. S., personal communication), acetylene and olefin complexes by direct reaction of the ligands with various rhenium compounds.

Acetylacetone reacts on refluxing with rhenium sesquioxide or rhenium dioxide to give rhenium *tris*(acetylacetonate) (Found: C, 36·7; H, 3·7; O, 20·1; Re, 38·9 per cent; required for Re($C_{15}O_6H_{21}$): C, 36·0; H, 4·3; O, 19·7; Re, 38·3 per cent). The complex forms brown paramagnetic crystals soluble in alcohol, acetone and chloroform. Its infrared spectrum shows peaks typical of other transitional metal acetylacetonates[2]. Susceptibility measurements show that the effective magnetic moment is dependent on temperature, varying between 1·9 and 2·3 B.M. The variation is probably due to antiferromagnetic effects and the low moment is similar to that of other octahedral Re(III) complexes[3] which have been interpreted by Kotani theory[4].

Very stable monomeric, diamagnetic acetylene complexes were obtained directly from rhenium trichloride and triphenylphosphine rhenium trichloride[5], for example, phenylacetylene gave $ReCl(C_6H_5C{\equiv}CH)_2$ with the trichloride. In these compounds the triple $C{\equiv}C$ bond is reduced effectively to a double $C{=}C$ bond as shown by the shift of the C—C stretching frequency down to 1,700 cm.$^{-1}$, and the acetylene may be regarded as bonded to the metal by two σ bonds from the carbon atoms adjacent to the multiple bond, as suggested by Chatt for the platinum acetylene complexes[6].

Complexes have also been obtained from hydroxy acetylenes; thus, with but-1-yne-3-methyl-3-ol a compound of formula $ReCl(C_5H_8O)_2$ is obtained from the trichloride and $ReCl.P(C_6H_5)_3.(C_5H_8O)_2$ from triphenylphosphine rhenium trichloride. Again the bonding in these compounds is similar to that in the analogous platinum complexes in which it is thought that the acetylene acts as a bidentate ligand with bonding from both the triple bond (μ bond) and the hydroxyl oxygen[7]. The infra-red spectra of the rhenium complexes show similar shifts in both the $C{\equiv}C$ and O—H stretching frequencies to those reported for the platinum compounds[7].

Rhenium trichloride and triphenylphosphine rhenium trichloride react with olefins; thus di*cyclo*pentadiene gives $ReCl_2(C_{10}H_{12})_2$ with rhenium trichloride. This black compound is insoluble in all solvents and is probably polymeric. From triphenylphosphine rhenium trichloride a compound $ReCl[P(C_6H_5)_3](C_{10}H_{12})_2$ is obtained which is readily soluble in organic solvents.

We thank the Atomic Energy Authority, Harwell (R. C.) and the Consejo Nacional de Investigaciones Cientificas y Tecnicas of the Argentine Republic (R. L.) for financial support.

R. Colton
R. Levitus
G. Wilkinson

Inorganic Chemistry Research Laboratories,
Imperial College of Science and Technology,
London, S.W.7.
Feb. 20.

[1] Green, M. L. H., and Wilkinson, G., *J. Chem. Soc.*, 4314 (1958).
[2] Cotton, F. A., "Modern Coordination Chemistry", edit. by Lewis, J., and Wilkins, R. G. (Interscience Pub., Ltd., London, 1960).
[3] Curtis, N. F., Fergusson, J. E., and Nyholm, R. S., *Chem. and Indust.*, 625 (1958).
[4] Kotani, M., *J. Phys. Soc. Japan*, **4**, 293 (1949).
[5] Colton, R., and Wilkinson, G., *Chem. and Indust.*, 1314 (1959).
[6] Chatt, J., Duncanson, L. A., and Guy, R. G., *Chem. and Indust.*, 430 (1959).
[7] Chatt, J., Duncanson, L. A., and Guy, R. G., *Nature*, **184**, 526 (1959).

Infra-Red Spectrum of Garnets

Regularities in the infra-red absorption spectra of silicate minerals have been pointed out by Launer[1]. Very recently, a much more detailed study of the strong absorption of the garnets in the 800–1,000 cm.$^{-1}$ range has been published by Wickersheim *et al.*[2]. My results in this field extend down to 280 cm.$^{-1}$ and may be summarized as follows.

(1) If titaniferous garnets are excepted, the general infra-red pattern is pretty uniform, irrespective of the nature of the trivalent and bivalent cations. This pattern is highly characteristic of the garnets, and has not been observed in more than a hundred other silicates so far investigated[3].

(2) The nearly linear relationship between the frequency ν of a given band and the length of the cell edge a_0, mentioned by Wickersheim[2] is verified for all the bands down to 500 cm.$^{-1}$; it does not hold, however, for the bands observed at low frequencies. This is readily explained by the fact that most of these low-frequency bands are related to metal-oxygen vibrations, their position being chiefly determined by the nature of the cation itself.

On the other hand, it should be pointed out that, for certain bands at least, the slope of the straight line ν versus a_0 is slightly but definitely different for the two principal families of garnets, namely, the pyralspite and the ugrandite series.

(3) Garnets of the pyralspite family always exhibit one or two bands of low or medium intensity in the 350–280 cm.$^{-1}$ range. These bands are either missing or extremely weak for the garnets of the ugrandite family. This is reasonably explained if these bands are assigned to metal-oxygen vibrations of the bivalent cation (Fe II, Mn II, Mg) in eight-fold co-ordination: in the ugrandite garnets, this cation is mainly calcium, and the ionic bonds Ca—O should not give rise to discrete infra-red absorption bands.

(4) Some details may be characteristic of a given type of garnet. The discussion of such details is out of place here, and will be given in a forthcoming paper.

(5) In titaniferous garnets of the melanite–schorlomite–ivaarite series, the general infra-red pattern is more or less altered, the degree of alteration being roughly proportional to the amount of titanium. In these garnets, titanium is in four-fold co-ordination (at least partly), and thus replaces silicon. This assignment has been discussed at length in a previous paper[4].

From a more theoretical point of view, the most important feature is the uniformity of the bands assigned to SiO_4 fundamental frequencies. This uniformity is somewhat surprising, as $R^{III}O_6$ octahedra and $R^{II}O_8$ dodecahedra are the nearest neighbours of the SiO_4 tetrahedra, and partial isomorphic replacement of either R^{III} or R^{II} (which always occurs in garnets) should alter the local symmetry around the SiO_4 group.

This is in contrast with the strong influence of the introduction of TiO_4 tetrahedra in the structure. This introduction does alter the infra-red pattern of the SiO_4 tetrahedra, although the TiO_4 and SiO_4 are not mutually linked.

This interesting behaviour is not restricted to the garnet type, and has been observed in other series of isomorphic orthosilicates[3].

P. Tarte

Institut de Chimie,
Université de Liège.

[1] Launer, P. J., *Amer. Mineral.*, **37**, 764 (1952).
[2] Wickersheim, K. A., Lefever, R. A., and Hanking, B. M., *J. Chem. Phys.*, **32**, 271 (1960).
[3] Tarte, P. (to be published).
[4] Tarte, P. (in the press).

BIOCHEMISTRY

Vitamin A_1 Aldehyde in Hen's Eggs

We have recently reported[1] that vitamin A_1 aldehyde occurs in the ripe eggs of several marine teleost fishes, and is the predominant form of vitamin A in them. In that paper we stated that we could not detect vitamin A_1 aldehyde in hen's eggs, but further experiments have shown it to be present.

Eggs from inseminated Light Sussex hens on a breeder's mash containing 2·4 mgm./kgm. of preformed vitamin A were used, the eggs being stored at 4° C. until used. The yolk was separated from the white, and extracted as previously described for fish eggs[1]. When the extract was subjected to gradient elution chromatography[1], with a large column to take 2 gm. of lipid, the fractions that might be expected to contain vitamin A_1 aldehyde gave in the Carr–Price test only a fleeting blue colour, which soon became reddish-brown. Ultra-violet absorption curves gave no definite proof of the presence of aldehyde. However, when these fractions were reduced with sodium borohydride and the product subjected to chromatography by a modification[2] of the method of Thompson, Ganguly and Kon[3], vitamin A_1 alcohol was found by the Carr–Price test to be present, and was presumably derived from vitamin A_1 aldehyde in the original extract, the calculated amount being about 11 μgm. in the whole yolk. The other lipid material in the fractions apparently interfered with the direct characterization of the aldehyde.

In herring eggs, the vitamin A_1 aldehyde is bound to a lipid and, either directly or indirectly, to protein[1]. If it were so in the yolk of hen's eggs, then by first extracting the lipids with a fat solvent without denaturing the proteins, and then denaturing them and extracting again, it might be possible to separate the aldehyde from most of the lipid. To test this possibility, each of several yolks was freeze-dried, ground to a powder and extracted with diethyl ether in a Soxhlet apparatus for 4 hr. The residue was then treated with 30 ml. water and 60 ml. ethanol and extracted with three 200 ml. lots of light petroleum in a Waring 'Blendor' under nitrogen. The two extracts were taken to dryness and the residues weighed, dissolved in *n*-hexane and vitamin A_1 esters and alcohol[2,3] and vitamin A_1 aldehyde[1] determined. The diethyl ether extract contained 75–80 per cent of the total lipids, 95 per cent of the total free and esterified vitamin A_1, but no vitamin A_1 aldehyde (qualitative test by reduction to the alcohol form). The light petroleum extract contained 20–25 per cent of the total lipid, 5 per cent or less of the total free and esterified vitamin A_1 and all the vitamin A_1 aldehyde, in amounts of about 20 μgm./egg. This aldehyde was identified by its chromatographic behaviour, by its characteristic absorption maxima in the ultra-violet and in the Carr–Price test, and by formation of vitamin A_1 alcohol under the action of sodium borohydride. No vitamin A_2 aldehyde was detected.

Table 1. MEAN VALUES FOR WEIGHTS OF WHOLE EGG AND OF YOLK AND FOR TOTAL AMOUNTS OF VITAMIN A_1 ESTERS, ALCOHOL AND ALDEHYDE IN EGGS FROM TWO LIGHT SUSSEX HENS

Bird	No. of eggs	Weight of whole egg (gm.)	Weight of yolk (gm.)	Vitamin A_1 esters* (μgm.)	Vitamin A_1 alcohol (μgm.)	Vitamin A_1 aldehyde (μgm.)
A	4	60 1	19·5	17·7	90	21·8
B	3	59·2	19 1	19·8	109	22·4

* Expressed as the equivalent quantity of vitamin A_1 alcohol.

No vitamin A in any form was found in egg white, which contains a negligible quantity of lipid, so that measurements on the yolk apply to the whole egg. Table 1 shows that, as has been previously reported[4], vitamin A_1 alcohol is the predominant form in hen's eggs, and that vitamin A_1 esters and vitamin A_1 aldehyde are present in about equal amounts.

P. A. PLACK

Unit for Biochemical Research bearing on Fisheries' Problems*,
National Institute for Research in Dairying,
University of Reading.
Mar. 10.

* Grant-aided by the Development Fund.

[1] Plack, P. A., Kon, S. K., and Thompson, S. Y., *Biochem. J*, 71, 467 (1959).

[2] Kon, S. K., McGillivray, W. A., and Thompson, S. Y., *Brit. J. Nutr.*, 9, 244 (1955).

[3] Thompson, S. Y., Ganguly, J., and Kon, S. K., *Brit. J. Nutr.*, 3, 50 (1949).

[4] Neff, A. W., Parrish, D. B., Hughes, J. S, and Payne, L. F., *Arch. Biochem.*, 21, 315 (1949).

Effect of Diphenylamine on the Synthesis of Carotene

A NUMBER of authors have shown that diphenylamine inhibits the synthesis of carotenoids mainly by micro-organisms[1–4]. We have carried out investigations with a red yeast rich in carotenoids in order to interpret the mechanism of this inhibition.

In 1953, Gyorgy Németh isolated from root nodules of *Lupinus luteus* certain micro-organisms which produced in a *Rhizobium* nutrient a red pigment and which were capable of fixing atmospheric nitrogen[5–7].

We used the same type of yeast. The micro-organism was allowed to multiply in Roux flasks in the form of a surface culture. The nutrient contained 5 per cent bean extract, and to it was added 5 and 20 mgm. of diphenylamine, respectively, in 100 ml.

On the agar nutrient containing 5 mgm. of diphenylamine, the content of carotenoids of the micro-organism essentially decreased and the red colour faded. On raising the concentration of diphenylamine to 20 mgm., the culture became completely colourless. Moreover, the quantity and nature of the carotenoids produced changes. In the presence of 5 mgm. of diphenylamine the content of carotenoids was 110 μgm. in 10 gm. of culture, and in the presence of 20 mgm. of diphenylamine it was 40 μgm. as compared with 285 μgm. in control cultures[8].

Control cultures free of diphenylamine contained torulin, γ- and β-carotene, and torularhodin. Of these compounds, torulin was present in the greatest quantity. On applying 5 mgm. of diphenylamine, the concentrations of carotenoids decreased by a similar extent, while in the presence of 20 mgm. of diphenylamine, neither torularhodin, the sole hypophasic pigment, nor γ-carotene could be detected. Accordingly, on evaluating the data of distribution between solvents, of chromatograms and of spectra[9], it can be stated that higher concentrations of diphenylamine inhibit the synthesis of the hypophasic pigment torularhodin and of γ-carotene, both of which belong, from a genetical aspect, to the group of 'younger' carotenoids. Obviously also the synthesis of other carotenoids is simultaneously reduced to a similar extent.

GY. SCHNEIDER
B. MATKOVICS
J. ZSOLT
Ó. KOVÁCS

Institute of Organic Chemistry,
University of Szeged.

[1] Goodwin, T. W., and Osman, H. G., *Biochem. J.*, 53, 541 (1953); 56, 222 (1954).

[2] Turian, G., *Helv. Chim. Acta*, 33, 1988 (1950).

[3] Cohen-Bazire, G., and Stanier, R. Y., *Nature*, 181, 250 (1958).

[4] Schlechta, L., Gabriel, O., and Hoffmann-Ostenhof, O., *Nature*, 181, 268 (1958).

[5] Németh, Gy, *Nyirségi Mezogazdasági Kisérleti Intézet Évkönyve*, 74 (1954).

[6] Németh, Gy., *Nyirségi Mezogazdasági Kisérleti Intézet Évkönyve*, 102 (1955).

[7] Németh, Gy., and Matkovics, B., *Naturwiss.*, 44, 621 (1957).

[8] Schneider, Gy., Matkovics, B., and Zsolt, J., *Acta Phys. Chem.* (in the press).

[9] Cholnoky, L., Gyorgyfy, K., Nagy, E., and Pánczél, M, *MTA VII, Oszt. Közl.*, 5, 419 (1955).

Interaction between Albumin, Lecithin and Cephalin

LECITHINS and cephalins form more or less stable combinations with proteins[1,2]. These are believed to be the result of lipid–protein interaction[3]. Provided the method is applicable, information regarding the interaction may be obtained by an electrophoretic method[4] used for the study of interaction between dextrans and proteins. Essentially, this method uses the Antweiler micro-Tiselius apparatus to obtain spikes, at various *p*H's and concentrations, of the two interacting substances and of their mixtures. Plotting the areas under the spikes against concentration enables one to determine a function of α, the specific refractive increment, and sometimes to decide as to whether the mixture of the two components has resulted in interaction between them.

In the case of albumin (Cohn's fraction V) and lecithin dissolved in alcohol or cephalin dissolved in wet ether, the protein undergoes a change (possibly denaturation) at 20° C., the temperature used for electrophoresis. This factor must be dealt with first.

1*a*. *'Denaturation' of albumin by alcohol at* 20° *C.* To 2 ml. of 4 per cent albumin dissolved in Michaelis buffer at *p*H 6·6 is added 1 ml. of the buffer and 1 ml. of 25 per cent, 15 per cent, and 5 per cent ethanol; after standing at 20° C. for 4 hr., the three systems are dialysed against Michaelis buffer at *p*H 6·6 for 8 hr. at 20° C. Electrophoretic patterns are obtained for each system, ascending migration being allowed to occur for 6 min. The areas under the spikes are measured and compared with the area under the spike (6 min. ascending migration) of a 2 per cent albumin in buffer at *p*H 6·6. For example, the area under the albumin spike was 86 arbitrary units, that under the spike for albumin plus 25 per cent ethanol 56 units, that under the spike for albumin plus 15 per cent ethanol 60 units, and that under the spike for albumin plus 5 per cent ethanol 70 units. Increasing concentration of ethanol reduces the area under the albumin–ethanol spike; the important reduction is that produced by 25 per cent ethanol, which is from 86 to 56 units. Call 56/86 = 0·65 or the factor *F*.

1*b*. *Effect of ether on albumin at* 20° *C.* Proceeding in exactly the same way as the above, at *p*H 6·6, and comparing the area under a 2 per cent albumin spike with the area under a 2 per cent albumin spike in a system containing 6·65 per cent of ethyl ether (nearly the highest concentration of ether miscible with water), the effect of the ether is slightly to increase the area under the albumin spike, *F* being 1·12. This small effect (10 per cent increase) may indicate an effect of ether on albumin, but not one like that produced by ethanol. There is no reason for thinking that what may be a 'denaturation effect' should not decrease the spike area in the case of ethanol, and increase it in the case of ether.

2*a*. *Interaction of albumin with lecithin.* The system contains 2 ml. of 4 per cent albumin in buffer at *p*H 6·6, 1 ml. of the buffer, and 1 ml. of Polanyi's lecithin (that is, about 25 mgm.) in absolute ethanol (Polanyi, M., private communication); the mixing of these components reduces the protein to 2 per cent, and the ethanol to 25 per cent. After standing for 4 hr. at 20° C., the mixture is dialysed against Michaelis buffer at *p*H 6·6 for 8 hr. at 20° C. The electrophoretic pattern now shows a spike moving at about the same rate as albumin moves; dialysed lecithin gives no electrophoretic spike. At 6 min. the area under the spike observed was 64 units, but this figure must be divided by *F* = 0·65 to allow for the 'denaturing effect' of 25 per cent ethanol. The division gives 98·5 units instead of 86 units for albumin alone. A reasonable explanation of this is that there has been an albumin–lecithin interaction, a new species having been formed which increases the area under the albumin–lecithin spike from 86 units (for the albumin alone) to 98·5 units for the new species, that is, an increase of about 15 per cent. Other experiments show increases of 14–20 per cent. The refractive index increment for the albumin is 0·0018, so that for the new species would be about 0 00204, assuming that the concentration of the new species is exactly the same as that of the albumin.

2*b*. *Effect of cephalin in ether on albumin at* 20° *C.* Using a system containing 2 ml. of 4 per cent albumin, 1·75 ml. of Michaelis buffer at *p*H 6·6 and 0·25 ml. of saturated cephalin in ether, electrophoretic patterns were obtained for 2 per cent albumin and for the mixture containing 2 per cent albumin plus cephalin in ether. Comparing the areas under the spikes, the incorporation of cephalin in ether produced substantially the same effect as that of ether alone, that is, an increase under the spike of about 10 per cent. Considering the interaction produced with albumin by lecithin in 25 per cent alcohol, the absence of an effect of cephalin in ether may seem surprising, but it has to be remembered that solubility determines that the quantity of cephalin in the protein–cephalin–ether systems is only 2·5 mgm., while the amount of lecithin in the protein–lecithin–ethanol systems is about 25 mgm. The latter gave a 15 per cent increase in spike area by interaction; the former, if the effect were proportional to weight, would give only a 1·5 per cent increase, which could be missed.

Finally, if washed red cells are added to the dialysed protein–lecithin–ethanol system, examination between plastic surfaces shows that they are spheres, that is, there is enough lecithin in the system to sphere them in spite of the albumin. If washed red cells are added to the dialysed protein–cephalin–ether system, they remain crenated disks, presumably because the concentration of cephalin is too small to render them spherical.

This work was done under a grant, No. *H*-1598, from the U.S. Public Health Service, and Contract No. *DA*-49-007-*MD*-458 from the Department of the Army.

We are grateful to Dr. D. G. Dervichian for his advice and suggestions.

ERIC PONDER
RUTH V. PONDER

Nassau Hospital,
Mineola, New York.
Oct. 29.

---

[1] Chargaff, E., "Adv. Protein Chem." (Academic Press, New York, 1944).

[2] Dervichian, D. G., Discussions of the Faraday Soc., "Lipoproteins" No. 6 (Aberdeen Univ. Press, 1949).

[3] Deuel, H. J., "The Lipids" (Interscience Pub., New York, 1951).

[4] Ponder, E., and Ponder, R. V., *J. Gen. Physiol.*, 43, 753 (1960).

Smilagenone and *Epi*-Smilagenin from *Dioscorea* Saponin

In examining the effect of prolonged keeping of *Dioscorea* yams[1] in contact with water, fresh yams of *Dioscorea prazeri* and *D. deltoidea*, after being cut to small pieces and crushed, were mixed with sufficient water for different periods ranging from a few weeks to several months. The filtered residue was dried and extracted with petroleum ether (b.p. 40–60°) in a Soxhlet.

From the petroleum ether extract a colourless crystalline product was obtained. On chromatography over alumina it yielded mainly the following products: (*A*) $C_{27}H_{42}O_3$, stout needles, m.p. 188–89°; $[\alpha]_D^{21}$ − 52° ($CHCl_3$) and (*B*) $C_{27}H_{44}O_3$, fine silky needles, m.p. 220–22°; $[\alpha]_D^{21}$ −43·8° ($CHCl_3$). Product *A* failed to give any acetyl derivative, but formed a semicarbazone, $C_{28}H_{45}O_3N_3$, m.p. 222–23° (decomp.). On catalytic hydrogenation in acetic acid it yielded product (*B*), which again on oxidation with chromic acid gave back product (*A*). Product (*B*) formed a monoacetate, $C_{29}H_{46}O_4$, m.p.

163–64°, and was identified as *epi*-smilagenin by a comparison of the mixed melting point with an authentic specimen. Product (*A*) was similarly identified as smilagenone.

In this connexion it may be mentioned that Marker *et al.*[2] showed that dehydrotigogenone (diosgenone) when administered to a dog on biscuit diet gave diosgenin, smilagenin and *epi*-smilagenin.

The work was financed by the Council of Scientific and Industrial Research, New Delhi. Thanks are due to Dr. A. Sandoval, director of the Instituto de Quimica, Mexico, and Prof. C. Djerassi, Wayne State University, for authentic specimens.

D. CHAKRAVARTI

Department of Chemistry,
Bethune College, Calcutta.

R. N. CHAKRAVARTI
M. N. MITRA

Department of Chemistry,
School of Tropical Medicine,
Calcutta.

---

[1] Chakravarti, D, Chakravarti, R. N., and Mitra, M. N, *Nature*, **179**, 1188 (1957).

[2] Marker, R. E., Wittbecker, E. L., Wagner, R B., and Turner, D. L, *J. Amer. Chem Soc.*, **64**, 818 (1942).

Thiobarbituric Acid Spray Reagent for Deoxy Sugars and Sialic Acids

RECENTLY, new sensitive assays have been reported for deoxy sugars[1], 2-keto,3-deoxy sugar acids[2–4], and sialic acids[5,6]. In these assays, the products of periodate oxidation, malonaldehyde from deoxy sugars and β-formylpyruvic acid from the latter two groups of compounds, are coupled with 2-thiobarbituric acid to produce a bright red chromophore. I wish to report an adaptation of these methods for spraying paper chromatograms.

The procedure for the detection of deoxy sugars and 2-keto,3-deoxygluconic acid is as follows. After removal of solvent the paper is sprayed with a 0·02 *M* aqueous solution of sodium periodate. After 15 min. a solution consisting of ethylene glycol, acetone and concentrated sulphuric acid (50 : 50 : 0·3) is sprayed on to the paper. After 10 min. the paper is sprayed with an aqueous solution of 6 per cent sodium 2-thiobarbiturate. (Although several chemical supply companies sell '2-thiobarbituric acid', we have found that the product is frequently mislabelled and that the product is a salt of 2-thiobarbituric acid. Only 0·9 gm. of the acid is soluble in 100 ml. water, whereas 6·5 gm. of the sodium salt is soluble in the same amount of water. The free acid may be rendered soluble by the addition of an equimolar amount of sodium hydroxide.) Red spots appear after heating at 100° for 5 min. Under an ultra-violet light ('Mineralight') the spots give a red fluorescence. As little as 0·5 μgm. of 2-deoxyribose can be seen. We have used the spray to detect 2-deoxyglucose, 2-deoxyxylose, and 2-deoxygalactose. Although 3-deoxyglucose can also be detected on paper, the colour intensity of the spot is considerably less than that of an equimolar amount of 2-deoxyglucose.

For the detection of sialic acids a solution of 0·05 *M* sodium periodate in 0·05 *N* sulphuric acid is used. The glycol and thiobarbituric acid solutions are the same as above. A longer heating time of about 10 min. is required. Approximately 3 μgm. of sialic acids can be detected.

Using this procedure, deoxy sugars and sialic acids have been successfully located on Whatman No. 1, 3 and 3 *MM* paper, using a variety of acidic, basic and neutral solvent systems.

LEONARD WARREN

National Institute of Arthritis and
Metabolic Diseases,
National Institutes of Health,
Bethesda 14, Maryland.

---

[1] Waravdekar, S., *J Biol. Chem*, **234**, 1945 (1959).

[2] Weissbach, A., and Hurwitz, J., *J. Biol. Chem.*, **234**, 705 (1959).

[3] Ashwell, G., Wahba, A. J, and Hickman, J., *Biochim. Biophys. Acta*, **30**, 186 (1958).

[4] Levin, D. H., and Racker, E, *Arch. Biochem. Biophys.*, **79**, 396 (1959).

[5] Warren, L., *J. Biol. Chem.* **234**, 1971 (1959).

[6] Aminoff, D., *Virology*, **7**, 355 (1959).

Enzymatic Deamination of 5-Deoxycytidylic Acid and of 5-Methyl-5′-deoxycytidylic Acid in Growing and in Non-growing Tissues

THE deamination by enzymatic hydrolysis of 5′-deoxycytidylic acid to 5′-deoxyuridylic acid and of CH_3-5′-deoxycytidylic acid to 5′-deoxythymidylic acid has been previously reported in sea urchin egg homogenates[1,2], and in adult rabbit liver[3].

The deamination of 5′-deoxycytidylic acid and of CH_3-5′-deoxycytidylic acid has been investigated in the developing sea urchin embryo[4], in normal and regenerating rabbit liver, in adult rats and in embryonic rat tissues, in adult chick and in chick embryos in order to correlate these enzyme activities with biosynthesis of deoxyribonucleic acid and hence with the metabolic activities of tissues that grow by increase in the number of the component cells.

In this preliminary communication some of our results for tissues of warm-blooded animals are reported. These clearly show that the 5′-deoxycytidylic acid and the CH_3-5′-deoxycytidylic acid deaminations occur to a greater extent in growing tissues than in normal non-growing tissues. In adult tissues of rat and of chick it is impossible to detect with our assay the activities in the unfractionated homogenate.

The tissues, as soon as they were removed from the animal, were homogenized in a Potter–Elvehjem glass homogenizer with phosphate buffer. The homogenate was centrifuged for 15 min. at 4° C. and at 18,000*g*. The supernatant was used for the enzymatic assay.

The enzymatic assays are based on the ultra-violet spectral variations caused by the deamination. Tables 1 and 2 show the assays. All the enzymatic determinations have been made in the range in which

Table 1. ASSAY OF 5′-DEOXYCYTIDYLIC ACID DEAMINASE

Time (min.)	Absorbance at 232 mμ	250 mμ	267 mμ	280 mμ
0·5	0·120	0·175	0·440	0·530
6	0·120	0·195	0·445	0·495
11	0·115	0·215	0·440	0·450
Δ*A*	−0·005	+0·040	0	−0·080

Centrifuged supernatant of a homogenate from chick embryo's liver: protein, 2 mgm.; 5′-deoxycytidylic acid, 1 μmole; *tris*, 30 μmoles. Final volume, 0·5 ml.; *p*H 7·2. Incubation at 38° C. At the indicated times 0·1 ml. was removed and 0·1 ml. 10 per cent perchloric acid was added. After high-speed centrifugation 0·1 ml. of the clear colourless supernatant was diluted with 2·4 ml. of 0·01 *N* hydrochloric acid, and the absorbance of this solution was determined with a Beckman *DU* spectrophotometer.

Table 2. ASSAY OF CH_3-5′-DEOXYCYTIDYLIC ACID DEAMINASE

Time (min)	Absorbance at : 236 mμ	260 mμ	273 mμ	290 mμ
0 5	0 175	0 345	0 545	0 560
6	0 175	0 360	0 540	0 525
11	0·170	0 375	0 545	0 490
ΔA	−0·005	+0 030	0	−0 070

The conditions were those of Table 1, except for the substitution of 5′-deoxycytidylic acid by 1 μmole of CH_3-5′-deoxycytidylic acid.

Table 3. RELATIVE SPECIFIC ACTIVITIES OF 5′-DEOXYCYTIDYLICASE AND CH_3-5′-DEOXYCYTIDYLICASE IN RESTING AND GROWING TISSUES

Animal	5′-Deoxycytidylicase	CH_3-5′-Deoxycytidylicase
Chick embryos' liver	40	35
Adult chick liver	0	0
Rat embryos without liver	34	29
Rat embryos' liver	30	18
Adult rat liver	0	0
Adult rabbit liver	17	13
Adult rabbit liver in regeneration after partial hepatectomy	28	24

The conditions of the assays were those of Tables 1 and 2. The specific activities of the two enzymes are measured respectively as ΔA 280 mμ and ΔA 290 mμ, multiplied by 10^3 per 10 min per mgm. of protein.

there is direct proportionality of the spectral variations with the amount of enzyme used.

When, instead of the deoxynucleotides, the corresponding deoxynucleosides or bases are used as substrates in the conditions of our assay, the absence of spectral variations in embryonic tissues of chick and of rat, and the absence of significant spectral variations in rabbit liver, indicate that the direct deamination of 5′-deoxycytidylic acid and of CH_3-5′-deoxycytidylic acid is being measured.

Furthermore, in every case 5′-deoxyuridylic acid and 5′-deoxythymidylic acid have been isolated in good yield from incubation mixtures containing ten times the amounts indicated in Tables 1 and 2. The techniques used for the isolation have been described in refs. 1 and 2.

The results presented in this communication, and other results on the behaviour of 5′-deoxycytidylic acid and CH_3-5′-deoxycytidylic acid deamination in the developing sea urchin embryo[4], emphasize the importance of these enzyme activities in biosynthesis of deoxyribonucleic acid and in cellular multiplication.

These results will be reported in detail elsewhere.

This investigation was supported by research grant No. C-3401 from the National Cancer Institute, U.S. Public Health Service.

EDUARDO SCARANO
MASSIMO TALARICO
LUISA BONADUCE
BENITA DE PETROCELLIS

Stazione Zoologica,
Naples,
and
Institute of Human Physiology,
University of Naples.

---

[1] Scarano, E., *Biochim. Biophys. Acta*, 29, 459 (1958); Fifth Internat. Cong. Biochem., Abst., 4, 27, 40 (1958).

[2] Scarano, E., *Boll. soc. it. biol. sper.*, 34, 945 (1958). Scarano, E., and Maggio, R., *Arch. Biochem. Biophys.*, 79, 392 (1959).

[3] Scarano, E., and Talarico, M., *Boll. soc. it. biol. sper.*, 35, 97, 745 (1959).

[4] Scarano, E., and Maggio, R., *Exp. Cell Res.*, 18, 333 (1959).

A Methyl Cytidine from the Ribonucleic Acid of *Anacystis nidulans*

A PROJECT was undertaken to characterize the nucleic acids from *Anacystis nidulans*, a blue-green alga. The present communication deals with the characteristics of ribonucleic acid and a new cytidine compound from it.

Freshly harvested cells grown in a continuous culture chamber[1] were used for isolating ribonucleic acid from *Anacystis nidulans*. It was found that the method of Ogur and Rosen[2] was most suitable. Ribonucleic acid constitutes 0·37–0·50 per cent of the fresh weight of the cells. Ribonucleic acid thus isolated was purified from protein with octanol–chloroform mixture and from polysaccharides with 2-methoxy ethanol[3]. The percentage of moles of different bases and nucleotides were estimated by ascending paper chromatography[4] and electrophoresis[5]. These results, together with nitrogen and phosphorus ratio, are given in Table 1. Ribonucleic acid records a maximum absorption at 260 mμ and minimum at 230 mμ. It shows a preponderance of guanylic acid compared to other nucleotides.

Table 1. PERCENTAGE OF MOLES OF NUCLEOTIDES IN RIBONUCLEIC ACID

Extraction	N (per cent)	P (per cent)	N/P	Max. (mμ)	Min. (mμ)	GA	AA	CA	UA
						Mole (per cent)			
10 per cent NaCl*	14 80	6·45	2 3	260	230	36	25	20	19
$HClO_4$	15·57	8 25	1·89	260	230	39	22	20	19

* Extraction of ribonucleic acid with 10 per cent sodium chloride was done according to the procedure of Heinrich *et al.* (ref. 8)

After hydrolysing ribonucleic acid with hydrochloric acid for 1 hr. at 100° C. the cytidylic acid was recovered from the paper chromatogram[4]. The cytidylic acid thus isolated was incubated with alkaline phosphatase (purchased from Nutritional Biochemicals Corporation, Cleveland, Ohio) in 0·2 *M tris* buffer at *p*H 9·0. After standing for 4 hr. at room temperature the incubated mixture was chromatographed[4]. It was observed that cytidylic acid was fully converted to cytidine within that time when the concentration of enzyme was 8–10 per cent of the substrate weight. The cytidine was further subjected to electrophoresis in borate buffer *p*H 9·2 for 6 hr. at a voltage gradient of 11 V./cm. The cytidine was resolved into two spots and the mobilities of those compounds are recorded in Table 2. The spots were eluted with 0·1 *N* hydrochloric acid and the spectra were taken on a recording Cary spectrophotometer. The spectral characteristics of the new compound, which resembles mostly cytidine, is given in Fig. 1. The sugar moiety of cytidine compound was further analysed after hydrolysis with 0·05 *N* sulphuric acid and the characteristic mobility of the sugar in borate buffer is given in Table 2. From the characteristics of the sugar moiety, cytidine from *Anacystis nidulans* contains 2-O-methyl ribose. The optical density at 280 mμ of methyl cytidine varies from 0·2 to 0·25 per cent of the total optical density at 280 mμ. Methyl ribosides of purines and pyrimidines have recently

Table 2. ELECTROPHORETIC MOBILITY OF CYTIDINE COMPOUNDS AND PENTOSES

Substances	Mobility	Substances	Mobility
Deoxycytidine	0·61	Sugar from *X*-cytidine	0·57
X-cytidine (unknown)	0·72	2-O-methyl ribose	0 60
Cytidine	1·00	3-O-methyl ribose	0 83
Deoxyribose	0·48	Ribose	1·00

Electrophoresis was carried out in borate buffer *p*H 9·2 for 6 hr., voltage gradient being 11 V./cm. The movements of the compounds are towards anode.

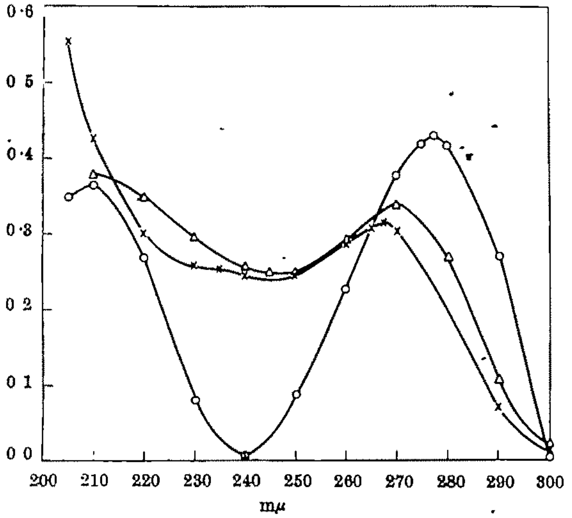


Fig. 1. Ultra-violet absorption spectrum of *X*-cytidine from ribonucleic acid. ○, *p*H 2·0; ×, *p*H 7·2; △, *p*H 11·5

been reported in some ribonucleic acid by Smith and Dunn[6]. (Methylated trityl adenosine was generously supplied by Dr. J. D. Smith from which 2-O-methyl and 3-O-methyl ribose were separated according to Brown *et al.*[7].) Other methyl ribosides were not detected in our preparations.

The precise role of this type of cytidine or other nucleosides or nucleotides in any type of ribonucleic acid is unknown. However, it may not be out of order to speculate upon their involvement in specific protein synthesis.

This work was supported by a fellowship from the University of Texas Graduate School and a grant from the Rockefeller Foundation.

B. B. Biswas*
J. Myers

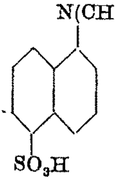
Laboratory of Algal Physiology,
University of Texas,
Austin 12, Texas.

* Present address Montefiore Hospital Institute of Research, 3459 Fifth Avenue, Pittsburgh 13.

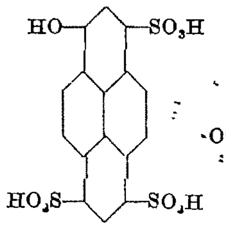
[1] Kratz, W. A., and Myers, J., *Amer. J. Bot.*, **42**, 282 (1956).
[2] Ogur, M., and Rosen, G., *Arch. Biochem.*, **25**, 262 (1950).
[3] Kirby, K. S., *Biochem. J.*, **64**, 405 (1956).
[4] Wyatt, G. R., *Biochem. J.*, **48**, 584 (1951).
[5] Davidson, J. N., and Smellie, R. M. S., *Biochem. J.*, **52**, 594 (1952).
[6] Smith, J. D., and Dunn, D. B., *Biochim. Biophys. Acta*, **31**, 573 (1959).
[7] Brown *et al.*, *J. Chem. Soc.*, 1442 (1954).
[8] Heinrich *et al.*, *J. Biol. Chem.*, **197**, 199 (1952).

Depolarization of the Fluorescence of Proteins labelled with Various Fluorescent Dyes

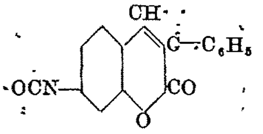
The technique by which measurements of the depolarization of fluorescence of protein conjugates is used for investigating rotational relaxation has been applied mainly with the fluorescent dye, 1-dimethylamino-naphthalene-5-sulphonic acid (I)[1,2]. The life-time of the excited state (τ) of this dye when conjugated to protein has been measured by independent methods by Weber[3] and by Steiner and McAlister[4]. Good agreement was reported, and in the present work the value $\tau = 1{\cdot}18 \times 10^{-8}$ sec. (probably accurate to $\pm 0{\cdot}05 \times 10^{-8}$), the mean of several determinations on conjugates with bovine serum albumin by Steiner and McAlister, has been assumed throughout. Assuming an absolute error in the experimental estimates of degree of polarization (*p*) of ± 0·003, it can be shown that the dye (with $p_0 = 0{\cdot}25$, the subscript referring to zero value of the temperature/viscosity ratio) is adequate for measuring relaxation times in the range $0{\cdot}5$–30×10^{-8} sec. to an accuracy of ± 10 per cent. These relaxation times correspond to a molecular weight range of 5,000–300,000 if the molecule is spherical and unhydrated. The corresponding molecular weights for hydrated and moderately asymmetric molecules will be less, usually by a factor of at least 2 or 3. The range is determined mainly by the magnitude of τ and the accuracy of measurements of the degree of polarization of the fluorescent light. If dyes having longer and shorter values of τ were available, the range of the method would be considerably extended.



I



II



III

The present communication describes the use of two such dyes: 3-hydroxypyrene-5:8:10 trisulphonic acid (II) with a longer life-time, and 3-phenyl-7-*iso*cyanato-coumarin (III) with a shorter life-time. Both dyes conjugate easily with proteins[5,6]. Such conjugates with bovine serum albumin have been prepared, and the τ values in each conjugate determined by Weber's method[3]. The degree of polarization of fluorescence of the conjugate was measured through a yellow filter (Ilford 110) over a range of temperature. Plotting the reciprocal of the degree of polarization of fluorescence as a function of the temperature/viscosity ratio, it was possible to calculate the τ values using Perrin's modified equation[8] and assuming Oncley's values for the principal relaxation time of bovine serum albumin[7]. From these results the range of relaxation times (ρ) measurable to ± 10 per cent with each type of conjugate has been calculated together with the corresponding range of anhydrous spherical molecular weights; these results are shown in Table 1. It can be seen that the pyrene derivative has a life-time some eight times greater, and the coumarin derivative almost five times smaller than the naphthalene compound. The range of relaxation time (and molecular weight) which can be investigated by this technique is correspondingly extended.

The total range of molecular weights covered by conjugates prepared from these three dyes is 1,000–2,500,000 for spherical unhydrated molecules, or

Table 1. Range of the Depolarization Method

Dye	$\tau \times 10^{-8}$ sec	Range of relaxation times × 10^{8}	Molec. weight range × 10^{-3} (spherical molecules)
3-Hydroxypyrene 5:8:10 trisulphonic acid	9·0	4–250	40–2,500
1-Dimethylamino-naphthalene 5-sulphonic acid	1·18	0·5–30	5–300
3-Phenyl-7-*iso*-cyanato-coumarin	0·25	0·1–7	1–60

about 400–1,000,000 for typical, moderately asymmetrical molecules. Experiments have already shown the usefulness of the newer dyes with certain protein molecules which are either too large or too small for investigation with the naphthalene dye[8], but it would be rash to expect that all such cases would be successful. The occurrence of protein inactivation, of specific protein effects on the fluorescent life-time, the onset of intramolecular rotations, and similar effects are largely unpredictable and must be excluded before a useful application in any one case can be proved.

C. S. CHADWICK
P. JOHNSON
E. G. RICHARDS

Department of Colloid Science,
University of Cambridge.

[1] Weber, G., *Biochem. J.*, 51, 145 (1952).
[2] Weber, G., *Biochem. J.*, 51, 155 (1952).
[3] Weber, G., "Adv. Prot. Chem.", 8, 415 (1953).
[4] Steiner, R. F., and McAlister, A. J., *J. Poly. Sci.*, 24, 105 (1957).
[5] Kuhleke, H., *Z. Naturforschung*, 131, 722 (1958).
[6] Chadwick, C. S., McEntegart, M. G., and Nairn, R. C., *Immunol.*, 1, 315 (1958).
[7] Oncley, J. L., *Chem. Rev.*, 30, 433 (1942).
[8] Chadwick, C. S., and Johnson, P. (to be published).

ANIMAL PHYSIOLOGY

Urinary Phenols in Stress

ABNORMALLY high rates of excretion of 4-hydroxy-3-methoxymandelic acid, a metabolite of both adrenaline and noradrenaline, are now well known to be associated with phaeochromocytoma and sympathoblastoma[1–3]. A convenient chromatographic technique enabling the substance to be estimated visually has been described elsewhere[3]. It seemed of interest to examine the possibility that the method would prove sufficiently sensitive to detect the increased secretions of the catecholamines to be anticipated in subjects exposed to stress.

In the first place we have examined urines from hospital patients under severe conditions of stress occasioned by spinal shock, surgical operations, accident injuries and burns. In contrast to young normal males who excreted 4-hydroxy-3-methoxymandelic acid at average rates varying from 1 to 2·5 μgm./min. (values not corrected for incomplete recovery from urine), many of these subjects excreted the acid in much greater quantity (4–10 μgm./min.). The behaviour of patients having complete transverse lesions of the cervical cord has proved of particular interest, since in these subjects the whole efferent sympathetic outflow is isolated from the control of the higher nervous centres. The excretion-rate of 4-hydroxy-3-methoxymandelic acid was observed to be markedly subnormal in fit subjects of this type, but was within the normal range in those under conditions of stress; this increase in stress may possibly be due to adrenaline release by a direct action of histamine on the adrenal medulla.

More detailed chromatography has indicated that other phenols may be excreted in increased amounts in stress. The most noticeable changes in the present experiments occurred with *p*-hydroxyphenyllactic acid; in spinal shock at least, the appearance of this substance is probably related to the difficulty of saturating the patients with ascorbic acid. Increased excretion of *p*-hydroxy-phenylpyruvic acid also occurred in some subjects. Increases in the excretion of homovanillic acid in stress were rather less well defined owing to the invariable presence of this acid in normal urine; however, several of the subjects excreted considerably more than the 8 mgm./24 hr. quoted as the upper limit of the normal range[4]. It seems possible that an increased metabolism of 3 : 4-dihydroxyphenylethylamine is implicated, and that this amine might play some part in the response of the human subject to stress. The two urines from cases of neuroblastoma examined by Sandler and Ruthven[2], to whom we are grateful for samples, have been examined chromatographically and both were found to contain large amounts of homovanillic acid in addition to 4-hydroxy-3-methoxymandelic acid; abnormal excretion of homovanillic acid was not noted in eight cases of phaeochromocytoma, however. A further example where excretion was high occurred in the one case of argentaffinoma examined.

One of us (P. S.) wishes to thank the Director-General of Medical Services, Royal Air Force, for permission to publish this work and Cpl. Tech. McKim for experimental assistance.

R. ROBINSON

National Spinal Injuries Centre,
Stoke Mandeville Hospital,
Aylesbury, Bucks.

P. SMITH

R.A.F. Institute of Aviation Medicine,
Farnborough, Hants.

[1] Armstrong, M. D., and McMillan, A., *Fed. Proc.*, 16, 146 (1957).
[2] Sandler, M., and Ruthven, C. J. R., *Lancet*, ii, 114 (1959).
[3] Robinson, R., Ratcliffe, J., and Smith, P., *J. Clin. Path.* (in the press).
[4] Shaw, K. N. F., McMillan, A., and Armstrong, M. D., *J. Biol. Chem.*, 226, 255 (1957).

Postural Changes in Chlorpromazine Hypothermia

THE relatively small disturbance in the chemical
component of thermoregulation i
injection of c
the expressi
LeBlanc pre
thermoregula
caused by ch
In work pres
aimed at a clo
and further
changes of bo

Male albino
Chlorpromazin
peritoneally at
temperature w
temperature w
thermocouple t
placing reaction
imed[5] at variou
istration of chl
absence in the
percentages.

Table 1 shows
placing reactions
each other. Wh
disappear in nea
significant drop of
are absent for wh
the brain stem sta
gradually later on
shaped posture of
their extremities [illegible] body, is

Table 1. RELATION BETWEEN BODY TEMPERATURE AND CHANGES OF POSTURE AFTER CHLORPROMAZINE

	n	Time after injection of chlorpromazine (min.)						
		0	3	6	15	90	180	390
Body temperature (° C.)*	40	37·3 ± 0·5	37·2 ± 0·5	36·5 ± 0·4	34·9 ± 0·4	31·7 ± 0·4	29·2 ± 0·3	31·3 ± 0·3
Placing reactions†	43	0·0	0·0	13·8	89·4	78·5	84·7	90·4
Righting reflexes†	43	0·0	42·8	73·3	57·4	52·6	43·5	37·8

* Mean ± *S.E.*
† Percentage of animals in the group where they are absent.

induced mainly by the disturbance of placing reactions. The reversible exclusion of these reactions is mainly responsible for the exposure of a wider surface of the animal's body to a lower temperature of the environment at the time when the chemical component of thermoregulation decreases.

D. SVORAD

Institute of Physiology,
Czechoslovak Academy of Sciences,
Prague 6.

[1] Courvoisier, S., Fournel, J., Ducrot, R., Kolsky, M., and Koetschet, P., *Arch. Internat. Pharmacodyn.*, **92**, 305 (1953).
[2] Giaja, J., and Marković-Giaja, L., *C.R. Soc. Biol.*, **148**, 842 (1954).
[3] LeBlanc, J., *J. App. Physiol.*, **13**, 237 (1958).
[4] Svorad, D., Symposium on Hypothermia, Belgrade, 161 (1959).
[5] Svorad, D., *Physiol. bohemoslov.*, **4**, 170 (1955).

Release of Acetylcholine in Rat Diaphragm

SEVERAL attempts have been made in the past to correlate the amount of acetylcholine released during activity at nerve endings with the amount needed to produce activation of the effector cell[1-3]. It is clearly of crucial importance for the acetylcholine hypothesis that there should be quantitative agreement between these amounts. Until recently, a very substantial discrepancy has remained, supporting the suggestion that acetylcholine is merely a by-product of transmission. One source of difficulty in making such correlations has been the paucity of results concerning the release of acetylcholine and the excitation produced by its application in the same preparation.

Intracellular recording of end-plate activity in muscle, and the ionophoretic application of acetylcholine in controlled amounts from micro-pipettes, have made possible a detailed analysis of end-plate potentials under conditions closely approaching those which obtain during normal transmission at the neuro-muscular junction. End-plate potentials have been produced by such methods in the isolated rat diaphragm with as little as $1 \cdot 5 \times 10^{-17}$ mole of acetylcholine[4]. We have now found that acetylcholine is released by nerve endings in the rat diaphragm, during stimulation of the phrenic nerve, in amounts which are of the same order of magnitude.

The isolated phrenic nerve diaphragm preparation was stimulated in a 'Perspex' chamber at room temperature (19–23° C.). The muscle was bathed in 5·0 ml. of Ringer–Locke solution continually agitated by oxygen bubbles, and the rate and duration of nerve stimulation were kept to a minimum consistent with the sensitivity of the preparation used for assay (the leech dorsal muscle, the heart of *Mya areneria* or the rat duodenum). To prevent destruction of acetylcholine, we either added physostigmine sulphate to the solution (10^{-5}), or administered di*iso*propyl fluorophosphonate to the rat (1 mgm./100 gm. body-weight). For control, active solutions were treated with strong alkali whenever possible.

It is difficult to be certain in this type of experiment that one is exciting all the nerve endings. The phrenic nerve was always stimulated with shocks two or three times greater than maximal, and the action potential of the nerve trunk was recorded close to its entrance into the muscle throughout the period of stimulation. This gave us a useful index of failure of excitation or conduction in the nerve, but no positive information about the activation of the nerve endings.

During periods of stimulation at a rate not greater than 5/sec. and lasting not more than 5 min., the amounts of acetylcholine collected from hemi-diaphragms varied between 0·4 and $2 \cdot 5 \times 10^{-13}$ mole per impulse. Fourteen estimates gave a mean value of $1 \cdot 1 \times 10^{-13}$ mole. Since there are about 10,000 muscle fibres in the hemi-diaphragm[5], the mean release per ending was $1 \cdot 1 \times 10^{-17}$ mole.

It is clear that in the rat diaphragm there is overlap between the least amount of acetylcholine needed to produce appreciable excitation at an end-plate ($1 \cdot 5 \times 10^{-17}$ mole) and the greatest amount released at nerve endings during stimulation ($2 \cdot 5 \times 10^{-17}$ mole). The latter should be more significant than the mean value, since the principal sources of error, imperfect activation of nerve endings and hydrolysis of acetylcholine, would both lead to an under-estimate.

K. KRNJEVIĆ
J. F. MITCHELL

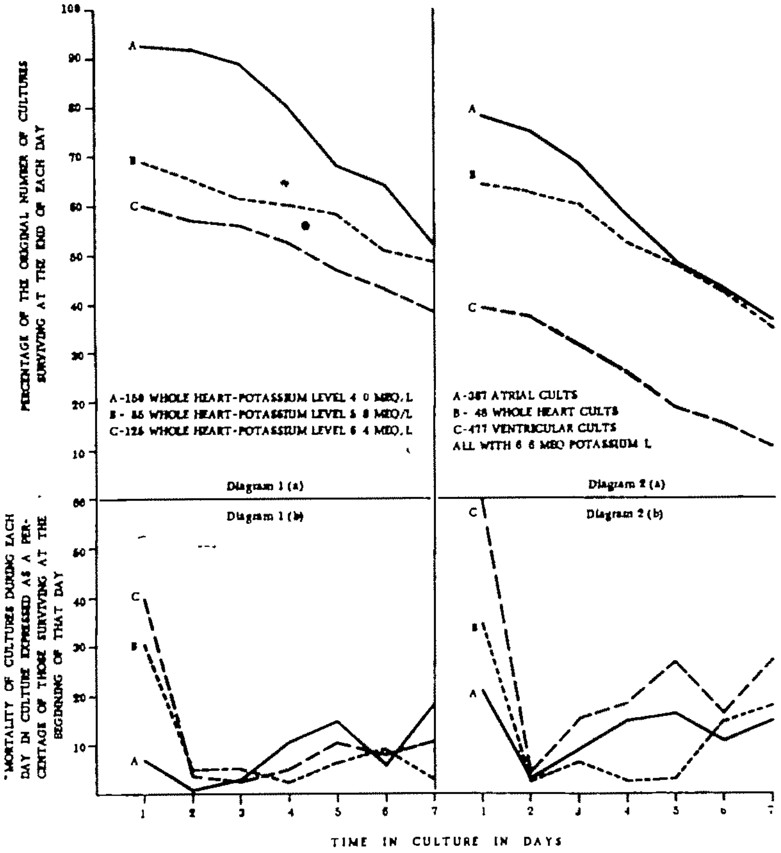
Agricultural Research Council
Institute of Animal Physiology,
Babraham, Cambridge. Dec. 30.

[1] Acheson, G. H., *Fed. Proc.*, **7**, 447 (1948).
[2] del Castillo, J., and Katz, B., "Prog. Biophys.", **6**, 121 (1956).
[3] Emmelin, N., and MacIntosh, F. C., *J. Physiol.*, **131**, 477 (1956).
[4] Krnjević, K., and Miledi, R., *Nature*, **182**, 805 (1958).
[5] Krnjević, K., and Miledi, R., *J. Physiol.*, **140**, 427 (1958).

Effect of Supernatant Potassium-Level on Cardiac Activity in Quantitative Tissue Culture

INADEQUATE functional 'survival' of hearts cultured in supernatant containing serum with a high potassium-level from lysed red cells led us to investigate the effects of supernatant potassium-levels on the electrical activity of 1,222 hearts in quantitative tissue culture. The criterion for 'adequate survival' is an ability to produce potentials of at least 0·02 mV. during a minimum of three periods of observation per day (8 a.m., 1 p.m. and 5 p.m.). The apparatus, etc., is described in previous papers[1]. The supernatants are 0·25 per cent solutions of human serum protein in balanced salt solutions—however, they differ in potassium-level. The 'adequate survival' time is given to the nearest day using the smallest figure in cases of doubt.

Fig. 1*a* relates time and percentage adequate 'survival' for three separate series of 6-day chick embryo whole hearts, all from the same breeder.



Figs. 1 and 2 The electrical functional survival and mortality of cultures of 6-day chick embryo whole hearts, isolated right atria and isolated right ventricles in supernatants of various potassium-levels

These series are grown in supernatants of different potassium-level and those in the supernatant of lowest potassium-level show the best 'survival'. The considerable initial 'survival' difference between the three series (particularly between series *A* and *B*) lessens with time. Supernatants *B* and *C* are made from the same serum containing lysed red cells but, since a low-potassium balanced salt solution is used to make supernatant *B*, they differ only in potassium-level. Thus, *B*'s better 'survival' makes it probable that, of lysed red cell products, the potassium has the greatest effect on 'survival' of hearts in culture. The small initial 'survival' in high potassium supernatants may be due to release of potassium from damaged muscle raising the total potassium-level around nearby healthy muscle fibres to the critical level which interferes with their electrical functions.

Fig. 1*b* shows the relationship between time and the number of hearts failing to 'survive' at the end of each day expressed as a percentage of the number of hearts surviving at the beginning of the same day. The first day's high 'mortality' supports the theory of the damaging effect of high local potassium-levels (a combination of high supernatant potassium and potassium released from damaged muscle). The potassium from damaged cells then diffuses into the general supernatant and the potassium-level around healthy cells is lowered, explaining the lessened 'mortality' during the second day. Thereafter, the slow rise in 'mortality' may be due in part to the progressive deficit of essential nutrients as they are utilized by the tissues. The potassium contents of salt solutions and supernatants commonly used in tissue culture are as follows: Eagle's solution, 4·09 m.equiv./l.; Dulbecco's, 4·2 m.equiv./l.; Osgood's, 5·2 m.equiv./l.; Gey's, 5·25 m.equiv./l.; Earle's, 5·4 m.equiv./l.; Melnick's, 5·6 m.equiv./l.; Hanks's *T.C.* 199 and Scherer's, 5·84 m.equiv./l. The potassium-level in several of them is above the physiological limits in humans and in the range which, according to the observations in this communication, causes a poor initial functional survival of hearts in culture.

Fig. 2*a* shows a comparison of the effects of the same high (6·6 m.equiv./l.) potassium supernatant on the electrical activity of 6-day chick embryo whole hearts, isolated right atria and isolated right ventricles in culture. Atria have the best, whole hearts next best and ventricles the poorest initial 'survival'. Atria and whole heart 'survival' differs only in the first four days in culture. The poor 'survival' of ventricles is not due to nutritional difficulties because of 'large' muscle bulk, for whole hearts have a larger bulk, nor to the relative amount of tissue damaged during explantation, for atria have a higher relative damage. It may result from the sensitivity of impulse-generating and conducting tissue to high potassium-levels since whole heart and isolated atrium have a higher proportion of such tissue than isolated ventricles. However, the best explanation for the poor 'survival' of ventricles in high potassium supernatants is that, since the isolated right atrium and whole heart have previously established initiating foci for contraction and the isolated right ventricle has to establish a new focus, the new focus is more sensitive to high potassium-levels than the older established foci.

Fig. 2*b* is similar to Fig. 1*b* and compares the daily 'mortality' percentages for whole hearts, isolated right atria and isolated right ventricles maintained in the same high-potassium (6·6 m.equiv./l.) supernatant. The lowest 'mortality' occurs during the second day, possibly for the reasons postulated in the discussion of Fig. 1*b*. Thereafter, the 'mortality' rises at a faster rate than for hearts in Fig. 1*b*. The whole-heart series shows the best and the ventricles the poorest relative 'survival' behaviour. Further studies of the factors affecting the 'survival' of hearts in culture is being undertaken.

This work was supported by grants from the American Heart Association and the National Institutes of Health.

A. W. B. Cunningham
K. Kleutch
W. Herbst
Department of Pathology, Medical Branch,
University of Texas, Galveston.

---

[1] Cunningham and Estborn, *Lab. Invest.*, 7, 156 (1958). Estborn, Cunningham *et al.*, *ibid.*, 7, 524 (1958).

Measurement of the Intrahepatic Shunted Flow of Blood in Cirrhosis of the Liver

THE most characteristic change in the hepatic circulation in cirrhosis of the liver is the appearance of pathological anastomoses in intrahepatic and extrahepatic blood vessels. The formation of intrahepatic and extrahepatic shunts markedly decreases the flow of blood through sinusoids, and increases the disturbance of liver cell function and liver cell damage, becoming one of the etiological factors of hepatic coma. Since there is apparently no published report of the quantitative measurement of the shunted flow of blood in liver cirrhosis, we have devised methods of measuring the intrahepatic and extrahepatic shunted flow in clinical cases. In this communication, the methods are presented for measuring the intrahepatic shunted flow of blood in cirrhosis of the liver. By these methods considerable amounts of intrahepatic shunted flow of blood is demonstrated in moderate and advanced liver cirrhosis.

The intrahepatic shunted flow of blood is measured either by the single administration method or by the continuous infusion method.

Single administration method. After the injection of an aqueous solution of 0·5 gm./kgm. body-weight of galactose in a single dose, blood is taken at successive intervals from the hepatic vein by means of hepatic venous catheterization and also from an arterial indwelling needle previously laid in the brachial artery. Quantitative analysis of galactose of these blood samples and urine is determined by a modified Fischer's[1] method. In normal subjects, at first, the peripheral arterial concentration curve shows the linear downward course, and hepatic venous concentration parallels the peripheral concentration, finally reaching zero level (first phase). When afterwards the amount of galactose entering the liver decreases below the maximal removing capacity of the liver, the peripheral concentration curve takes the shape of a simple exponential curve, and hepatic venous concentration remains at zero level (second phase). The hepatic flow of blood is calculated from the disappearance constant of the peripheral concentration in the second phase (k_2), the volume of distribution (V), and average urinary clearance of galactose (U_{cl}), according to the following modified equation of Waldstein[2]:

$$F = \frac{k_2 V - U_{cl}}{\left(1 - \frac{0\cdot4 \times \text{hæmatocrit}}{100}\right)} \times \frac{1}{\text{surface area}}$$

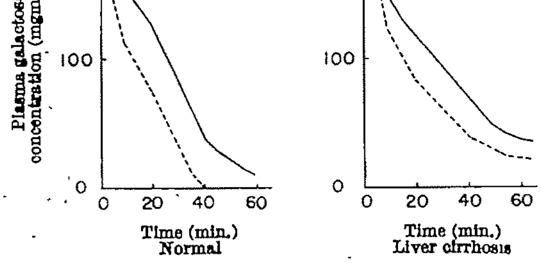


Fig. 1. Peripheral arterial (———) and hepatic venous (- - - - -) galactose concentration curves by single administration method in a normal subject and in a patient with advanced liver cirrhosis

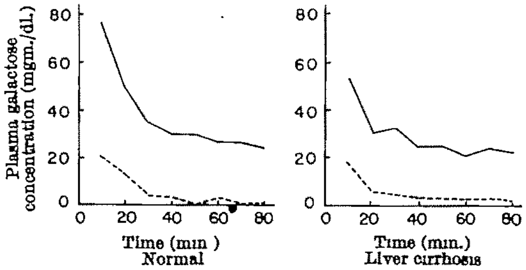


Fig. 2. Peripheral arterial (———) and hepatic venous (- - - - -) galactose concentration curves by continuous infusion method in a normal subject and in a patient with mild liver cirrhosis

When there is an intrahepatic shunt between portal and hepatic veins in liver cirrhosis, the concentration in the hepatic vein does not drop to zero in the second phase, that is, galactose flows into the hepatic vein through the shunt, and the hepatic venous concentration curve in this stage takes the form of a simple exponential curve, too (Fig. 1). Therefore, in the presence of an intrahepatic shunt, the above equation does not give the total amount of blood flowing through the liver, but gives the amount of blood which enters the sinusoids in unit time, namely, effective hepatic flow of blood. On the same principle as in the Diodrast or *para*-aminohippuric acid clearance in renal physiology, total and shunted hepatic flow of blood can be calculated from effective hepatic flow of blood ($EHBF$) and the extraction ratio in the second phase (E).

$$\text{Total hepatic flow of blood } (THBF) = \frac{EHBF}{E}$$

$$\text{Shunted hepatic flow of blood } (SHBF) = THBF - EHBF$$

Continuous infusion method. After a priming dose of 10 gm. of galactose, constant infusion of galactose is made at a rate that does not exceed the maximum removing capacity of the liver, which is usually 200 mgm. per min. The curves become horizontal after 40 min. (Fig. 2). The total hepatic flow of blood is calculated on the basis of Fick's principle[3].

$$THBF = \frac{I_m - U_m}{(P - H)\left(1 - \frac{0\cdot4 \times \text{hæmatocrit}}{100}\right)} \times \frac{1}{\text{surface area}}$$

(I_m is galactose infused per min., U_m galactose excreted into urine per min., P peripheral plasma concentration, and H hepatic venous plasma concentration.) On the same principle as by the single administration method, the effective and shunted flow of blood is calculated:

$$EHBF = THBF \times E$$

$$SHBF = THBF - EHBF = THBF\ (1 - E)$$

In normal subjects the extraction ratio was in the vicinity of 100 per cent, and there was no estimated intrahepatic shunted flow of blood. In four cases with mild liver cirrhosis, the shunted flow of blood was 0–155 c.c./min./sq.m. or 0–20 per cent of the total hepatic flow of blood. In eleven cases with moderate or advanced cirrhosis, on the other hand, the shunted flow of blood was calculated at 62–867 c.c./min./sq.m., or 18–78 per cent of the total hepatic flow. On the average, about half the total hepatic flow by-passed the liver in liver cirrhosis. Depressed extraction ratio was also noticed in two out of four cases with viral hepatitis in the icteric stage. Therefore, the intrahepatic shunted flow of blood calculated in this experiment is generally considered to include not only the flow of blood through the anatomic shunt, but also the functional shunted flow of blood due to hepatic dysfunction.

T. NAKAMURA
S. NAKAMURA
K. TOKITA

First Department of Internal Medicine,
Tohoku University School of Medicine,
Sendai.

[1] Fischer, H., Hansen, R. G., and Norton, H. W., *Anal. Chem.*, **27**, 857 (1955).
[2] Waldstein, S. S., and Arcilla, R. A., *Amer. J. Digest. Dis.*, **3**, 137 (1958).
[3] Tygstrup, N., and Winkler, E., *Clin. Sci.*, **17**, 1 (1958).

Inhibition of Monoamine Oxidase by Benactyzine *in vitro* and *in vivo*

VOJTĚCHOVSKÝ[1] has found recently that large doses of benactyzine (the diethylaminoethyl ester of benzylic acid) exert a psychotogenic effect. In doses of 40–200 mgm. it reduces the excretion of 5-hydroxyindole acetic acid in the urine to unmeasurable values[2]. These effects manifested themselves simultaneously. We suspected that benactyzine inhibits the monoamine oxidase which participates in the inactivation of serotonin[2]; and to confirm this hypothesis we tried to follow the effect of benactyzine on monoamine oxidase *in vitro* and *in vivo*.

For estimation of the activity of monoamine oxidase we used a 33 per cent homogenate of rat liver and 50 per cent homogenate of rat brain. The activity was determined using the modified method of Sjoerdsma *et al.*[3]. Instead of a decrease of serotonin we estimated production of 5-hydroxyindole acetic acid. After deproteinization of the homogenate with hydrochloric acid, we used the method of Udenfriend *et al.*[4], and the type of inhibition was determined by using Lineweaver and Burk's method[5]. Inhibition of monoamine oxidase *in vivo* was investigated in a homogeneous group of seven white rats, Wistar strain, weighing 200–250 gm. Benactyzine was administered subcutaneously in doses of 35 mgm. per 100 gm. body-weight. Normal values were obtained in a similar group of seven animals to which no benactyzine was administered. The animals were followed up for 60 min. following the dose of benactyzine and were afterwards killed.

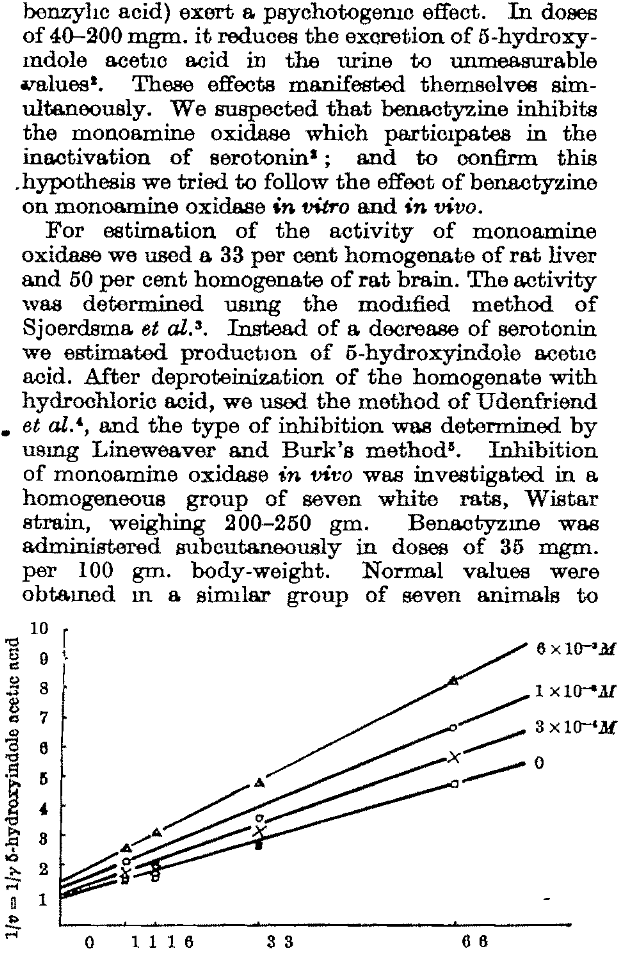


Fig. 1. Lineweaver–Burk plot of benactyzine inhibition as a function of 5-hydroxytryptamine concentration

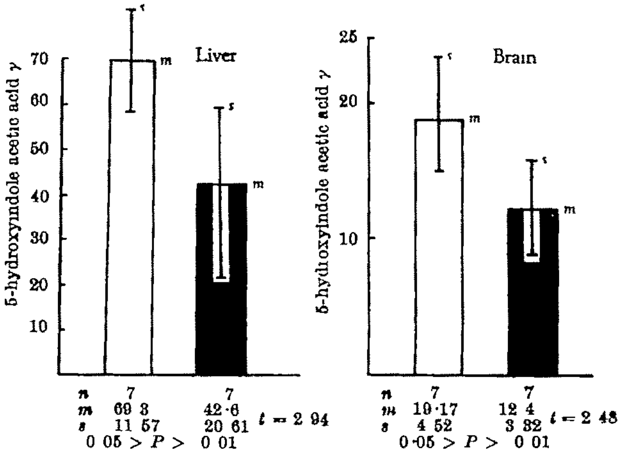


Fig. 2. Activity of monoamine oxidase *in vivo*

After homogenizing the brain and liver of both groups, monoamine oxidase activity was estimated[4].

Our experiments showed that benactyzine in concentrations of 4×10^{-3} *M* inhibits monoamine oxidase by 29 per cent, 4×10^{-4} *M* not at all; under similar conditions, 4×10^{-3} *M* 'Marsilid' inhibits it by 40 per cent and at concentrations of 4×10^{-4} *M* by 9 per cent. Benactyzine is thus a weaker inhibitor than 'Marsilid'. As shown by Fig. 1, benactyzine acts as a non-competitive inhibitor. Fig. 2 illustrates the inhibition of monoamine oxidase *in vivo*. It presents average values of the activity of the enzyme in the liver and in the brain; normal values, white columns; after benactyzine, black columns. Fig. 2 shows the variation of values and their statistical significance. Benactyzine when used in the above doses inhibits *in vivo* the monoamine oxidase in rat liver by 38·5 per cent on an average, and in rat brain on an average by 40 per cent. The results are somewhat distorted by the fact that two animals were resistant to benactyzine; thus they showed no signs of intoxication, and their behaviour did not change. In these animals no inhibitory effect was revealed in the organs investigated. This seems to us to explain also the great variations of values following the administration of benactyzine.

From our experiments it appears that benactyzine is a non-competitive inhibitor of monoamine oxidase *in vitro* as well as *in vivo*.

We are indebted to Mrs. J. Doubravová and Miss V. Kordová for technical assistance, and to Prof. V. R. Pickles, University of Sheffield, and to Sandoz, Ltd., Basle, for generous gifts of 5-hydroxytryptamine.

V. VÍTEK
K. RYŠÁNEK

Department of Experimental Therapeutics,
Institute of Human Nutrition, and Medical Clinic
of the Postgraduate Medical Institute,
Budějovická 800, Prague 14.

[1] Vojtěchovský, M., *Acta Psychiat.* (Kbh.), **33**, 514 (1958).
[2] Vojtěchovský, M., Vítek, V., Ryšánek, K., and Bultasová, H., *Experientia*, **14**, 422 (1958).
[3] Sjoerdsma, A., Smith, T. E., Stevenson, T. D., and Udenfriend, S., *Proc. Soc. Exp. Biol. and Med.*, **89**, 36 (1955).
[4] Udenfriend, S., Titus, E., and Weissbach, H., *J. Biol. Chem.*, **216**, 499 (1955).
[5] Lineweaver, H., and Burk, D., *J. Amer. Chem. Soc.*, **56**, 658 (1934).

Antigen-induced Damage to Isolated Sensitized Mast Cells

THERE is now quite convincing evidence that damage to mast cells always occurs when histamine is released during anaphylaxis. Thus damage to these cells is known to occur after active or passive sensitization either when antigen is injected in the intact animal or when a piece of sensitized tissue is incubated with the specific antigen[1]. However, all the evidence is derived from experiments made with tissues containing not only mast cells but also a mixed cell population, and therefore it is not possible to know whether damage to the mast cells is a direct consequence of the antigen–antibody reaction or whether antibodies are located on or in the mast cells.

We present here the results of some experiments performed in order to find out whether isolated mast cells would react to the specific antigen. Wistar rats of both sexes and weighing 150–250 gm. were used. The animals were sensitized by injecting 1 ml. of horse serum plus 1 ml. of *Haemophilus pertussis* vaccine containing 20,000 million organisms intraperitoneally and were used twenty-five days later. Mast cells were isolated by a method similar to that described by Padawer and Gordon[2]. The animals were bled under ether anæsthesia and 2 ml. of saline (sodium chloride 0·85 per cent) containing 50 μgm. heparin per ml. were injected into the abdominal cavity, and gentle massage of the gut through the abdominal wall was performed for about 1 min. The abdominal wall was then incised along the mid-ventral line and the fluid from the abdominal cavity collected with a pipette. This was carefully layered over 1·5 ml. of a 30 per cent water solution of bovine serum albumin (fraction *V*., Armour) and centrifuged in an International refrigerated centrifuge model *PR* 1 at 900 r.p.m. for 2 min. The albumin solution was then removed with a pipette, avoiding contamination with interface cells, diluted to 20 ml. with Tyrode solution and centrifuged at 1,000 r.p.m. for 5 min. This last operation was repeated once more and finally the deposit in the bottom of the tube was resuspended in 0·2–0·3 ml. Tyrode solution. This procedure resulted in a suspension containing 90–98 per cent of mast cells most of which were well preserved. These cells were then studied by aid of phase contrast microscopy either under dry magnification (× 800) or with oil immersion objective (× 1,000). A drop of the mast cell suspension was placed on a slide and covered with a square coverslip two sides of which were sealed with melted paraffin. A small well of paraffin was then made at each free side of the coverslip in the same way as was described by Strangeways and Canti[3], the preparation kept in a warm stage at 37° C., and a suitable group of well-preserved mast cells selected for observation. Horse serum heated at 37° C. was then placed in one free side of the coverslip and sucked on to the cells with a piece of filter paper. Usually the mast cells stood still when the antigen was sucked through, although sometimes many were washed away. As a control to these experiments the effect of horse serum on non-sensitized mast cells was also observed.

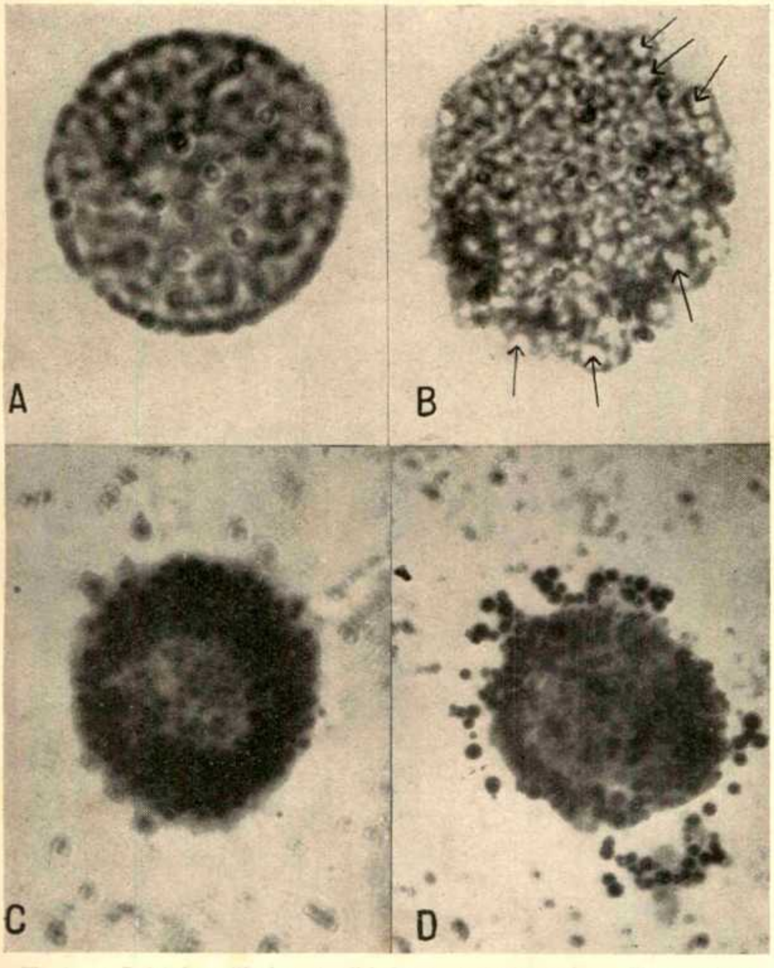


Fig. 1. *A*, Isolated sensitized mast cell before contact with antigen. Phase contrast (× *c*. 666); *B*, the same cell after contact with antigen. Arrows point to vacuoles (× *c*. 666). *C*, Isolated mast cell after fixation with 1 per cent formaldehyde and stained with toluidine blue (× *c*. 533). *D*, Isolated mast cell after contact with antigen. Note granules outside the cell. Fixed and stained as stated above (× *c*. 533)

In these conditions the effect of the antigen on sensitized mast cell was a very striking one. A few seconds after the antigen had been sucked on to the cells there was a slight increase in cell size followed by a sudden appearance and disappearance of successive vacuoles which made the cell look as if it were 'bubbling'. Sometimes it was possible to observe extrusion of the granules, which occurred, so far as could be observed, without damage to the cellular membrane. This phenomenon was very rapid, but was slowed down by low temperature and could be more easily followed at 25° C.—a temperature at which the phenomenon took as long as 1 min. to complete. When cell change was no longer seen, the cell had lost its regular contour, the granules had become more apparent and large empty spaces could be seen among them (Fig. 1). However, we were not able to see any alteration in the form of the mast granules, most of which remained inside the cell. This phenomenon is very like that produced by compound 48–80 on rat mast cell[4]. The very conspicuous damage induced to mast cells in anaphylaxis[1] led us to propose the hypothesis that mast cells might contain antibodies[1]. Later on, Humphrey and Mota[5], concluded that the antigen–antibody reaction in anaphylaxis must occur in, or very near, the mast cells. However, at that time no direct proof could be produced that the mast cells contain antibodies. Our present results showing that washed isolated mast cells taken from sensitized animals are still able to respond to the specific antigen strongly suggest that mast cells contain antibodies and that damage induced to these cells in anaphylaxis is the consequence of an antigen–antibody reaction occurring in the mast cell itself. How the antigen–antibody complex once formed damages the cell is a challenging problem. However, there is some evidence that antibodies are located on the cell surface[5], and if it is assumed that γ-globulin is one of the protein constituents of the cell membrane, its combination with antigen could disturb the molecular equilibrium of the membrane and in so doing start the process of cell damage. Further experimental work is needed on this point.

I. MOTA
W. DIAS DA SILVA*

Laboratory of Cell Physiology and Department of Histology,
Faculty of Medicine,
University of São Paulo,
Brazil.

* Fellow from the C.A.P.E.S.

[1] Mota, I., thesis, University of S. Paulo (1953); *Brit. J. Pharm.*, **12**, 453 (1957); *J. Physiol.*, **140**, 6*P* (1957); *Nature*, **182**, 1021 (1958); *J. Physiol.* (in the press). Mota, I., and Vugman, I., *Nature*, **177**, 427 (1956).

[2] Padawer, J., and Gordon, A. S., *Proc. Soc. Exp. Biol. Med. N.Y.*, **88**, 29 (1955).

[3] Strangeways, T. S. P., and Canti, R. G., *Quart. J. Micro. Sci.*, **71**, 1 (1927).

[4] Mota, I., Beraldo, W. T., and Junqueira, L. C. U., *Proc. Soc. Exp. Biol. Med. N.Y.*, **83**, 455 (1953).

[5] Humphrey, J. H., and Mota, I., *Immunology*, **2**, 31 (1959).

'Weightless' Micro-electrodes for recording Extracellular Unit Action Potentials from the Central Nervous System

IN order to record the activity of single nerve cells in the mammalian central nervous system it is necessary to maintain the tip of the recording electrode (a micropipette or metal needle) within some 30μ of the cell body[1]. The skeleton of the animal is usually rigidly clamped to a heavy metal base and in many experiments this base also carries the micro-electrode upon a rigid support. Unfortunately the exposed central nervous system expands with every beat of the heart and also with exhalation of air from the lungs. Because such movements can make records of unit activity difficult or impossible to obtain, a technique has been developed[2,3] for recording from cells in the cerebral cortex in a rigidly enclosed cranial cavity. This system has proved so successful that lengthy records can be obtained from unanæsthetized, mobile animals. There are, however, limitations to this technique. It is not readily adaptable to exploration of a wide area of cortex; moreover, it cannot be applied to an examination of the spinal cord or brain-stem. For this reason we have developed the 'weightless' micro-electrode described below.

The principle of the device illustrated in Fig. 1 is to suspend the micro-electrode (with its tip appropriately placed) from a spring which is sufficiently light to allow the electrode to follow movements of the nervous system. A weak spring *S* is soldered at the upper end to a length of brass rod *R*; the lower end of the spring is soldered to a trace *T* which encircles a strip of thin celluloid *C* carried on a transparent 'Perspex' collar fixed on the end of the protective glass tube *G* that encases the whole assembly. The lower part of the diamond-shaped trace *T* is soldered to a chlorided silver wire; when the micropipette *M* is screwed into the conical-spring *CS* the chlorided silver wire dips into the saline that fills the butt of the electrode. The trace *T* also carries two central prongs *P* so arranged that they are in line and separated at the tips by a distance *d* where $d - (\text{celluloid thickness}) \simeq 1$ mm. Electrical connexion with the cathode follower input is made through the whole metallic system supporting the weight of the micro-electrode.

The dimensions of the system are unimportant and cannot very well be decided without prior knowledge of the average weight of an electrode and the strength of the spring. In general, the electrodes used should be as light as is convenient for handling; the mass of trace and spring should be kept small, and the spring itself should be stretched to at least 150 per cent of its resting length by addition of the electrode. The dimensions of the instrument which we are using are provided in Fig. 1.

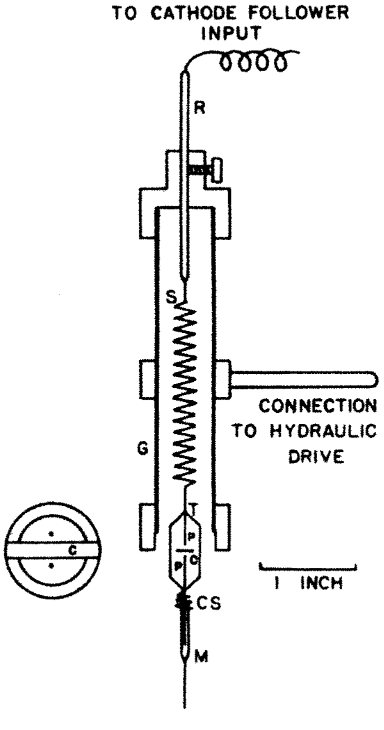


Fig. 1. *S*, Spring of 0·0054-in. nichrome wire; *T P*, trace of 0·0075-in. stainless steel; *M*, micropipette of average weight 70 mgm. when fitted. Other details are provided in the text

After attaching a particular micro-electrode, the electrode is weighed by raising or lowering *R* in relation to the upper 'Perspex' cap until the prongs *P* of the trace just ride clear of the celluloid gate *C*. The whole assembly may now be attached to an appropriate drive by a third 'Perspex' collar encircling the tube *G* and swung into position over the exposed nervous system. During insertion of the micro-electrode, as the whole carriage descends and the electrode touches the surface the celluloid gate comes in contact with the lower prong *P*. Insertion is continued until the micro-electrode's tip encounters a cell suitable for recording. If possible, it is desirable to descend 50–100μ below the optimal recording position; when the drive is reversed and an attempt is made to withdraw the electrode, the celluloid gate loses contact with the lower prong of the trace. Considerable movement of the whole carriage now leads to very small movements (in the same direction) of the micropipette, which is 'floating'. In this way the desired cell can be found again and, ideally, recording should be begun only when the celluloid gate is half-way between the two prongs. An instrument of this form must be designed to meet the owner's particular requirements. Our own carriages permit ±200μ upward or downward movement of the nervous system and allow ±2 mm. lateral movement of the preparation without loss of the record from a single unit. Lateral movements of 2 mm. can be made without causing any detectable alteration in amplitude of recorded spikes. This system completely eliminates the periodic variations of spike height which are due to respiration and the pulse in the fully exposed brain or brain-stem, and allows one to record from single units (deeper than about 100μ) for 6 hr. or more.

B. DELISLE BURNS
J. G. ROBSON

McGill University,
Montreal,
Canada.

[1] Mountcastle, V. B., Davies, P. W., and Berman, A. L., *J. Neurophysiol.*, **20**, 374 (1957).

[2] Ricci, G., Doane, B., and Jasper, H., Premier Congrès Internationale des Sciences Neurologique. Réunions plenières 401 (1958).

[3] Hubel, D. H., *J. Physiol.*, **147**, 226 (1959).

HÆMATOLOGY

Bacterially Mediated False-Positive Reactions in Lytic Blood-Typing Tests

IN blood-typing tests which employ lytic techniques, false-positive reactions can be brought about by the use of improperly rinsed and improperly dried test-tubes that still contain residues of acid or detergent or traces of water. In the course of performing routine blood-typing tests on citrated samples of cattle blood sent into this laboratory for blood-group analysis[1], we have encountered certain false-positive reactions which cannot be attributed to the use of dirty tubes. Rather, they appear to be of the order of true antigen–antibody reactions.

It is observed that the red cells in certain infected or bacterially contaminated samples of cattle blood are modified or transformed in such a manner that they react with certain natural antibodies which do not react with and cannot be absorbed by unmodified cattle red cells. These particular natural antibodies seem to be universally present, in varying concentrations, not only in virtually all our cattle blood-typing reagents[1] but also in fresh rabbit serum which is used as complement in the cattle tests.

We believe that these bacterially mediated transformations of cattle red cells may be closely akin or identical to the well-known transformations of human red cells—the Thomsen hæmagglutination phenomenon—brought about by certain bacteria or their filtrates[2]. At present, the main difference seems to be in the manifestation of the serological reactions. Transformed human red cells are said to be panagglutinable. That is, they agglutinate in virtually any serum including the autologous serum. Transformed cattle red cells are rarely if ever panagglutinable, an observation made long before us by Friedenreich[2]. This is in keeping with the observation that unmodified cattle red cells rarely exhibit agglutination even when sensitized with multiple doses of blood-typing antibodies—a fact which has necessitated the use of lytic techniques in the cattle studies[3].

Transformed cattle red cells, when sensitized with sufficient natural antibodies, are usually lysed in the presence of an appropriate complement (C') such as that in fresh rabbit serum. Whether they will be lysed by the action of natural antibodies and C' seems to depend largely on the degree of transformation and upon the concentration of natural antibodies not only in the various dilutions at which our blood-typing reagents are used but also on the concentration of natural antibodies in fresh rabbit serum.

When the red cells are what we shall refer to as maximally transformed, they are essentially panhæmolytic. That is, they become lysed in the tests with each reagent and also in the complement controls. Therefore, the complement controls alone are usually adequate in screening maximally transformed cattle red cells. Such controls are not, however, adequate in screening minimally transformed cattle red cells, and herein lies the fallacy in the notion that complement controls in conjunction with saline controls are sufficient to detect those samples of blood which are unfit for typing in lytic tests. The complement controls alone will not do this because, in our experience, the concentration of natural antibodies in pooled rabbit serum is usually not above a threshold necessary to bring about lysis of minimally transformed cattle red cells during the ordinary time-course of the blood-typing tests. When minimally transformed red cells are lysed in the complement controls, the lysis may not begin to make its appearance until the final reading (check-reading) of the tests and it is usually of a very weak degree. Furthermore, in the absence of reactions brought about by the specific blood-typing antibodies, the minimally transformed red cells seem to maintain their stability as well as or even better in tests with the majority of our reagents than they do in the complement controls. We suspect, as indicated by titrations, that certain constituents in the serum of the reagents exert a protective influence on the transformed red cells.

Some of our reagents, however, are rather richly endowed with the offending natural antibodies, and it is in the tests with such reagents that lysis of minimally transformed red cells takes place in spite of the protective influence of the serum. Such reactions can simulate closely those brought about by the specific blood-typing antibodies, thereby providing a previously unsuspected and a particularly subtle kind of false positives in lytic tests.

The observations which led us to the discovery of false positives of this order is another story which we hope to publish elsewhere along with results of transformation of cattle red cells brought about not only by various bacteria isolated from cattle blood samples but also with borrowed cultures of organisms known to transform human red cells. In the meantime, it may be well to mention at least one of the steps which we have taken in order to detect those samples in which the red cells may be minimally transformed. In addition to being cognizant of those reagents which are richly endowed with natural antibodies and are thereby capable of producing false-positive reactions with minimally transformed red cells, we employ, as a control, a bovine serum which contains no specific blood-typing antibodies but does contain natural antibodies in sufficient concentration to react with minimally transformed red cells. Red cells which become lysed in this reagent are regarded as transformed and are thereby subjected to close scrutiny with respect to their reactions with the regular blood-typing reagents. When there is any doubt regarding the latter reactions, antibody-absorptions can be performed to distinguish those reactions which may be brought about by natural antibodies rather than by the specific blood-typing antibodies.

CLYDE STORMONT
YOSHIKO SUZUKI
W. J. MILLER

Serology Laboratory,
School of Veterinary Medicine,
University of California,
Davis, California.

---

[1] Stormont, C., Proc. Tenth Internat. Congr. Genetics, Montreal, 1, 206 (1958).

[2] Friedenreich, V., *Acta Pathol. et Microbiol. Scand.*, 5, 59 (1928).

[3] Stormont, C., and Cumley, R. W., *J. Hered.*, 34, 35 (1943).

Antithromboplastin in Human Serum and Plasma

THE existence of antithromboplastin as a blood coagulation factor has been well documented (for example, see ref. 1). While it is likely that antithromboplastin plays a part in the prevention of blood coagulation in the body in health, it does not appear to have been characterized physiologically. Berry[2] has indicated a suitable technique for its demonstration which we have applied with slight modifications in detail only to whole serum, whole plasma (platelet-free) and also to the electrophoretic fractions of serum and plasma. These fractions were eluted by mechanical squeezing from strips cut from pieces 36-cm. wide of Whatman No. 3 paper used in a 'fakir's mattress' type of electrophoresis apparatus[3]. Our technique was, basically, to incubate serum, plasma or the electrophoretic fractions with human brain thromboplastin and calcium chloride at 37° C., and at known intervals to add an aliquot of this incubation mixture to a substrate platelet-free plasma and note the time it takes to clot. A saline control repeatedly gave coagulation times of about 20 sec. (shown as 100 units on the ordinate in Fig. 1). It should be noted that this technique demonstrates antithromboplastin active only against the extrinsic tissue type of thromboplastin and not against the thromboplastin formed by blood undergoing the natural coagulation mechanisms (intrinsic thromboplastin).

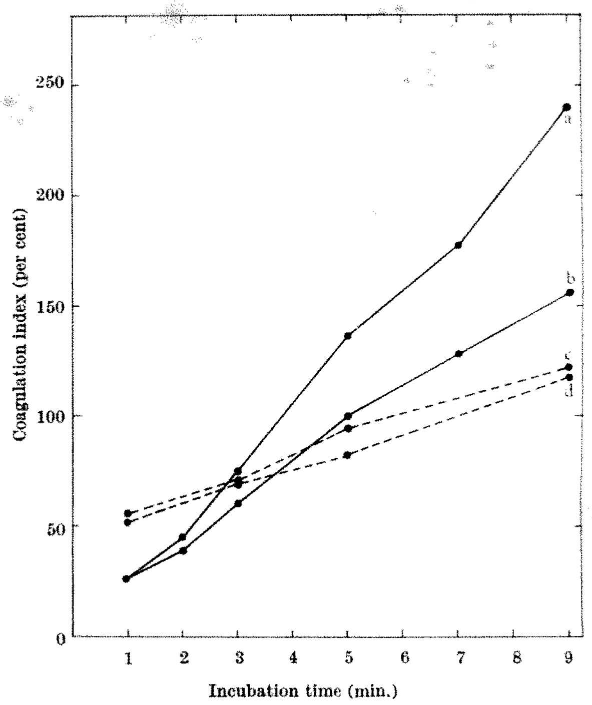


Fig. 1. Curves (*a*) and (*c*) show the progressive retardation effect of plasma and serum respectively on brain thromboplastin. Curves (*b*) and (*d*) show the effect after the addition of thrombin. The units of the ordinate are percentages. All coagulation times, including those in Table 1, were expressed as percentages of the saline control, so as to overcome differences due to slight day-to-day variations in the latter

Serum, when thus treated, showed an initial acceleration followed by a progressive lengthening of coagulation times (curve *c*). It is this progressive inhibition of the thromboplastin, claimed by Berry[2] to be due to an antithromboplastin, which can be estimated semi-quantitatively by the gradient of the curve ; steeper curves indicating greater amounts of activity.

Plasma showed a greater level of activity than serum (curve *a*). The initial acceleration of coagulation in both cases is probably due to the presence of factor VII, since it is absent after absorption by aluminium hydroxide[2]. The eluates from the α_1-globulin region of serum show an accelerating effect (that is, a coagulation index less than the 100 per cent control-level) ; see Table 1, column *a*. This, again, is probably due to factor VII, which has been shown to migrate in this region[4]. We cannot explain the accelerating effect seen in the β-globulin region. It is possible that it is associated with lipoproteins, many of which migrate in this zone.

Retarding effects appear in the α_2-globulin and the γ-globulin regions in both serum and plasma (columns *a*, *c* and *d*). Only in plasma is the retarding effect from both these regions progressive (column *d*) and therefore probably due to antithromboplastins. From columns *c* and *d* it can be seen that there is an increase in coagulation times when the fractions are incubated for 2 min., and then for 1 hr. In serum, this progressive retardation is seen only in the α-globulin region (column *c*). This suggests that there are two circulating antithromboplastins ; one, which migrates in the α-globulin region, present in serum

Table 1. COAGULATION TIMES (PERCENTAGE OF NORMAL) OF ELECTROPHORETIC FRACTIONS

Electrophoretic fractions		Serum	Serum plus thrombin	Difference in times after 2- and 60-min. incubation	
Stainable protein	Fraction No.	(*a*)	(*b*)	Serum (*c*)	Plasma (*d*)
Albumen	1	87	35	−7	3
,,	2	81	26		
,,	3	76	34	19	4
α_1-Globulin	4	84	31		
None	5	84	62	14	36
α_2-Globulin	6	98	124		
,,	7	109	117	13	22
β-Globulin	8	80	30		
,,	9	72	32	4	19
None	10	81	26		
γ-Globulin	11	107	26	−6	37
,,	12	132	23		
,,	13	125	35	−6	47
,,	14	100	34		

The difference in times in columns (*c*) and (*d*) is given in the sense: (time after 60 min. incubation) minus (time after 2 min. incubation). The fractions in columns (*c*) and (*d*) were paired in order to conserve materials.

and plasma, and another, migrating in the γ-globulin region, in plasma only.

Further evidence for two antithromboplastins was shown by the effect of adding a preparation of thrombin to the incubation mixtures. The amount of thrombin added was that which shortened the coagulation time of a saline - thromboplastin - calcium chloride mixture from 28 to 16 sec. When added to serum during incubation, no effect on the steepness of the curve was produced (curve *d*), but there was a marked decrease in antithromboplastic activity when thrombin was added to plasma (curve *b*).

When thrombin was added to the electrophoretic fractions during incubation, the retarding action in the γ-globulin region was neutralized (column *b*). The presence of long coagulation times in the α_2-globulin region in this column cannot, however, be assumed to be due entirely to antithromboplastin. It is probably also partly due to antithrombin, which is known to migrate in this region[4]. (Note that the activity in this region in column *b* exceeds the 100 per cent control level—a somewhat unexpected finding.)

The above findings suggest to us that there are two circulating antithromboplastins in plasma. One of them (the γ-globulin one) is neutralized by thrombin and presumably also during normal coagulation processes; and the other one in the α-globulin region remains unchanged throughout and is present in serum.

We thank Prof. K. R. Hill, Dr. Francis Gardner, and Dr. A. T. Richardson for their encouragement in this work.

T. G. SCOTT*
Department of Pathology,
C. SYMONS
Cardiac Department,
R. L. MARKHAM
Department of Physical Medicine,
Royal Free Hospital,
Gray's Inn Road,
London, W.C.1.

---

*Present address: Department of Morbid Anatomy, The Hospital for Sick Children, Great Ormond Street, London, W.C.1.

[1] Collingwood, B. J., and MacMahon, M. T., *J. Physiol.*, **45**, 119 (1912). Tocantins, L. M., *Fed. Proc.*, **1**, 85 (1942). Macfarlane, R. G., *Proc. Roy. Soc. Med.*, **35**, 410 (1942).
[2] Berry, C. G., *J. Clin. Path.*, **10**, 342 (1957); **11**, 39 (1958).
[3] Dettker, A., and Anduren, H., *Scan. J. Clin. and Lab. Invest.*, **6**, 74 (1954).
[4] Owen, C. A., and McKenzie, B. F., *J. App. Physiol.*, **6**, 696 (1954).

Determination of Calcium in Blood Serum by Atomic Absorption Spectroscopy

ALTHOUGH many methods have been described for the determination of calcium in blood serum, they give results which vary over a range of nearly 20 per cent[1,2], and there is still no agreement as to which method is the most reliable. In general, the values given by the flame photometric methods are 3–4 per cent higher than those obtained from the classical oxalate–permanganate titration, which in turn are about 10 per cent higher than those given by complexometric and colorimetric methods, while the values given by spectrographic emission methods are lower still.

A completely new approach to the problem is afforded by the development of the technique of analysis by atomic absorption spectroscopy[3,4], and, following the development of a simple method[5] for determining serum magnesium by this means, I have now investigated the determination of serum calcium also.

With the same equipment as in the earlier work, but using a calcium hollow-cathode tube and passing the radiation through the lowest part of the air-acetylene flame, just above the zone of unburnt gas, accurate measurements of the absorption of the calcium resonance line (4227 Å.) were possible in solutions containing 5–15 p.p.m. calcium. The presence of phosphorus lowers the absorption markedly; but this can be entirely overcome by the addition of large concentrations of strontium chloride or of the disodium salt of ethylenediamine tetraacetic acid. Provided a rich acetylene–air mixture is used, the protein in serum nullifies the effect of the phosphate present, and for routine purposes measurements can be made on serum diluted 10- or 20-fold with water. Since only 2·5 ml. of solution are required for duplicate calcium determinations, less than 0·2 ml. of serum is required for the estimation of this metal. Magnesium, even in quantities far in excess of its concentration in serum, is without effect on the calcium absorption. The sodium and potassium present in serum have only a small influence on it, which is allowed for in any event by standardizing the instrument with solutions of calcium containing about the same concentration of sodium as do the serum solutions.

Table 1 shows calcium contents of sera obtained in the following ways: (*a*) The calcium was precipitated as oxalate, and the supernatant liquid removed by draining after centrifuging. The precipitate was dissolved in a drop of hydrochloric acid and made

Table 1. CALCIUM CONTENT (MGM./100 ML.) OF BLOOD SERUM

Serum No.	Type	(*a*) Calcium pptd. as oxalate	(*b*) Serum deproteinized	(*c*) Serum diluted with water	Oxalate-permanganate titration
1	Bovine*	11·15	11·35	11·0	11·1
2*A*	Equine†	8·5	8·95	8·6	9·1
4	Human	—	10·4	10·2	9·9
5	,,	9·8	9·85	9·35	—
17	,,	—	10·35	9·75	—
18	,,	—	8·85	8·6	—
20	,,	—	9·7	9·9	—
22	,,	—	10·3	10·4	—
9	,,	6·9	6·95	—	—
12	,,	8·1	8·2	—	—
15	,,	7·05	6·85	—	—
19	,,	—	9·35	—	8·8

* Freeze-dried serum.
† This sample had stood in the refrigerator for several months and was centrifuged to remove the precipitate which had formed.

up to 5 ml. with strontium chloride solution (2,500 p.p.m. strontium). (*b*) The serum solution was deproteinized by the addition of trichloracetic acid containing strontium chloride and measurements were made on the supernatant liquid after centrifuging. (*c*) The serum was diluted directly with water to 5 ml.

It will be seen that there is good agreement between the values obtained for the calcium content of serum by these three variations of the atomic absorption technique, and that in general the results are slightly higher than the values obtained by the oxalate–permanganate titration. There is a small but significant difference between the results obtained by methods (*a*) and (*b*), which is of the magnitude to be expected from a combination of two factors, namely: (1) the failure of the oxalate buffer to precipitate the last 0·8–2·0 per cent of serum calcium[6] and (2) the decrease in volume, estimated at 0·5 per cent, of the serum solution after deproteinization in method (*b*).

It is clear that method (*b*) is an accurate procedure for determination of calcium in serum, while method (*c*) gives very rapidly results which may be of sufficient accuracy for many purposes.

A fuller account of this and the earlier[5] work will be submitted to *Spectrochimica Acta*.

J. B. Willis

Chemical Research Laboratories,
Division of Chemical Physics,
Commonwealth Scientific and Industrial Research Organization,
Melbourne.

---

[1] Hunter, G., *Nature*, **182**, 263 (1958).
[2] Harper, T. A., *Nature*, **183**, 232 (1959).
[3] Walsh, A., *Spectrochim. Acta*, **7**, 108 (1955).
[4] Russell, B. J., Shelton, J. P., and Walsh, A., *Spectrochim. Acta*, **8**, 317 (1957).
[5] Willis, J. B., *Nature*, **184**, 186 (1959).
[6] MacIntyre, I., *Biochem. J.*, **67**, 164 (1957).

PATHOLOGY

Cirrhosis of the Liver induced in Rabbits by Gastric Instillation of 3-Monohydroxycholanic Acid

Daily administration to rabbits of a desiccated whole bile preparation rapidly gives rise to cirrhosis of the liver[1]. Later findings suggested that the effect was linked to the activity of bile acids[2] although several of the first tested and more common variants of them showed only a feeble liver damaging effect when used according to the present method[2].

On the basis of further analysis of the dried bile preparation, several variously substituted cholanic acid derivatives have been investigated. Of the bile acids so far tested 3-monohydroxycholanic acid (lithocholic acid) has been found highly effective. Daily gastric instillation to rabbits (mean weight 2·5 kgm.) of 10 ml. of a 0·5 per cent water suspension of the sodium salt of this acid (L. Light and Co., Ltd.) induced cirrhosis of the liver in 10 of 11 animals within three months. In several control groups of equal size no cases of cirrhosis were found. Higher concentrations led to more extensive liver damage and death of the animals.

Massive fat infiltration was not observed. The extent of necrosis varied with the dose administered and the individual resistance of the animal. Hydropic degeneration of the liver cells was prominent. The ultimate picture was usually that of a finely nodular diffuse cirrhosis. A detailed report will be published elsewhere.

This work was supported in part by grants from the Sigrid Juselius Foundation, Helsinki, and from Finska Läkaresällskapet, Helsinki.

Paul Holsti

Department of Pathology,
University of Helsinki,
Helsinki.

---

[1] Holsti, P., *Acta path. et microbiol. Scand.*, Supp. 113 (1956).
[2] Holsti, P., *Naturwiss.*, **45**, 165 (1958).

Estimation of Mouse Tumour Blood Volumes employing a Radioactive Isotope Technique

Changes in radiosensitivity and growth-rate in a serially irradiated line of the mouse sarcoma 37 have been reported elsewhere[1]. The effect of oxygen concentration on radiosensitivity has been reviewed recently by Gray[2] and might have contributed to the results obtained with sarcoma 37. The reduction in growth-rate in the serially irradiated line may have been due wholly, or in part, to a less-adequate development of blood vessels and capillaries within the tumour—resulting in longer diffusion paths. The evaluation of the internal vascularity of control and irradiated-line tumours was undertaken in an attempt to elucidate the causes of the observed changes. Macroscopic observations of the tumours *in situ* (developing on the abdominal skin) indicated a comparable increase in size of the cutaneous vessels in control and irradiated-line tumours.

Evaluation of the internal vascularity was undertaken by counting the ionization events within excised tumours after blood-labelling with a suitable tracer. This technique was possible owing to the lack of necrotic regions and blood sinuses in these tumours below a weight of approximately 700 mgm. The radioactive isotope employed had to be bound to a relatively inert molecule incapable of diffusion through the capillary walls. Radioiodine (^{131}I) bound to human serum albumin and suspended in a buffered saline[3] conformed to these requirements. This preparation was kindly made available by the National Institute for Medical Research, Mill Hill, London, N.W.7. The activity was of the order of 350–400 μc. per ml. on preparation.

The solution was injected into a lateral tail vein of lightly anæsthetized mice. Owing to the small quantity available from each preparation (about 3·5 ml.), approximately equal numbers of mice from each group were injected from each batch. Some batches produced a marked anaphylaxis, consequently the volume injected varied between 0·25–0·15 ml. per mouse. 3–5 min. after injection were allowed for mixing before killing by cervical dislocation. The tumours were then immediately excised, blotted with No. 5 filter paper and weighed. A blood sample was taken from the heart, placed in a 'Perspex' chamber of about the same volume as the tumour and weighed. Activity counts were made by a scintillation counter on the tumour, blood sample and background. The weight of blood in each tumour was calculated from the resulting data.

The results of these measurements for 19 irradiated *B* line (*B*12) and 22 control tumours are shown in Fig. 1. Blood weights are plotted against tumour weights on a double logarithmic scale. The trend

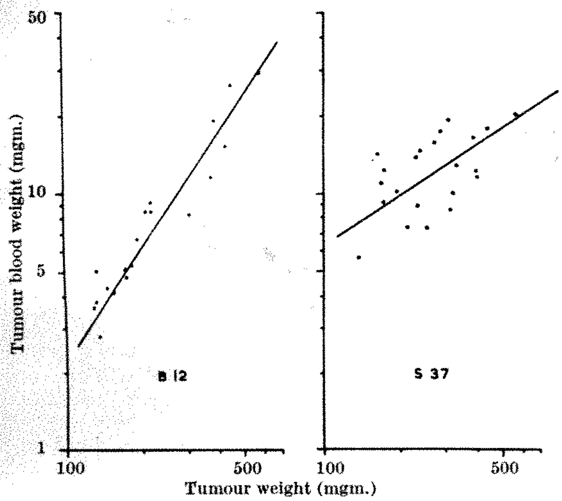


Fig. 1. Estimations of tumour blood proportions in sarcoma 37 and its serially irradiated line *B*12

lines for *B*12 and control data corresponded to slopes of 3/2 and 2/3 respectively. The scatter for *B*12 tumours was small, the correlation coefficient being 0·948—indicating a high degree of correlation (perfect functional relationship being unity). For control tumours a wider scatter was apparent, the correlation coefficient being 0·584—indicating the presence of a trend, but with a low degree of correlation.

The smaller blood volume values in *B*12 as compared with control tumours below a weight of about 350 mgm. (comparable to a tumour area of about 35 sq. mm.) suggest that the increase in time of tumour establishment experienced with this line may be due to a reduced vascular response by the host to the initial implant. A comparison of the trend lines and values for tumour weights greater than 350 mgm. indicates that vascularity is not a factor in explaining the reduction in growth-rate of established irradiated-line tumours.

The high degree of correlation between blood and tumour weights experienced with the *B*12 tumour results would appear to indicate that accurate evaluations of tumour blood content can be made by this technique.

F. S. STEWART
A. E. G. PEARSON

Departments of Physics and Experimental Pathology,
Mount Vernon Hospital,
Northwood,
Middlesex.

[1] Pearson, A. E. G., *Brit. J. Cancer* (in the press).

[2] Gray, L. G., "Organic Peroxides in Radiobiology", ed. by Haissinsky, M., 104 (Pergamon Press, London, 1958).

[3] McFarlane, A. S., *Biochem. J.*, **62**, 135 (1956).

Synovial Proliferation induced by Polysaccharides

ONE of the characteristic histopathological changes that occur in rheumatoid arthritis is the formation of pannus. This synovial granulation tissue grows over the surface of the articular cartilage, and in so doing erodes the underlying matrix. If remission of the disease process occurs at this stage, then the resulting abnormal joint surfaces will eventually lead to the development of secondary osteoarthritic changes, irrespective of further exacerbations in rheumatoid disease. The development of synovial pannus is therefore of critical importance in the natural history of the disease process in a given joint, and the study of substances that are capable of producing a similar condition in experimental animals is of interest.

Jones and Carter[1,2] have shown that a proliferative synovitis can be induced in guinea pigs by the subcutaneous or intravenous injection of bacterial polysaccharide complexes. These findings raised the possibility of inducing a similar effect by the intra-articular injection of other polysaccharides the chemical nature of which was better understood, and consequently we have investigated the effect of intra-articular carrageenin, a polygalactose sulphate employed by other workers to produce connective tissue granulomas[3-5].

The polysaccharide solution in normal saline was sterilized by autoclaving, and then injected, under pentothal anæsthesia, through the antero-lateral approach into the femorotibial joints of young adult male rabbits. Following varying periods of time, the animals were killed by air injection and the synovial membranes dissected, fixed and stained. Cultures from all joints were made in Robertson's cooked meat or Brewer's thioglycollate media, so that all infected material could be discarded. The degree of synovial response to the polysaccharide was measured by the changes in either (*a*) the average number of cells per unit area or (*b*) the mitotic index, expressed as the number of mitoses/1,000 cells/per hr., following colchicine arrest.

After a single injection of 4 mgm. of carrageenin there is a wave of proliferation, the number of synovial cells per unit area being at a maximum on the tenth day, and then falling gradually. The effects of 0·2, 2·0 and 20 mgm. of polysaccharide per knee differed significantly in the degree of synovial proliferation. The effect of the highest concentration, however, was to elicit a much more marked influx of leucocytes and macrophages. In consequence, doses of between 2 and 3 mgm. of polysaccharide were used in further experiments, as with this dose-level proliferation was easily stimulated and wandering cells were at a minimum. Table 1 shows the variation of mitotic indices with time following a single intra-articular injection of 3 mgm. of carrageenin. The contralateral knee was used as a control, as no increase in mitotic index above normal limits was ever observed in these knees following injection of their treated pairs.

The results are expressed as the ratio of the treated mitotic index to the mean control mitotic index, which was 0·19 (standard error of mean 0·02).

Table 1

Days after injection	1	2	3	4	5
$\frac{\text{Treated}}{\text{Control}}$ mitotic index	4·3	30·9	29·3	21·9	17·0

Parallel investigations of the levels of ribonucleic acid, deoxyribonucleic acid, phosphocreatine, diphosphopyridine nucleotide and the *in vitro* uptake of oxygen, lactate production and glucose utilization showed that their maximum changes occurred at about the same period. These findings will be reported in full elsewhere.

When carrageenin was injected weekly for several weeks, the resulting massive synovial proliferation was accompanied by areas of early pannus formation caused by the erosion of the matrix of the articular cartilage by the synovial granulation tissue. In some rabbits, areas of small round cell accumulations were found in the proliferating villi, which resulted in a general histological picture very similar to that found in rheumatoid arthritis.

Other polysaccharides, with widely varying structures, were also compared for their effect upon synovial proliferation by the use of a balanced incomplete block design. Glycogen, fucoidin, chondroitin sulphate, dextrin, starch (soluble) and pectic acid were inactive but alginic acid and agar (Japanese) were significantly active, although less so than carrageenin. Prof. Choji Araki, Kyoto Technical University, Japan, very kindly supplied us with specimens of agarose and agaropectin, the two components of this agar. The former compound has little effect; but agaropectin is as active as carrageenin in the induction of synovial proliferation.

It is of interest that the two most active compounds both contain galactose. Carrageenin is a mixture of two polysaccharides, one containing sulphated galactose, the other sulphated galactose and 3 : 6-anhydro galactose chains. However, both constituents of agar contain galactose and 3 : 6-anhydro galactose[6], the active component, agaropectin, also containing small amounts of sulphate, glucuronic acid and pyruvic acid. It is unfortunate that little is known of the detailed structure of agaropectin.

Further work is in progress on the possible relationship between polysaccharide structure and the induction of synovial proliferation; but it is suggested that the experimental system reported here may have some use for the screening of therapeutic substances, such as steroids and their synthetic analogues, for anti-proliferative activity in synovial membrane.

We are indebted to Dr. E. Booth, Institute of Seaweed Research, Inveresk, and Dr. G. F. Springer, University of Pennsylvania, for gifts of fucoidin, to Dr. M. J. Egerton, Beecham Foods, Ltd., for the pectic acid used in this investigation, and to Dr. L. Stoloff, Marine Colloids, Inc., New York, for samples of carrageenin.

D. P. PAGE THOMAS
J. T. DINGLE
E. R. COOK

Medical Research Council
Rheumatism Research Unit, Bath.

[1] Jones, R. S., Carter, Y., and Rankin, J. W., *Brit. J. Exp. Path.*, **35**, 37 (1954).
[2] Jones, R. S., and Carter, Y., *Arch. Path.*, **63**, 472 and 484 (1957).
[3] Robertson, W. B., and Schwartz, B., *J. Biol. Chem.*, **201**, 689 (1953).
[4] Slack, H. G. B., *Biochem. J.*, **65**, 459 (1957).
[5] Williams, G., *J. Path. Bacteriol.*, **83**, 557 (1957).
[6] Araki, C., "Carbohydrate Chemistry of Substances of Biological Interest", ed. by Wolfrom, M. L., 15 (Pergamon Press, 1959).

Anthelmintic Efficiency of Tetrachlorodifluoroethane against *Fasciola hepatica* in Sheep

CARBON tetrachloride and hexachloroethane are the most frequently used anthelmintics against *Fasciola hepatica*, the common liver fluke of sheep. These drugs are not always fully effective, and both at times produce severe toxic symptoms or death. Consequently, there remains the need for a safer and more effective agent active against liver fluke.

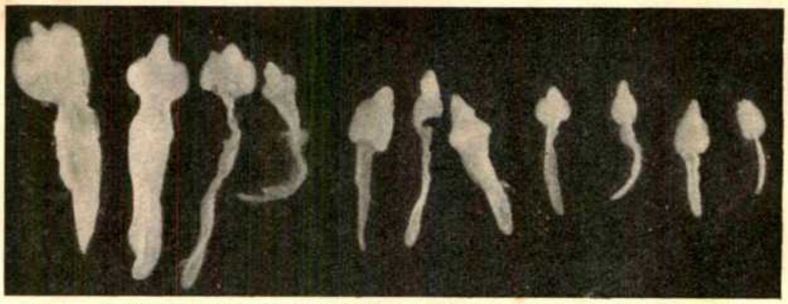


Fig. 1. Ascending necrosis of body of *F. hepatica* following treatment of sheep with 'Freon-112'

Inorganic[1,2] and organic[3,4] fluorine compounds have been shown to possess anthelmintic qualities, and it has been stated[5] that substitution of fluorine for chlorine in the methane series decreases toxicity.

Laboratory and field trials with 29 and 126 sheep, respectively, have shown that tetrachlorodifluoroethane ('Freon-112', E.I. du Pont de Nemours and Co. (Inc.), Delaware) is highly effective against mature *F. hepatica* at a dose-rate of 0·15 gm./lb. body-weight. Admixture with liquid paraffin to give a 50 per cent w/v mixture lowered the high freezing point and vapour pressure and gave a convenient solution for drenching. There was regularly a drop of 99–100 per cent in fæcal egg count. No living flukes were found in 29 previously infested sheep when the livers were examined at an abattoir 19 days after treatment. The drug was administered by intra-abomasal injection to two sheep and intrarumenally to four with similar results.

The effect on immature flukes was variable, and ranged from a complete kill to very little reduction in numbers. The low toxicity of 'Freon-112' will permit higher dose-rates to be employed in future trials of its efficiency in acute fasciolosis.

It has been reported[6] that doses of 2 gm./kgm. per day for up to 33 days did not produce liver damage in rats. No pathological changes were found in the liver, kidney or myocardium following single doses of 0·75 and 1·0 gm./lb. given orally to sheep 24 hr. before slaughter. No clinical symptoms of toxicity were observed in more than 150 sheep in 5 different locations treated with 'Freon-112'.

Three sheep were killed 24, 48 and 72 hr. respectively after treatment, and the flukes and eggs were collected. A very strong contraction of the uterus was observed, and it appeared that all eggs had been extruded from the flukes. In some cases the whole body except the oral and ventral suckers and the extreme oral portion of the fluke was necrotic (Fig. 1). In others most of the body had disintegrated and vanished, but the suckers and oral part were still active. This ascending necrosis of the fluke body has been observed by us at only one of many examinations following treatment of infested sheep with carbon tetrachloride. 'Freon-112' produced an adverse effect on the development and hatching of fluke eggs collected from the gall bladder and then incubated

Table 1. EFFECT OF 'FREON-112' ON FLUKE EGGS
Results given as percentage of total eggs examined after 2 weeks incubation

Sheep	Hr. after treatment	No development	Development started	Hatched
C 71	24	22	64	14
C 74	48	42	48	10
C 277	72	70	28	2

at 28° C. for 2 weeks. The intensity of this effect was increased with the length of the period during which the eggs had remained in the treated sheep (see Table 1). This is a useful residual effect.

Details of these experiments will be published in the *Australian Veterinary Journal*.

J. C. Boray
I. G. Pearson

Division of Animal Health,
McMaster Animal Health Laboratory,
Commonwealth Scientific and Industrial
Research Organization,
Parramatta Road,
Glebe, N.S.W.,
Australia.

[1] Mönnig, H. O., *Onderstepoort J. Vet. Sci.*, 1, 67 (1933).
[2] Habermann, R. T., Enzie, F. D., and Foster, A. O., *Amer. J. Vet. Res.*, 6, 131 (1945).
[3] Rep. U.S. Bur. Anim. Ind., 1932–33, 46 (1933).
[4] Demidov, N. V., *Veterinariya*, 32 (4), 29 (1955).
[5] Jenkins, G. L., Hartung, W. H., Hamlin, K. E., and Data, J. B., "The Chemistry of Organic Medicinal Products", 22 (Wiley, New York, 1957).
[6] Greenberg, L. A., and Lester, D., *Arch. Indust. Hyg.*, 2, 345 (1950).

Subnormal Level of Carbonic Anhydrase in Blood of Carcinoma Patients?

It was shown in a recent paper[1] that the zinc content of whole blood in cases of very different cancers was subnormal (a mean decrease of about 20 per cent being found). Various metalloproteins are known which contain zinc as an essential part[2]. It seems wise to devote careful attention to carbonic anhydrase, a substance present in relatively large amounts in red blood corpuscles and described in detail by Keilin and Mann[3].

If, when using the preparation method of these authors quantitatively, it should turn out that the quantity of zinc present in whole blood equals the quantity of zinc present in carbonic anhydrase prepared from this blood, one might characterize carcinomas by a subnormal level of carbonic anhydrase. Table 1 shows results of determinations of zinc carried out by analysing various blood fractions which Dr. H. J. van den Berg was kind enough to prepare. After centrifuging off the serum, hæmolysing the erythrocytes and precipitating hæmoglobin with ethyl alcohol and chloroform, the remaining carbonic anhydrase was precipitated with lead acetate. The determination of zinc was carried out spectrochemically[4].

According to Keilin and Mann, 50–60 per cent of carbonic anhydrase is occluded during the precipitation of hæmoglobin, which can also be seen from Table 1.

Table 1

	Weight (gm.)	Zinc content (p.p.m.)	Weight of zinc (gm.)	Weight of zinc (gm.)
Whole blood	201	5·7		0·00115
Plasma	102	0·9*	0 000097	
Leucocytes + water	1 25	25	0·000031	
Erythrocytes	105	9 9	0 00104	
		Total	0 00117	0 00115
Erythrocytes	105	9 9		0·00104
Hæmoglobin:				
First fraction	25	13·6	0 00034	
Second fraction	3	43 8	0 00013	
Lead precipitate	4	136	0 00054	
		Total	0·00101	0 00104

The lead precipitate cannot be decomposed without destroying the protein. For this reason the clear solution of carbonic anhydrase was dialysed against water, whereby according to Vikbladh[5] once again zinc ("loosely-bound zinc") is lost up to about 70 per cent. The dialysed solution, free from chloroform, alcohol and salts, was dried *in vacuo* at a low temperature (about 5° C.).

Table 2 shows the zinc balance.

Table 2

	Mgm. zinc
100 ml. of whole blood contains	0·65
The serum fraction contains	0·1
remainder	0·55
60 per cent loss owing to co-precipitation with hæmoglobin remainder	0·22
70 per cent loss owing to loosely bound zinc being dialysed remainder	0·07
45 mgm. of impure carbonic anhydrase (containing 0·15 per cent zinc) prepared from 100 ml. of whole blood contain also	0 07

It appeared to be possible to increase the purity of the product: its zinc content varied between 0·25 and 0·35 per cent (Keilin and Mann, 0·33 per cent; other investigators, between 0·2 and 0·32 per cent).

The properties of the preparations are as follows:

(1) One of them appeared to contain 14·1 per cent nitrogen (Dr. F. J. Spruit); Keilin and Mann mention a value of 14·95 per cent.

(2) Paper electrophoresis (Dr. J. Voogd) showed the existence of two protein fractions (see also Bate-Smith[6]). The main fraction appeared to change proportionally with time into the second fraction, which has a smaller rate of migration and probably a larger molecular weight. This change appeared to be closely related to the zinc content of the carbonic anhydrase. It is known that zinc facilitates the formation of larger molecules. On the other hand, this effect of change was shown to be absent when all manipulations were carried out in the absence of oxygen. It is therefore probable that carbonic anhydrase is sensitive to oxygen.

(3) Semi-quantitative spectrochemical analyses showed the following results: 0·2–0·8 per cent potassium and also sodium; 0·7 per cent calcium; 0·1–0·2 per cent phosphorus; 0·05–0·1 per cent magnesium; 0·01–0·03 per cent copper; 0·01 per cent iron and 0·001 per cent manganese (a preparation made from ox blood appeared to contain twice as much of these elements, but only 8 per cent nitrogen).

The following hypothesis seems worth serious consideration. A subnormal level of carbonic anhydrase in carcinoma cases can have a serious effect on the metabolism. The transport of carbon dioxide can be hindered, and this is certainly the case in a tumour resulting in a process of fermentation[7]. Therefore in my opinion it would be worthwhile to study intensively the anti-carcinogenic activity of carbonic anhydrase.

Thanks are due to Dr. H. J. van den Berg, Dr. F. J. Spruit and Dr. J. Voogd for their valuable help as well as to Miss H. Savenije for her careful determinations of zinc.

N. W. H. Addink

Philips Research Laboratories,
Eindhoven. Dec. 24.

[1] Addink, N. W. H., and Frank, L. J. P., *Cancer*, 12, 544 (1959).
[2] Vallee, B. L., "Adv. Protein Chem.", 10, 317 (Academic Press, New York, 1955).
[3] Keilin, D., and Mann, T., *Biochem. J.*, 34, 1163 (1940).
[4] Addink, N. W. H., *Rec. Trav. Chim. Pays-Bas*, 74, 197 (1955).
[5] Vikbladh, I., *Scand. J. Clin. and Lab. Invest.*, 3 (Supp. 2), 1 (1951).
[6] Bate-Smith, E. C., *Biochem. J.*, 34, 1176 (1940).
[7] Greenstein, J. P., "Biochemistry of Cancer", 450 (Academic Press, New York, 1954).

RADIOBIOLOGY

Inability of Thiotaurine to protect Mice against Ionizing Radiation

One of the theories proposed for explaining the protective role of certain substances on animals submitted to a lethal dose of ionizing radiation involves the capture of free radicals by the protective compound (scavenger action). As a consequence of this process the compound is chemically modified in the biological structures where it happens to be, which then survive the irradiation. If such a theory is correct a certain degree of correlation would be expected between the protecting activity of a substance and its lability towards radiation, unless a catalytic mechanism is involved.

Cystamine, one of the best-known biological protectors against radiation[1], is relatively resistant to radiation in solution. A low percentage of degradation products has been detected only after heavy irradiation[2]. Thiotaurine, a metabolic product of cystine and cystamine, has been recently found more sensitive than cystamine to an equal amount of X- and γ-rays[3].

The validity of the presumed correlation between radiochemical degradation and biological protection has been investigated by comparing the protective effects of thiotaurine and cystamine against a lethal dose of X-rays on mice. Three groups of 15 white male mice of the Swiss strain weighing 20 gm. were placed in a wooden box with a 'Perspex' cover in mixed groups of 15 animals and exposed to a dose of 600 r. in the space of 15 min. One group was the control: another was injected intraperitoneally with half the *LD*50 of cysteamine neutralized with *N* hydrochloric acid (cysteamine and cystamine have equal protective power[1]), 15 min. before irradiation. The third group received half the *LD*50 of thiotaurine[4] in the place of cysteamine. Under our conditions the *LD*50 for cysteamine and thiotaurine were respectively 0·27 gm./kgm. and 3·52 gm./kgm., that is, thiotaurine is tolerated much more than cysteamine. On the molar base, the thiotaurine injected represents an amount seven times higher than that of cysteamine.

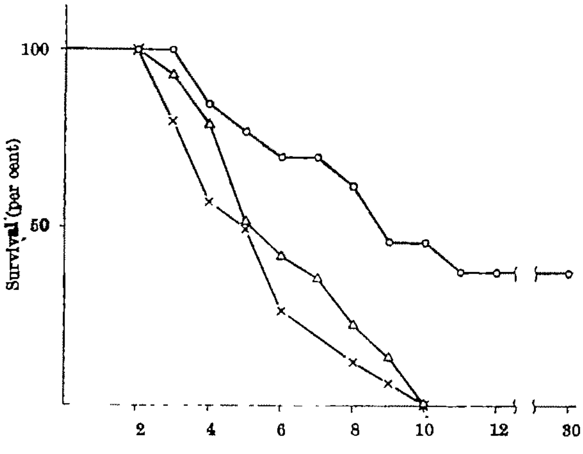


Fig. 1. Effect of cysteamine and thiotaurine on the survival of mice after exposure to X-rays. ×, 600 r.; ○, 600 r. and half the *LD*50 of cysteamine (0·135 gm./kgm.); △, 600 r. and half the *LD*50 of thiotaurine (1·760 gm./kgm.)

The results are shown in Fig. 1. It may be seen that all the thiotaurine-treated mice died within 10 days of irradiation, while little less than 50 per cent of the cysteamine-injected mice are still alive. This clear-cut result excludes any possible role of thiotaurine as a protective agent despite its relative lability towards radiations, and despite the large dose injected. This finding suggests that the correlation of the radiochemical degradation of a substance with its biological protective power is untenable. Moreover, it supports the view of those who believe that the 'scavenging action' plays only a minor part in the mechanism of the chemical protection[5].

This work has been assisted by a grant of the Comitato Nazionale Ricerche Nucleari.

D. Cavallini
L. Tentori

Institute of Biological Chemistry of the
University of Modena and Department
of Biology of the Istituto Superiore di
Sanità of Rome.

---

[1] Bacq, Z. M., and Alexander, P., "Principes de Radiobiologie" (Masson, Paris, 1955).

[2] Shapiro, B., and Eldjarn, L., *Rad. Res.*, 3, 255 (1953).

[3] Cavallini, D., Mondovì, B., Giovannella, B., and De Marco, C., *Nature*, 184, 61 (1959).

[4] Cavallini, D., De Marco, C., and Mondovì, B., *Bull. Soc. Chim. Biol.*, 40, 1711 (1958).

[5] Cohen, J. A., Vos, O., and van Bekkum, D. W., "Advances in Radiobiology", edit. by Hevesy, G. de, Forssberg, A., and Abbatt, J. D., 184 (Oliver and Boyd, Edinburgh, 1957).

Divergence between Lethal Doses and Sterilizing Doses of X-Rays with Progressive Development in *Habrobracon* Females

In the present work I have determined the weakest link in an insect life-cycle and related this to the quantitative differences between the sterility and lethality doses when virgin females were irradiated at various developmental stages. The wasp used is known in genetic literature as *Habrobracon juglandis* (Ashmead). The females were chosen since it was believed that a non-sterile female would normally live and copulate with a son and afterwards produce both males and females. Critical stages for exposure were selected at significant changes in somatic and/or gonadic differentiation.

The stock, derived from a mother–son mating in 1952 of wild type Whiting stock No. 33, has maintained excellent egg production and viability for more than 270 generations. The small braconid wasp parasitizes various lepidopteran larvæ. *Ephestia kuehniella* (Zeller) caterpillars are the standard host employed. *Habrobracon* females usually mate once. Fertilized eggs develop into diploid females; unfertilized eggs develop parthenogenetically into haploid males. All rearing was done at 30° C., and samples of 20 wasps per stage were used.

Eggs or immature forms of known age were irradiated at the Marine Biological Laboratory, Woods Hole, Massachusetts (25 m.amp., 250 kV. peak, filtration ≡ 0·2 mm. copper). A constant target–tube distance of 23 cm. was maintained to produce 600 r./min.

Females were considered sterile if oviposition failed; or in the case of forms more than 6 days old, if oviposition ceased after the deposit of eggs preformed at the time of irradiation. The lethal dose is considered to be that X-ray exposure which prevented eclosion; consequently, death could occur between

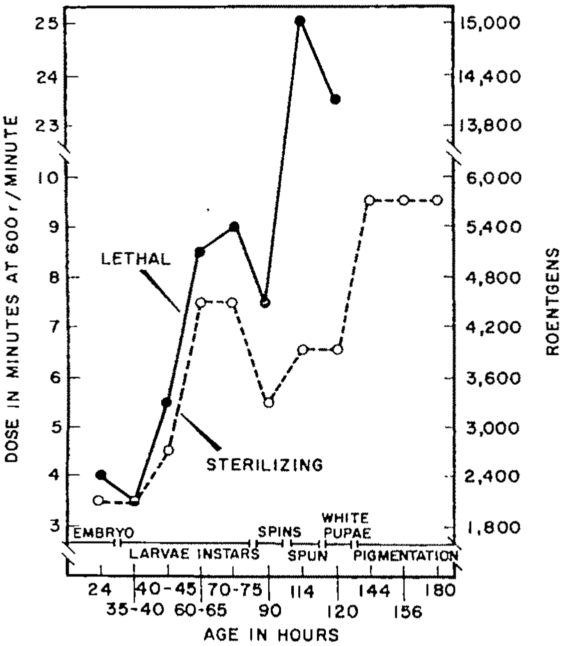


Fig. 1. Sterilizing and lethal X-ray doses for significant developmental stages in the life-cycle of *Habrobracon juglandis* (Ashmead)

treatment and pre-eclosion, usually at some developmental crisis.

Specific controls were not used. Stock performance during the experiments and its subsequent performance are sufficient evidence of an unaltered and high reproductive capacity of untreated wasps.

The pattern of radiation-induced effects is shown in Fig. 1 for most of the life-cycle to demonstrate the divergence between sterilizing and lethal doses. At stages earlier than shown, the gonad is no more radiosensitive than the soma, since females developing after doses at the lethal threshold are as fertile as unexposed wasps. Very little radiation, 100–200 r., kills 1–3 hr. embryos. This, the weakest link in the life-cycle, is the time at which primitive germ cells differentiate and begin posterior migration. These cells are not seriously influenced by irradiation up to the dose that prohibits hatching. Selective irradiation of the posterior pole was not successful in destroying this cell population. The bulk of the egg (9–13 hr. old) was shielded with lead so that only the posterior pole was irradiated with 170 r./min. Samples were exposed from 1 to 90 min. The 10-min. exposure appeared to be lethal.

The curve (Fig. 1) for increased radiosensitivity does not progress smoothly. Biological considerations are offered in explanation. During early larval life, all basic organ systems differentiate from embryonic germ layers, but the business of ingestion seems of chief concern during the instars. Then at 90 hr. there is a highly active physiological condition in preparation for spinning, as well as critical internal histological changes. Then, somatic radioresistance increases appreciably at the postmeconium stage (114 hr.), followed by a drop back toward sensitivity in white pupæ. Compared with older forms which withstand up to 300,000 r. (ref. 2), white pupæ are very sensitive probably because muscle and other tissues are forming while the fat body, the predominant tissue, is resorbed. Active cell division and physiology could account for the radiosensitivity. Thus, the over-all pattern of effects appears consistent with a modernized version of the radiobiological 'law' of Bergonie and Tribondeau (see ref. 4) which stated that sensitivity of cells to radiation depends upon their reproductive activity and degree of differentiation.

I thank Dr. D. S. Grosch for his help and guidance during this investigation and preparation of this communication. The work was carried out as part of the requirement for a Ph.D. thesis at North Carolina State College, Raleigh, North Carolina.

HOWARD E. ERDMAN
Biology Operation, Hanford Laboratories,
General Electric Co., Richland, Washington.

[1] Henschen, W., *Ан. Morphol. Okol. Tiere.*, 13, 144 (1928). Speicher, B. R., unpublished Master's thesis at Pittsburgh University (1931). Grosch, D. S., *Growth*, 12, 243 (1948); *J. Elisha Mitchell Sci. Soc.*, 65, 61 (1949); 65, 205 (1949). Amy, R. L., *Radiation Res.*, 3, 166 (1955).

[2] Heidenthal, G., *Genetics*, 30, 197 (1945).

[3] Grosch, D. S., *J. Elisha Mitchell Sci. Soc.*, 65, 205 (1949).

[4] Bacq, Z. M., and Alexander, P., "Fundamentals of Radiobiology" (Academic Press Inc., New York, 1955).

Changes in Structure of a Periclinal Chromosomal Chimera of Apple following X-Irradiation

THREE types of periclinal chromosomal chimeras in apple have been found in Nature[1-3]. Their apical meristems are characterized by one, two or three layers of diploid cells over tetraploid interior cells. Plants with one diploid layer (designated 2–4–4–4) produce diploid gametes, but the others (2–2–4–4 and 2–2–2–4) produce haploid gametes[3]. Since 2–4–4–4 chimeras are a source of diploid gametes for use in breeding polyploid apples, it would be desirable to produce this chimera in varieties in which only the other types have been found. X-rays have been shown to alter the structure of a periclinal chimera in carnation[4]. The effects of X-radiation on a 2–2–4–4 chimera of apple, 'Giant Spy (Loop)'[1-3,5], has been reported as an abstract[6] and are here described in more detail.

Dormant one-year-old shoots from trees seven to twenty years old of 'Giant Spy (Loop)' apple were irradiated in February, 1957, at Brookhaven National Laboratory, Upton, New York. A General Electric Maxitron X-ray machine was operated at 250 kVp. and 30 m.amp. with 1 mm. aluminium filtration to deliver doses of 3,000 r. A single layer of scions was exposed at one time and only those buds which occurred on the exposed side of the shoot were selected to grow. Treated and control scions were bench-grafted to apple seedlings and the plants forced in the greenhouse.

Buds just starting to grow were fixed in Randolph's modification of Navashin's fluid[7]. Slides of about 40 buds were prepared and stained in safranin and fast green[7] or in crystal violet[1].

The remaining plants were grown for two years. All trees sampled had grown from the irradiated scion and not from the rootstock. The terminal portion of each main branch (1–5 per tree) of 38 treated and 6 control trees was cut in the spring of 1959 and forced in water in the greenhouse. About 270 growing buds were collected and processed as described by Blaser and Einset[1].

The distribution of diploid and tetraploid cells, which were distinguished by the comparative size of division figures, chiefly metaphase plates[1], was noted in the apical meristem, deeper stem tissues and young leaves of 2–15 buds per tree. Shoot tips with the constitution 2–2–4–4 and 2–2–2–4 could be distinguished only by comparison of figures in the apical meristem itself. At least one shoot tip with a definite determination of ploidy of layers was necessary to identify the type of chimera present.

Buds from the trees which were the source of the irradiated material were found to be 2–2–4–4 chimeras either in the present or earlier[3] studies. The chromosomal constitution of buds from control plants was 2–2–4–4.

Buds collected two weeks after forcing of the irradiated bench-grafted scions showed a pattern of radiation damage similar to that found in other irradiated apple shoot apices[7]. The walls, cytoplasm and nucleus of cells of the first layer generally stained like those of normal meristematic cells. Occasionally a few cells showed collapse or 'absence' of the protoplast. Many deeper cells in the central area of the tunica and corpus showed heavily stained walls, collapsed cytoplasm and disorganized nucleus, or protoplast so lightly stained that the cell appeared 'empty'. The axillary meristems had a pattern of radiation damage similar to that of the apical meristem.

In about one-third of the apices collected 2–6 weeks after forcing where the damaged area was still conspicuous, division figures were found in living cells near the damaged cells, both in the first layer and, more frequently, in the deeper cells.

The chromosomal constitution of branched or unbranched shoots which had grown for two years after irradiation of the original bud is presented in Table 1. The high frequency (33 out of 41 surviving buds) of types different from the one irradiated makes it probable that these have occurred as a result of shifting of layers during the re-organization of the shoot apex after radiation damage, and not as a result of changes in ploidy induced by radiation. Divisions observed in cells near the area of damaged cells suggest that a shoot apex may be formed from cells peripheral to the injury, either in the terminal or axillary meristems. Unfortunately, no stages in the re-organization of the apex were found, perhaps due to too widely spaced collections. The formation of a shoot primarily from the inner tetraploid cells with the original surface cells propagating themselves as a single diploid layer, which produces a 2–4–4–4 type, was much less frequent than formation of a new shoot from the upper diploid layers, which produces 2–2–2–4 and diploid shoots.

Table 1. CHROMOSOMAL CONSTITUTION OF TWO-YEAR-OLD SHOOTS EACH FROM ONE IRRADIATED BUD OF 'GIANT SPY (LOOP)' (2–2–4–4)
Figures refer to the number of shoots of each type.

2–4–4–4	2–2–4–4	2–2–2–4	2–2–2–2	2–2–4–4 and 2–2–2–4	2–2–4–4 and 2–2–2–2	2–2–2–4 and 2–2–2–2
3	8	10	12	3	1	4

Eight shoots were not uniform in type (Table 1). The chromosomal constitution of buds in four instances was consistent within a branch, but in four others variable within a branch. The buds themselves appeared to be of one type. This lack of uniformity may result from the segregation of chimeral or diploid buds from different sectors of some reorganized apices. The instability of 2–2–2–4 chimeras may also be related to the slight tendency of natural 2–2–2–4 chimeras to produce diploid buds[3].

The pattern of radiation sensitivity of cells in the apple shoot apex, as indicated by their survival, is similar whether a wholly diploid shoot or a chimeral one is irradiated with a dose semi-lethal to the bud[7]. Sensitivity to these doses seems to be related to the position of the cells in the meristem rather than to the ploidy of those cells.

X-irradiation seems to be a tool for producing from 2–2–4–4 chimeras, which produce haploid gametes, 2–4–4–4 chimeras, which may be expected, barring chromosomal or genic changes, to produce diploid gametes for use in breeding polyploid apples.

CHARLOTTE PRATT

Department of Pomology,
New York State Agricultural Experiment Station,
Geneva, New York.

[1] Blaser, H. W., and Einset, J., *Amer. J. Bot.*, **35**, 473 (1948).
[2] Blaser, H. W., and Einset, J., *Amer. J. Bot.*, **37**, 297 (1950).
[3] Einset, J., *Proc. Amer. Soc. Hort. Sci.*, **59**, 291 (1952).
[4] Sagawa, Y., and Mehlquist, G. A. L., *Amer. J. Bot.*, **44**, 397 (1957).
[5] Einset, J., Blaser, H. W., and Imhofe, B., *J. Heredity*, **37**, 265 (1946).
[6] Pratt, C., Abst. Fifty-sixth Ann. Meeting Amer. Soc. Hort. Sci., 38 (1959).
[7] Pratt, C., Einset, J., and Zahur, M., *Amer. J. Bot.*, **46**, 537 (1959).

BIOLOGY

Autocatalytic Particles and Steady States

THERE are several phenomena in microbial heredity which are suggestive of cytoplasmic inheritance in that a particular self-perpetuating state can be induced rapidly in a large majority of the population by relatively simple changes in the growth conditions. These include long-term adaptation in yeast[1], auto-adaptation in bacteria[2], and the adaptive formation of β-galactosidose in *Escherichia coli* grown at maintenance-levels of inducer[3].

The first of these systems to be analysed in detail with respect to the points of interest here was long-term adaptation. One question which was asked was whether the ability of the cells of slow fermenters to metabolize galactose depends on the presence in these cells of some kind of autocatalytic particles. From an analysis of the kinetics of the loss during growth on galactose-free medium of the capacity to form galactose-positive colonies, it was deduced that this was indeed the case, and that a small number of such particles (of the order of one per cell) was necessary to function autocatalytically[4].

Several models were proposed for the mechanism of the autocatalysis, some of which did, and others of which did not, require that the particles be self-duplicating[5,6]. These have all been superseded by the recent detailed analysis of the β-galactosidose system of *Escherichia coli*[3,7], in which it was possible to equate the autocatalytic particle with the β-galactosidose permease.

There is one point in the discussion of these results which should be clarified. The 'autocatalytic particle' hypothesis originally considered for long-term adaptation is of course logically valueless unless one can imagine some alternative model. The alternative generally considered is an aparticulate model depending on the existence of multiple steady states. There has been some disagreement in recent years[8] as to whether these two alternatives are really distinct. It has been implied that the 'steady state' hypothesis is simply a mathematical description which can be applied to autocatalytic particles among other things[9]. This is presumably also the point of view of Cohn and Horibata[7], since they interpret their results, which certainly involve autocatalytic particles, to be an example of the steady-state model.

I wish to point out here: (1) that there is a logical distinction between autocatalytic particle models and stable steady-state models; and (2) that no example of the latter has as yet been provided.

Steady states. Consider a cell which contains n chemical species involved in related reactions. Let c be the concentration of the ith species. Then we have, in general, a system of n simultaneous differential equations of the form:

$$\frac{dc_i}{dt} = f_i\,(c_1\, c_2 - - - - c_n)$$

A stable steady state is said to exist at some set of values $(C_1, C_2 - - - C_n)$ of the concentrations if two conditions are satisfied: (1) $f_i\,(C_1, C_2 \ldots C_n) = 0$ for all i; (2) the system will tend to return to the steady state following a sufficiently small displacement in any direction from the steady-state values.

It is easy to find examples of such steady state. It is also easy to construct examples in which more than one solution exists for condition (1). Condition (2) is also easy to satisfy for a single solution; but it is not satisfied by most of the systems with multiple solutions which have been proposed in more or less mathematical detail by various authors[10,11].

Condition (2) is, however, critical. Without it, the steady state is unstable in the same sense that the equilibrium of a cone balanced on its vertex is unstable. Any small fluctuation will cause it to diverge permanently from the steady state in question.

Autocatalytic particles and unstable steady states. The autocatalytic particle hypothesis can be defined as follows. There is some subcellular particle X with the properties that: (*a*) A cell with at least one particle of X will synthesize more such particles during growth; (*b*) a cell with no such particles will not form any.

Such a system will generally have at least two steady states. One of these (at $X = 0$) is, however, unstable. The most basic distinction is therefore between stable and unstable steady states, the autocatalytic particle hypothesis being a special case of the latter. The mechanism of autocatalysis is irrelevant in the context.

Condition (*b*) cannot of course be taken literally, since any molecular event must have some non-zero probability. In practice, what is meant is that the probability of forming a particle during one cell division cycle is much less than one. The genes themselves approximate this rule well enough to have allowed the construction of the science of genetics.

Stable steady states could in principle be maintained indefinitely in growing, well-mixed tubs of protoplasm which are never subdivided into smaller isolated regions. The 'hereditary' character of unstable steady states, on the other hand, depends completely on the fact that the cell has a finite size. Each cell division creates a certain possibility for the occurrence of occasional cells with a large disparity in the numbers or kinds of certain critical molecules, and one such fluctuation has occurred, its results being confined to the progeny of the cell in which it took place. The process is reminiscent of genetic drift or gene fixation; or, more properly, these phenomena are themselves examples of unstable steady states within a population rather than within a cell.

Another type of unstable state may explain some of the antigenic changes in *Paramecium*, for which Delbrück's[10] steady-state hypothesis was originally proposed. These are states which are not steady at all, but for which the change from one state to another is sufficiently slow to require many cell generations. The continuation of such states for a limited number of generations does not depend on finite cell size, and they cannot be perpetuated indefinitely even among sublines continually selected as being apparently in the original state.

ALLAN CAMPBELL

Department of Biology,
University of Rochester,
Rochester, New York.

[1] Spiegelman, S., Sussman, R. R., and Pinska, E., *Proc. U.S. Nat. Acad. Sci.*, **36**, 591 (1950).

[2] Wright, B., *J. Bact.*, **66**, 407 (1953).

[3] Novick, A., and Wiener, M., *Proc. U.S. Nat Acad. Sci.*, **43**, 553 (1957).

[4] Spiegelman, S., DeLorenzo, W. F., and Campbell, A. M., *Proc. U.S. Nat. Acad. Sci.*, **37**, 513 (1951).

[5] Spiegelman, S., *Cold Spring Harbor Symp. Quant. Biol.*, **16**, 87 (1951).

[6] Campbell, A. M., and Spiegelman, S, *C R. Trav. Lab. Carlsberg, Ser. Physiol.*, **26**, 13 (1956).

[7] Cohn, M., and Horibata, K., *J. Bact.*, **78**, 613 (1959).

[8] Discussion following paper by Nanney in "The Chemical Basis of Heredity" (Johns Hopkins Press, 1957).

[9] Lederberg, J., and Lederberg, E. M, in "Cellular Mechanisms in Differentiation and Growth" (Princeton University Press, 1956).

[10] Delbruck, M., in "Unités Biologiques Douées de Continuité Génétique", 33 (Centre National de la Recherche Scientifique, Paris, 1949).

[11] Reiner, J. M., "Behavior of Enzyme Systems", 201 (Burgess Press, 1959).

Chromosome Numbers of Slugs

CHROMOSOME numbers are becoming increasingly part of the taxonomic descriptions of animal and plant species.

Very few figures are known for the slugs, the collective name given to members of the three families of almost shell-less pulmonate molluscs which occur in Britain. Some pulmonate species have been examined in France and Switzerland by M. and J. L. Perrot[1-3], and the comparison of their results with mine, given in Table 1, shows that the number of chromosomes is the same for British and Continental samples. No evidence has been found of chromosome races, as in the populations of *Sorex araneus* studied by Ford *et al.*[4].

Chromosome counts were made at the first meiotic prophase and metaphase stages of spermatogenesis, and also the mitotic metaphases found in ovotestes of mature or nearly mature animals. The ovotestis was fixed in alcohol-acetic, teased to separate the cells, and stained and squashed in aceto-orcein.

The taxonomic arrangement of this list is that of Quick[5], containing the alteration of *Limax arborum* Bouchard-Chantereaux to *Lehmannia marginata* Muller; the name *Lehmannia* having been used generically by Malm in 1868. Cytotaxonomy fully supports the withdrawal of this species from the genus *Limax*; a change made on the structure of the radula. *Limax tenellus* seems to correspond more closely with *Lehmannia marginata* in chromosome number than with the other three British species of *Limax*. Intrageneric variation in chromosome number in the genus *Arion* emphasizes the close relationship between *A. ater* L. and *A. rufus* L.; considered as subspecies by Cain and Williamson[6].

Little or no variation has been found within the other genera, and the number of chromosomes cannot

Table 1

Family	Genus	Subgenus	Species	Author	Chromosome number: Present work	Chromosome number: Counts by Perrot and Perrot
Testacellidae	*Testacella*		*haliotidea*	Draparnaud	$n = 32$	—
Arionidae	*Arion*	*Micrarion*	*intermedius*	Normand	$n = 28$	—
		Carinarion	*circumscriptus*	Johnston	$n = 29$	—
		Kobeltia	*hortensis*	Ferussac	$n = 28$	—
		Mesarion	*subfuscus*	(Draparnaud)	$n = 25$	—
		Arion s.s.	*ater*	(L.)	$n = 26$	—
			*rufus**	(L.)	$n = 26$	
Limacidae	*Milax*		*gagates*	(Draparnaud)	$n = 33$ or 34	—
			sowerbii	(Ferussac)	$n = 34$	—
			gracilis	(Leydig)	$n = 33$	—
	Limax	*Malacolimax*	*tenellus*	Nilsson	—	$n = 24$
		Limax s.s.	*cinereoniger*	Wolf	$n = 31$	$n = 31$
			maximus	(L.)	$n = 31$	$n = 31$
		Limacus	*flavus*	(L.)	$n = 31$	$n = 31$
	Lehmannia		*marginata*	Muller	$n = 24$	$n = 24$
	Agriolimax	*Agriolimax*	s.s. *agrestis*	(L.)	$n = 30$	—
			reticulatus	(Muller)	$n = 30$	†
		Malino	*laevis*	(Muller)	$n = 30$	—
			caruanae	Pollonera	$n = 30$	—

* Collected in France.
† Perrot, J. L., quotes $n = 30$ for *A. agrestis*, but probably refers to animals now included in *A. reticulatus*.

be used to distinguish between morphologically rather similar species of, for example, *Agriolimax*. *Testacella maugei* Ferussac, *T. scutulum* Sowerby, and *Geomalacus maculosus* Allman, on the British list, are not included in Table 1, as no cytological analysis has been carried out.

I wish to thank Dr. M. Fischberg, especially, for his advice on this work, and E. A. Ellis and L. M. Cook for collections of animals.

GILLIAN E. BEESON

Embryology Laboratory,
Department of Zoology and
Comparative Anatomy,
University Museum,
Oxford.

[1] Perrot, M., *Rev. Suisse Zool.*, **45**, 530 (1938).
[2] Perrot, J. L., *Rev. Suisse Zool.*, **37**, 397 (1930).
[3] Perrot, J. L., and Perrot, M., *Rev. Suisse Zool.*, **44**, 203 (1937).
[4] Ford, C. E., Hamerton, J. L., and Sharman, G. B., *Nature*, **180**, 392 (1957).
[5] Quick, H. E., "Synopses of British Fauna", **8** (Linn. Soc., London, 1949).
[6] Cain, A. J., and Williamson, M. H., *Proc. Malac. Soc. Lond.*, **33**, 73 (1958).

An Apparatus for Panning in Cine Micrography

IN ciné micrography it has not been possible to vary the viewpoint or introduce variety by devices equivalent to 'panning' or 'tracking' in ordinary ciné photography. This limitation makes it difficult to show some aspects of a microscopical field which demand the use of a moving stage.

The movement of the usual rack and pinion of the mechanical stage of a microscope, when enlarged 300–400 times on the film before projection, is so irregular owing to the backlash and the tremor of the operator's hand and the need for changing the grip that it is quite unacceptable.

After a number of attempts, a successful apparatus has been made which combines the principles used in the De Fonbrune and the Singer micromanipulators. This gives smooth control of movement in both directions separately or combined.

The arrangement consists of two pieces of aluminium plate, the bottom one bolted by two easily detachable brass brackets to the microscope stage, the upper one stuck to it with petroleum jelly.

The lower plate has a central hole over the condenser lens, and the upper plate has an excentric opening which overlaps the condenser hole by about 2 cm. When arranged ready for use, the upper plate projects for about 2 cm. beyond the lower, both to the left and forward.

Two small syringes with metal plungers are mounted horizontally and at right angles to each other beside the stage. Slots cut in the heads of the plungers rest against the upper, moving plate. This gives both a certain grip and at the same time permits automatic re-arrangement of one syringe as the other is in use. Both syringes are carried at the correct height by metal rods on top of which are spring clips. The rod which provides anterior–posterior movement is placed off-centre to clear the beam of light from the lamp. A plastic or wooden base with stops for the foot of the stand is also required. The supporting rods are screwed to this.

Each of the syringes is connected to another syringe by narrow rubber pressure tubing. Plastic tubing is too rigid in the wall and too springy to be a satisfactory alternative. The syringes on the free end of the rubber tubes are pressed to drive the stage. They need not be the same size as the others, but no advantage appeared to be derived from using smaller syringes as no gearing ratio was necessary in practice.

In use, the slide to be filmed is placed on the upper sliding plate. The pair of syringes on the free ends of the tubing are held between the fingers of the left hand and their plungers compressed with the thumb; one alone, or both, may be used to give movements in two directions at right angles or diagonal movement. The right hand is available for the normal controls of the microscope.

No special return mechanism is provided. At the end of the run, the sliding plate is simply pushed back to the starting position.

W. H. HUGHES
P. N. CARDEW

St. Mary's Hospital Medical School,
London, W.2.

GENETICS

Position of the Gene determining the Diploid-like Meiotic Behaviour of Wheat

COMMON wheat (*Triticum aestivum* $2n = 6x = 42$) has attained the hexaploid condition by the combination of the full chromosome complements of the three diploid species *Triticum monococcum*, *Aegilops speltoides* and *Aegilops squarrosa*[1-3]. However, at meiosis in *T. aestivum*, despite the close genetical and cytological relationships of its diploid ancestors, each chromosome pairs with its fully homologous partner and only bivalents are formed. There is no pairing between corresponding, homœologous, chromosomes derived from different diploid ancestors, although considerable similarity in the genetical activities of homœologues still remains[4].

Riley and Chapman[5] showed that homœologous pairing was no longer precluded in the absence of a particular chromosome, the *HH* chromosome, from 20-chromosome haploids and 40-chromosome nullisomics of the variety Holdfast. Thus the control of the diploid-like, bivalent-forming, meiotic regime in wheat can be ascribed to a gene-system on this chromosome.

Simultaneously, Sears and Okamoto[6] interpreted the high incidence of meiotic pairing in hybrids between *T. monococcum* and *T. aestivum* variety Chinese Spring, deficient for chromosome V, to mean that the regular meiotic behaviour of wheat was due to the activity of this chromosome.

The deficiency of the *HH* chromosome in nullisomics of Holdfast, and of chromosome V in nullisomics of Chinese Spring, results in equivalent modifications of external plant morphology. Also, both chromosomes are alike in structure, being among the largest in their respective complements, and having one arm more than twice the length of the other. Thus it seems likely that they are homologous, but for an understanding of the cytogenetic structure of wheat it is necessary to determine their exact relationships.

For this purpose hybrids were made between 41-chromosome plants of Holdfast, with the *HH* chromosome monosomic, and plants of Chinese Spring in which chromosome V was represented by a pair of telocentrics for the long arm and the other arm was completely deficient. At meiosis, the 41-chromosome hybrids, which had not received the unpaired *HH* chromosome from Holdfast, had 20 normal bivalents, and the telocentric of chromosome V, from Chinese Spring, was a univalent. Consequently, V and *HH* must be fully homologous chromosomes and investigation of the two varieties concerned has revealed the same genetic control of meiosis.

Since the absence of chromosome V results in homœologous pairing, there is evidently no independent control, on any other chromosome, capable of causing the meiotic isolation of chromosomes of the different basic diploid sets. However, it might have been that the gene on chromosome V was part of a complementary system, the removal of any part of which would result in the breakdown of the normal regulation of meiosis. To test this a series of 21 wheat – rye hybrids was made in which hybrids were deficient, in turn, for each of the 21 chromosomes of wheat. The hybrids were produced by pollinating with rye (*Secale cereale* $2n = 14$) the 21 lines of Chinese Spring wheat which were monosomic for chromosomes I–XXI. Use was made of the 27-chromosome hybrids to which the chromosome which was unpaired in the monosomic wheat parent had not been transmitted.

Table 1. MEAN CHROMOSOME PAIRING AT FIRST METAPHASE OF MEIOSIS IN NORMAL HYBRIDS OF *T. aestivum* × *S. cereale* AND IN THE 21 HYBRIDS DEFICIENT, IN TURN, FOR EACH WHEAT CHROMOSOME

Chromosome number	Chromosome deficient	Cells scored	Bivalents	Trivalents	Quad.
28	—	300	0·48 ± 0·0485	—	—
27	I	100	0·11 ± 0·0386	—	—
27	II	100	0·15 ± 0·0352	—	—
27	III	100	0·14 ± 0·0446	—	—
27	IV	100	0·37 ± 0·0684	0·01	—
27	V	200	3·36 ± 0·1591	0·88 ± 0·0326	0·08
27	VI	100	0·31 ± 0·0581	—	—
27	VII	100	0·40 ± 0·0685	—	—
27	VIII	100	0·32 ± 0·0584	0·01	—
27	IX	100	0·75 ± 0·0936	—	—
27	X	100	0·83 ± 0·0587	0·01	—
27	XI	100	0·06 ± 0·0239	—	—
27	XII	100	0·49 ± 0·0595	—	—
27	XIII	100	0·12 ± 0·0331	—	—
27	XIV	100	0·22 ± 0·0504	—	—
27	XV	100	0·71 ± 0·0808	—	—
27	XVI	100	1·00 ± 0·0885	0·04	—
27	XVII	100	0·77 ± 0·0925	—	—
27	XVIII	100	0·86 ± 0·0363	—	—
27	XIX	100	0·47 ± 0·0666	—	—
27	XX	100	0·23 ± 0·0428	—	—
27	XXI	100	0·29 ± 0·0478	—	—

Riley, Chapman and Kimber[7] have already shown that there is much higher pairing in wheat – rye hybrids, deficient in chromosome V, than in normal, euploid hybrids. The extra pairing results from homœologous associations within the wheat complement as well as from associations of wheat and rye chromosomes. It may, therefore, be expected that the absence from a wheat – rye hybrid of any other wheat chromosome, carrying a gene similar in effect to that on chromosome V, would cause similarly altered meiotic pairing.

First metaphase of meiosis was examined in 50 pollen mother cells from each of at least two plants of every type of chromosome-deficient hybrid, as well as in six euploid hybrid controls (Table 1). Hybrids deficient for chromosome V had much higher pairing than euploid hybrids, and higher pairing than hybrids deficient for any other chromosome. The mean number of trivalents in V-deficient hybrids exceeded the mean number of bivalents in most other lines, and the number of bivalents was more than three times greater in the absence of V than in any other condition. There can be no doubt that the deficiency of chromosome V is unique in its effect on meiotic behaviour, for the differences among all the other hybrids are of an order which may be ascribed to environmental effects.

Thus the meiotic isolation of corresponding chromosomes of the different genomes of wheat is due to the activity of chromosome V alone. It has also been shown that this activity is due to the long arm of the chromosome[5], but there is no evidence concerning the number of loci involved.

However, the localization is consistent with the notion that a single mutant gene, having the observed effect on meiosis, was selected because of its influence on fertility and genetic stability, early in the development of polyploidy in *Triticum*. The selection of a single powerful, cytologically stabilizing, mutant would presumably be rapid and efficient. By contrast, it is difficult to visualize the processes by which, as required by the discarded alternative hypothesis, a system of complementary genes controlling the diploid-like meiosis could have evolved. This would have required the independent selective incorporation of a number of mutually dependent genes, each of which was vital for the occurrence of regular meiotic behaviour with its attendant reproductive stability.

Nevertheless, genes other than the one at the critical locus on chromosome V must influence the meiotic behaviour of wheat, and some may modify in one direction or another the regular, bivalent-forming, pattern Meiosis in wheat is, therefore, delicately balanced between excessive pairing leading to multivalent formation and genetic instability, and failure of pairing, leading to univalent formation and aneuploidy. This balance has made possible the simultaneous occurrence of pronounced genetical triplication with high fertility and stable inheritance.

RALPH RILEY
VICTOR CHAPMAN
GORDON KIMBER

Plant Breeding Institute,
Cambridge.

[1] Sax, K., *Genetics*, 7, 513 (1922).
[2] McFadden, E. S., and Sears, E. R., *J. Hered.*, **37**, 81, 107 (1946).
[3] Riley, R., Unrau, J., and Chapman, V., *J. Hered.*, **49**, 91 (1958).
[4] Sears, E. R., *Res. Bull. Mo. Agric. Exp. Sta.*, **572** (1954).
[5] Riley, R., and Chapman, V., *Nature*, **182**, 713 (1958).
[6] Sears, E. R., and Okamoto, M., Proc. Tenth Internat. Cong. Genet., **2**, 258 (1958).
[7] Riley, R., Chapman, V., and Kimber, G., *Nature*, **183**, 1244 (1959)

Experimentally Induced Inter-bivalent Redistribution of Chiasmata in *Delphinium*

THE non-random distribution of chiasmata in a bivalent due to the occurrence of interference is well known. It has been suggested by some authors that the inter-bivalent distribution of chiasmata may also not be independently determined. Correlation studies on chiasma frequencies have demonstrated competition for chiasmata between bivalents in some organisms but not in others[1,2]. In the course of investigations on the cytogenetic effects of ionizing radiations on plants, we have been able to affect changes of chiasma frequency in one group of chromosomes in the nucleus and observe the reaction of the other group to this experimentally induced condition.

Dry seeds of *Delphinium ajacis* variety 'Comet' were irradiated with an X-ray dose of 15,000 r. (50 kV.). The X_1 plants raised from these showed certain cytological characteristics which appeared to be of interest. Apart from gross structural changes in the chromosomes of some of the plants which indicate interchange multiple associations, several others were characterized by disturbed chromosome pairing and chiasma frequencies. Observations on the control plants show that eight bivalents are regularly formed in most of their pollen mother-cells, a few of the cells showing seven pairs and two univalents. Since two of the eight chromosome pairs are considerably larger than others, they can be easily identified, and they appear mostly as ring bivalents at metaphase with two terminal or sub-terminal chiasmata; the remaining six smaller pairs appear in most pollen mother-cells as one ring, and five rods or all rods, each with a sub-terminal or nearly terminal chiasma. The two univalents whenever present are members of one of the smaller pairs of chromosomes.

The plants from the seeds treated with radiation differ from the controls in having two or more univalents present in many of their pollen mother-cells. Both the large and the small group chromosomes may appear as univalents, quite often in the same pollen mother-cell; their number varies from plant to plant as shown in Table 1. Also shown are observations on each of the 5 control and 9 X_1 plants with regard to the mean number of ring bivalents found in their pollen mother-cells. The proportion of rings formed by the large and small chromosomes respectively has been indicated separately.

The results for X_1 plants have been arranged in an order which helps to emphasize the relationship that appears to exist between the frequencies of the large and the small ring bivalents. The results show clearly that as the frequency of ring bivalents formed by the large chromosomes is reduced due to their occurrence as univalents or rod bivalents, the frequency of such configurations formed by the smaller chromosomes is either increased significantly beyond the level in the control material, as in plants 4, 6 and 11, or is maintained at a similar level, as in plants 7, 8 and 9, in spite of the fact that a number of small chromosomes also appear as univalents. In some of these plants it is quite common to find pollen mother-cells in which the two large ring bivalents were replaced by a similar number of small ring bivalents. The only exception is provided by plant 12, in which the frequencies of both the large and the small rings are reduced.

Although both chromosome pairing as well as chiasma formation and terminalization are known to be genotypically controlled, it is obvious that neither

Table 1. MEAN FREQUENCIES OF UNIVALENTS AND RING BIVALENTS IN THE CONTROL AND X_1 PLANTS

Plant No.	No. of pollen mother-cells	Frequency of univalents: Mean No. of univalents per cell	Frequency of univalents: Percentage of small univalents	Mean percentage chromosome pairs as: Large ring bivalents	Mean percentage chromosome pairs as: Small ring bivalents
Controls (C)					
1	20	—	—	20·00	9·88
2	25	—	—	22 00	9 50
3	25	—	—	21·50	6·50 } $\bar{C}$ = 7 48 ± 0 955
4	25	—	—	23·50	5·50
5	25	—	—	23·50	6·50
Treated (T)					
4	25	10·48	67 18	1·50	17·00
11	18	3·33	60·00	5·50	11·75 } $\bar{T}$ = 14 25 ± 1 234
6	25	2·40	16·67	10·50	14·00
12	14	3·14	77·28	10·71	3·57
9	24	2·00	100·00	14·49	7 99
8	20	2·00	100·00	15·62	7·50
7	14	2 00	100·00	17·00	5·87
13	15	2·40	94·45	20·00	3·25
10	20	2·00	100·00	20·00	1·25

$$\bar{T} - \bar{C} = D$$

$$t = \frac{D}{S.E.(D)} = \frac{6{\cdot}77}{1{\cdot}56} = 4\ 34^{**}$$

the occurrence of univalents nor the changes in chiasma frequency in the plants from X-irradiated seeds are genetically determined. Not only do the univalents occur in most of the X_1 plants but also their frequency shows great variation; and the smaller chromosomes, which outnumber the larger ones, are affected more often as would be expected on a random basis. It may be supposed that the X-irradiation of seeds induces structural changes in a number of chromosomes at random, affecting their pairing at pachytene and formation of chiasmata. The re-distribution of chiasmata described above occurs probably in those plants in which a number of smaller chromosomes have escaped damage.

The non-random distribution of chiasmata, for which evidence has been presented here, emphasizes the co-ordination existing in the control of chiasma formation in different chromosomes in the nucleus. How this control is exercised is not very evident. The chromosome changes induced by radiation, which result in the re-distribution of chiasmata, also stress the evolutionary significance of spontaneously occurring structural changes of chromosomes. Not only may many of these changes give rise to new variation by producing effects which simulate point mutations, but also they may release latent variability through re-distribution of points of crossing-over. The importance of such re-distribution resulting from a different kind of agency, in relation to natural selection, has been discussed by Mather and Harrison[4].

We are grateful to Dr. B. P. Pal and Dr. A. B. Joshi for their interest and encouragement. Thanks are also due to Dr. M. S. Swaminathan for discussing the results with us.

H. K. JAIN
A. K. BOSE

Division of Botany,
Indian Agricultural Research Institute,
New Delhi.

[1] Mather, K., *Proc. Roy. Soc.*, **120**, 208 (1936).
[2] Prakken, R., *Hereditas*, **29**, 475 (1943).
[3] Rees, H., *Heredity*, **9**, 93 (1955).
[4] Mather, K., and Harrison, B. J., *Heredity*, **3**, 1 (1949).

VIROLOGY

Somatic Antigen 15 as a Precursor of Antigen 34 in *Salmonella*

PHAGE ε^{34} is a temperate phage produced by group E_3 *Salmonellae* with O antigens (3), (15), 34 and capable of converting group E_2 *Salmonella* (O antigens 3, 15) to group E_3 *Salmonella* (O antigens (3), (15), 34) by lysogenization[1–5]. The formation of antigen 34 is accompanied by partial loss of antigens 3 and 15[5], suggesting a close relationship between antigens 34 and 3 or 15. The experiments described here indicate that antigen 15 is a precursor of antigen 34.

Group E_1 *Salmonellae* with O antigens 3, 10 do not adsorb phage ε^{34}. However, the possibility of infecting group E_1 cells directly with phage ε^{34} is suggested by the experiments of Uetake, Luria and Burrous[6]. They reported that when *Salmonella anatum* (group E_1, O antigens 3, 10) is infected with phage ε^{15}, antigen 15 and receptors for phage ε^{34} appear within a few minutes, the cells which survive infection segregate phage-carrier and non-carrier cells in their progeny, and in the non-carrier segregants the changes in antigenic structure and in phage receptors initiated by phage infection persist for several generations. Therefore, if the non-carrier progenies with receptors for ε^{34} are infected with ε^{34}, *S. anatum* might probably be lysogenized with ε^{34} without carrying ε^{15}. This proved true in the following experiments.

Cells of *S. anatum* were infected with phage ε^{15} at a multiplicity of 3·6, and progenies of the cells, which survived infection with ε^{15}, were infected with another phage ε^{34} 3 hr. after ε^{15}-infection, at which time about 90 per cent of cells were not carrying ε^{15}. Approximately 87 per cent of cells survived infection with ε^{34}. Among the survivors, 82 per cent proved to produce ε^{34}, but most of them not to produce ε^{15} by replica plating[6,7]. By agglutination and absorption tests these ε^{34}-producing cells ($= A(\varepsilon^{34})$) proved to possess somatic antigen 3, 10, the same structure as that of *S. anatum*. Most important is that they do not possess antigen 34. They are sensitive to phage ε^{15} and its mutants, while they adsorb neither phage ε^{34} nor its mutants, being similar to *S. anatum*. The only difference from *S. anatum* is in resistance to phage C_{341} to which *S. anatum* is sensitive, although $A(\varepsilon^{34})$ cells still adsorb phage C_{341} at an adsorption-rate constant of $3 \cdot 1 \times 10^{-9}$ ml. per min. (Table 1). When $A(\varepsilon^{34})$ cells were infected with ε^{15}, both antigens 15 and 34 appeared within several minutes in infected cells.

Among the above, most remarkable are the findings that $A(\varepsilon^{34})$ cells do not form antigen 34 irrespective of presence of prophage ε^{34}, which always leads to the formation of antigen 34 when it infects 3, 15 cells of group E_2, and that antigen 34 appears when $A(\varepsilon^{34})$ cells form antigen 15 by infection with phage ε^{15}. These observations, together with Nakagawa's finding[5] mentioned above, indicate that the formation of antigen 15, at least partially, is a necessary prerequisite for the formation of antigen 34. Antigen 3 is also partially lost when 3, 15 cells are converted to (3), (15), 34 by lysogenization with ε^{34}; but it does not seem to be necessary for the formation of antigen

Table 1

Bacterial strain	Sensitivity to phage (/ml.)												O antigens
	ε^{15}			ε^{y}			C_{341}			ε^{34}vir			
	10^{10}	10^{7}	10^{4}	10^{10}	10^{7}	10^{4}	10^{10}	10^{7}	10^{4}	10^{10}	10^{7}	10^{4}	
$A(\varepsilon^{34})$	+	+	+	+	+	+	(+)	−	−	−	−	−	3, 10
A	+	+	+	+	+	+	+	+	+	−	−	−	3, 10
$A(\varepsilon^{15})$	−	−	−	−	−	−	−	−	−	+	+	+	3, 15
$A(\varepsilon^{15}, \varepsilon^{34})$	−	−	−	−	−	−	−	−	−	−	−	−	(3), (15), 34

Phage sensitivity was examined by spot test. ε^{y} is a mutant of ε^{15}. As to the phages C_{341} and ε^{34}vir, refer to Uetake *et al* (ref. 6). +, lysis −, no lysis; (+), abnormal lysis.

34, since antigen 3 of *S. anatum* is identical with that of group E_2 cells or of $A(\varepsilon^{15})$ cells but there is neither formation of antigen 34 nor loss of antigen 3 in $A(\varepsilon^{34})$.

Hisao Uetake
Shin Hagiwara

Department of Microbiology,
Sapporo Medical College,
Sapporo.

[1] Uetake, H., Proc. Intern. Genetics Symposia, Tokyo, 645 (1956).
[2] Uetake, H., *Nisshin-Igaku*, **44**, 66 (1957) (in Japanese).
[3] Harada, K., *Virus*, 6, 285, 300 (1956) (in Japanese).
[4] Nakagawa, A., *Jap. J. Bacteriol.*, 12, 47, 107 (1957) (in Japanese).
[5] Nakagawa, A., *Jap. J. Bacteriol.*, 14, 693 (1959) (in Japanese).
[6] Uetake, H., Luria, S. E., and Burrous, J. W., *Virol.*, 5, 68 (1958).
[7] Hagiwara, S , *J. Virol.* (in the press) (in Japanese).

Virus Release from Single Cells of Mouse Parotid Tumours

In vitro studies have shown that cells from polyoma-induced mouse tumours in mass culture can release virus, and that the release can vary in different tumours[1,2]. One of the factors responsible for this difference in release is the proportion of virus-releasing cells as measured by plating the tumour cells on mouse embryo monolayers, and determining the relationship between the number of tumour cells plated and the number of plaques[2]. The present communication is concerned with a study on single cells from mouse parotid tumours grown in microdrops, in order to obtain information on: (*a*) the proportion of cells releasing virus by plating in microdrops, and (*b*) the virus release per cell.

The parotid tumours were induced by inoculation of polyoma virus into 2- or 3-day old mice, and the tumour cells were dispersed by trypsinization with a 0·25 per cent trypsin solution (trypsin 1–300). Virus release per cell was tested either by seeding the cells directly in microdrops, or by seeding in microdrops cells that had been in mass culture. In all cases, the medium consisted of 0 5 per cent lactalbumin hydrolysate in Earle's saline and 20 per cent horse serum.

Cell suspensions were diluted in medium to about 10^3 cells in a 50-mm. Petri dish, and these were then used for the single cell seedings. The single cells were distributed freehand in microdrops with micropipettes under a dissecting microscope in an enclosed box, maintained at 37° C., with a humidified atmosphere containing 10 per cent carbon dioxide. The microdrops were made in 50-mm. Petri dishes under silicone fluid (Dow "Corning 200')[3], and the Petri dishes with microdrops were kept in an incubator with a humidified atmosphere containing 10 per cent carbon dioxide. The presence of only a single cell in each microdrop was checked by observation with an inverted phase-contrast microscope.

For collecting the samples, each drop was sucked up with a micropipette, and the cell was then washed twice with new medium. The complete sample per cell thus consisted of three drops, which were added to 0 2 ml. of medium. The samples did not include cell-associated virus. When cells were tested after they had been in mass culture (5 × 10^5 cells seeded in a 50-mm. Petri dish) the cultures were washed twice with medium and the cells removed from the glass by trypsinization with a 0·25 per cent trypsin solution for 10 min. at 37° C. Not all the cells came off the glass by this procedure, and only those that were detached after 10 min. trypsinization were used for the microdrops. The samples collected from th single cells were tested for plaque-forming units o mouse embryo monolayers as described previously The number of plaque-forming units was read at 1 days after inoculation of the monolayers, and in th case of *MP*12 again at 16 days.

The proportion of single cells, from 6 paroti tumours, releasing virus under these conditions shown in Table 1. Cells from two of these tumou were tested without previous mass culture, and th samples were taken at periods of 28–80 hr. afte seeding the single cells. The highest proportion o releasing cells, 9/19, was found in tumour *MP*2 and this tumour had also given the highest releas by cells in mass culture (hæmagglutination titre o 2,048 per ml. on the day equivalent to that used fo sampling from microdrops). In the other five tumours virus release was detected in only 3 out of 172 cell tested. None of the single tumour cells was seen t divide under these conditions.

Table 1. Proportion of Single Cells from Six Mouse Paroti Tumours releasing Virus in Microdrops

Tumour	Strain of mouse	No. of days in mass culture	No. of cells tested	No. of cells releasing virus	Release period (hr)
*MP*4	*AKR*	0	16	1	72
*MP*8	*AKR*	0	13	0	80
*MP*2	*AKR*	2	19	9	28
*MP*12	*DBA*/2	3	26	1	28
*MP*13	*SWR*	4	76	1	36 and 72
*MP*14	*SWR*	4	41	0	36 and 72

Total No. of cells tested, 191; total No. of cells releasing virus, 12

The number of plaque-forming units released pe cell in tumour *MP*2 during a 28-hr. release period is shown in Table 2. The release varied from 0 to 9 plaque-forming units per cell with an average of 5 for the virus-releasing cells. This figure is similar to that reported for the Rous chicken sarcoma[5], and whether parotid tumour cells have a regular release per day is now being tested. The release from the other 3 positive cells (Table 1) in 3 other tumours were 17 plaque-forming units in *MP*4, 4 in *MP*12, and 2 in *MP*13.

Table 2. Virus Release from Single Cells in Microdrops durin a 28-hr. Period

No. of plaque-forming units per cell	0	1	2	3	4	5	6	7	8	9
No. of cells	10	0	1	2	2	1	1	1	0	1

No. of cells releasing virus, 9/19, average release of virus releasing cells, 5 plaque-forming units.

The above results provide further information on the existence of a difference in virus release from different tumours, and they also show that under the conditions of these tests in microdrops, single cells from polyoma-induced parotid tumours have at most only a low virus release per day.

We are indebted to the David Josephine and Winfield Baird Foundation for a grant in support of this work.

Mathilde Krim
Leo Sachs

Department of Experimental Biology,
Weizmann Institute of Science,
Rehovoth, Israel.

[1] Sachs, L., Fogel, M., Winocour, E., Heller, E., Medina, D., and Krim, M., *Brit. J. Cancer*, **13**, 251 (1959).
[2] Sachs, L., and Winocour, E., *Nature*, **184**, 1762 (1959).
[3] Lwoff, A., Dulbecco, R., Vogt, M., and Lwoff, M., *Virology*, 1, 128 (1955).
[4] Winocour, E., and Sachs, L., *Virology*, **8**, 397 (1959).
[5] Rubin, H., *Ann. N.Y. Acad. Sci.*, **68**, Art. 2. 459 (1957).

FORTHCOMING EVENTS

Wednesday, April 20

OYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, .7), at 5 p.m.—Annual General Meeting. Dr. J. M. Stagg: Presiaal Address.

ACULTY OF THE HISTORY OF MEDICINE AND PHARMACY (at the shipful Society of Apothecaries of London, Black Friars Lane, don, E.C.4), at 5.30 p.m.—Sir John Charles, K.C.B. "Roger m on the Errors of Physicians" (The Gideon Delaune Lecture).

Wednesday, April 20—Thursday, April 21

OIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the re Memorial Hall, Church House, Westminster, London, S.W.1), 0 a.m. daily—Symposium on "Advances in the Chemical Analysis oils, Fertilizers and Plants".

Thursday, April 21

STITUTION OF MINING AND METALLURGY (at the Geological ety, Burlington House, Piccadilly, London, W.1), at 5 p.m.— A. R. Gibson and Mr. J. R. Chalkley: "Production of Thorium al"; Prof. H. Borchert: "Genesis of Marine Sedimentary Iron s".

INNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, don, W.1), at 5 p.m. Mr R. I. Currie, Dr. D. H. Cushing and G. E. Fogg: "Productivity of the Sea".

ONDON MATHEMATICAL SOCIETY (at the Royal Astronomical ety, Burlington House, Piccadilly, London, W.1), at 5 p.m.— . E. Artin "On a Theorem of Gelfand with Applications to mber Theory".

HYSICAL SOCIETY, ACOUSTICS GROUP (in the Physics Department, erial College of Science and Technology, Imperial Institute Road, don, S.W.7), at 5.30 p.m.—Annual General Meeting, followed by R. S. Forster: "Noise—Legal Control".

OYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical gineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m. r. J. E. Allen: "On Reducing Costs of Space Research".

OCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at 14 Belgrave are, London, S.W.1), at 6 p.m.—Annual General Meeting, followed Mr. D. H. Collins: "Electrode Processes in Primary Batteries"

RITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at London School of Hygiene and Tropical Medicine, Keppel Street, wer Street, London, W.C.1), at 6.30 p.m. Dr. J. G. Nicholls: erve Impulses from Stretch Receptors in Muscle".

OYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson use, 26 Portland Place, London, W.1), at 7.30 p.m.—Scientific pers.

Thursday, April 21—Friday, April 22

FERTILIZER SOCIETY AND SOCIETY FOR ANALYTICAL CHEMISTRY Church House, Westminster, London, S.W.1), at 2.45 p.m. on ursday and 9.15 a.m. on Friday—Symposium on "Fertiliser alysis".

LANT PHENOLICS GROUP (at Shoreditch College, Egham, Surrey) ymposium on "Current Chemical Research on Plant Phenolics".

Friday, April 22

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, ndon, W.1), at 4.15 p.m.—Discussion of papers. Chairman: Dr. Stoneley, F.R.S.

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. George L. nssen and Mr. Richard W. James: "The Economics of Ship outing".

NSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION ROLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion "Broadening University Courses", opened by Prof. H. E. M. rlow.

ROYAL AERONAUTICAL SOCIETY, AGRICULTURAL AVIATION GROUP 4 Hamilton Place, London, W.1), at 7 p.m.—Meeting on "Pilot aining".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, ndon, W.1), at 7.30 p.m.—Discussion Meeting on "Unconventional rms of Energy". Chairman: Prof. Pierre Auger. Speakers Prof. Sambursky, Mr. P. D. Dunn and Prof. M. W. Thring.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or fore the dates mentioned:

DEPUTY LIBRARIAN (with a good honours degree and administrative perience in a library) OF THE BROTHERTON LIBRARY—The Regisr, The University, Leeds (April 21).

ASSISTANT EXPERIMENTAL OFFICER (with a degree in science or rticulture) IN THE ENTOMOLOGY SECTION; and an ASSISTANT XPERIMENTAL OFFICER (with a degree or higher national certificate) THE CHEMISTRY SECTION—The Secretary, National Vegetable search Station, Wellesbourne, Warwick (April 28).

ASSISTANT, Grade B (with a good honours degree and preferably me teaching experience) IN CHEMISTRY at Brighton Technical llege, to teach general chemistry up to G.C.E. (Advanced Level) standard and to assist with the teaching of inorganic chemistry at degree level—The Director of Education, 54 Old Steine, Brighton (April 23)

EXPERIMENTAL OFFICER (with at least a pass degree or equivalent, and preferably considerable experience in a biochemical or pharmacological laboratory)—The Secretary, Institute of Animal Physiology, Babraham, Cambridge (April 23).

ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, The University, Sheffield (April 25).

LECTURER (with a university degree in mechanical or chemical engineering or equivalent qualifications) IN CHEMICAL ENGINEERING —The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (April 25).

TECHNICAL ASSISTANT (with some knowledge of zoology), for culture work in protozoan research—Dr. E. M. Brown, Department of Zoology, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (April 25).

ASSISTANT ANALYST (member of the Royal Institute of Chemistry and practical experience in the examination of water samples)—The Public Analyst, City of Leicester Health Department, 7 Salisbury Road, Leicester (April 26).

SENIOR SCIENTIFIC OFFICER (with an honours degree in microbiology or in agricultural science, and postgraduate experience in food bacteriology, preferably in eggs and egg products) IN THE AGRICULTURAL BACTERIOLOGY DIVISION, Ministry of Agriculture—The Secretary, Civil Service Commission, Stormont, Belfast 4 (April 26).

SENIOR LECTURER or LECTURER IN PHILOSOPHY; and a SENIOR LECTURER or LECTURER IN AGRICULTURAL CHEMISTRY at the University of Khartoum—The Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 27).

ASSISTANT (biochemist, with a first- or second-class honours degree) IN BACTERIOLOGY at the Western Infirmary—The Secretary of University Court, The University, Glasgow (April 30).

ASSISTANT IN THE DEPARTMENT OF CHEMISTRY—The Secretary, The University, Edinburgh (April 30).

ASSISTANT INSPECTOR (HORTICULTURE) (man or woman at least 25 on May 1, 1960, with a degree or diploma in horticulture and at least five years appropriate practical experience, and able to drive a car)—Department of Agriculture and Fisheries for Scotland, Room 266, St. Andrew's House, Edinburgh 1 (April 30).

ASSISTANT LECTURER IN CROP PRODUCTION; and an ASSISTANT LECTURER IN ANIMAL PRODUCTION, with special reference to Dairy Production—The Registrar, Wye College (University of London), near Ashford, Kent (April 30).

LECTURER (with a degree in engineering and Corporate Member of the appropriate professional institution) IN ELECTRICAL ENGINEERING at the Royal Technical College of East Africa, Nairobi—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (April 30).

LECTURER (with a veterinary, medical or science degree) IN VETERINARY PHYSIOLOGY—The Secretary of University Court, The University, Glasgow (April 30).

LECTURER or ASSISTANT LECTURER IN MATHEMATICAL STATISTICS, and a LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS —The Secretary, The University, Exeter (April 30).

LECTURERS (3) IN PHARMACEUTICAL CHEMISTRY at the Nigerian College of Arts, Science and Technology, Ibadan—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (April 30).

STATISTICIAN (Scientific Officer or Senior Scientific Officer), to be responsible for advising on statistical aspects of (*a*) the design and interpretation of environmental surveys of radioactive substances in human diet and agricultural materials; and (*b*) a programme of laboratory and field experiments in soil science and plant physiology —The Secretary, Agricultural Research Council, Radiobiological Laboratory, Letcombe Regis, near Wantage, Berks (April 30).

ASSISTANT (medical, veterinary or science graduate with B.Sc. (Hons.) in pharmacology or physiology) IN THE DEPARTMENT OF PHARMACOLOGY—The Secretary, Department of Pharmacology, University College, Merville Foster Avenue, Stillorgan, Dublin (May 1).

SENIOR LECTURER (registered medical graduate) IN ANATOMY— The Secretary of University Court, The University, Glasgow (May 1).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF GEOLOGY (with special reference to Economic Geology and Geophysics) —The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (May 7)

LECTURER or ASSISTANT LECTURER (with a degree in physiology or some related subject) IN PHYSIOLOGY; and a LECTURER or ASSISTANT LECTURER (with a degree in biochemistry or some related subject) IN BIOCHEMISTRY—The Registrar (Room 29, O.R.B.), The University, Reading (May 7).

SENIOR LECTURER or LECTURER (honours graduate in electrical engineering or physics and with suitable research and teaching experience in electronics and radio communication) IN ELECTRICAL ENGINEERING—Joint Clerk to the University Court, Queen's College (University of St. Andrews), Dundee (May 7).

ASSISTANT LECTURER (with a good honours degree in physics and preferably some interest in electronics) IN THE PHYSICS DEPARTMENT —The Dean, Guy's Hospital Medical School, London, S.E.1 (May 9).

ASSISTANT LECTURER (with special qualifications in pure mathematics) IN MATHEMATICS—The Registrar (Room 29, O.R.B.), The University, Reading (May 9).

RESEARCH FELLOW IN THE CHEMISTRY DEPARTMENT, for work on fundamental aspects of heterogeneous catalysis, in collaboration with Dr. G. C. Bond—The Professor of Chemistry, The University, Hull (May 9).

EDWARD A. DEEDS FELLOW (man or woman), for research in Engineering, Metallurgy, Chemistry, Physics, Mathematics or any cognate subject—Joint Clerk to the University Court, Queen's College (University of St. Andrews), Dundee (May 10).

LECTURER/SENIOR LECTURER IN NUTRITION at the University of New England, Australia, to undertake teaching and research in Livestock Nutrition in the Department of Nutrition and Chemical Pathology—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, May 13).

Bowman Chair of Physiology—The Registrar, The University, Edgbaston, Birmingham 15 (May 14).

Chamber of Manufactures Chair of Physics in the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (May 15).

Lecturer or Assistant Lecturer in Botany at the University of Malaya (Singapore Division)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 15).

Lecturer (with special qualifications and experience in the food industry (other than the dairy industry) or in biochemical engineering) in Food Science—The Registrar (Room 22, O.R.B), The University, Reading (May 16).

Assistant Lecturer or Lecturer in the Department of Histology—The Registrar, The University, Liverpool, quoting Ref. CV/N (May 21).

Lecturer (graduate in engineering, with an interest in the application to agricultural operations of electronic and other control methods) in Farm Mechanization (Electrical Engineering)—The Registrar (Room 29, O.R.B.), The University, Reading (May 21).

Elder Chair of Physics in the University of Adelaide—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 31).

Reader or Senior Lecturer (with appropriate qualifications and experience needed to take charge of the newly established Statistics Unit) in Statistics at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong and London, May 31).

Assistant Lecturer (with a Ph.D. in microbiology and research experience in this field) in the Department of Industrial Microbiology—Prof. E. Kuster, Department of Industrial Microbiology, University College, Ardmore House, Stillorgan Road, Dublin.

Astronomer (Senior Assistant) (with main interest in stellar astronomy)—The Director, Armagh Observatory, Armagh, Northern Ireland.

Demonstrator in Biochemistry—The Administrator, Department of Biochemistry, South Parks Road, Oxford.

Director (age 40–45, with a good degree or diploma in geology plus wide experience) of the Pakistan Geological Survey—The Recruitment Officer, Pakistan High Commission, 39 Lowndes Square, London, S.W.1.

Instructors or Assistant Professors (well-qualified candidates) in the Department of Chemistry—Prof. C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver 8, B.C., Canada.

Lecturers in the Mathematics Department—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

Research Assistant (chemistry graduate), to continue and extend a research project into the kinetics and mechanism of the reaction of sulphur monochloride with olefines—Head, National College of Rubber Technology, Northern Polytechnic, Holloway, London, N.7.

Research Fellow (Fellow of the Library Association)—The Secretary, Library Association, Chaucer House, Malet Place, London, W.C.1.

Senior Scientist (with experience in the use of radioactive isotopes for medical research), to organize an active research group and initiate a programme of fundamental research including the development of new clinical procedures—Dr. H. G. Thode, Vice-President, McMaster University, Hamilton, Ontario, Canada.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Coke and Chemistry, U.S.S.R., 1959, No. 8. (Organ of the State Scientific-Technical Committee of the Council of Ministers of the U.S.S.R.) (An English version of the monthly journal *Koks i Khimiya*, prepared by the Coal Tar Research Association, in collaboration with the British Coke Research Association.) Pp. 59. Annual subscription 105*s*. Single issues 20*s*. (Gomersal, Leeds: The Coal Tar Research Association, 1959.) [32

Department of Scientific and Industrial Research: Road Research Laboratory. Road Research Technical Paper No. 44: A Study of the Granulators used in the Production of Roadmaking Aggregates. By F. A. Shergold. Pp. v+70+8 plates. (London: H.M. Stationery Office, 1959.) 5*s*. 6*d*. net. [32

Platinum: Production and Price Policy. (An extract from a Statement by Mr. D. A. B. Watson, Chairman of Rustenburg Platinum Mines Limited.) Pp. 8. (London: Johnson, Matthey and Co. Ltd., 1959.) [32

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 1007, Vol. 252 (28 January 1960): The Absorption Spectrum of the Free NCO Radical. By R. N. Dixon. Pp. 165–192. 12*s*. No. 1008, Vol. 252 (28 January 1960): X-ray Studies of some Carbonized Coals. By R. Diamond. Pp. 193–228. 10*s*. (London: Royal Society, 1960.) [32

Association of Universities of the British Commonwealth. Report of the Executive Council, together with the Accounts of the Association for the year 1st August, 1958, to 31st July, 1959. Pp. 28. (London: Association of Universities of the British Commonwealth, 1959.) [42

The Manchester Public Libraries. The 107th Annual Report of the Libraries Committee, 1958–1959. Pp. 28+4 plates. (Manchester: Manchester Public Libraries, 1960.) [42

Production Engineering Research Association of Great Britain. PERA Report No. 13: Tapping, Part 1: Relationship between Core Hole Size, Tapping Torque and Thread Strength. Pp. 12. (Melton Mowbray: Production Engineering Research Association of Great Britain, 1959.) [42

United Kingdom Atomic Energy Authority: Research Gro Report AERE-R3127: Radiostrontium and Radiocaesium in Drink Water in the United Kingdom—Results up to Mid 1959. By R. Crooks, R. G. D Osmond, M. J. Owers, Miss E. M. R. Fisher and T. Evett. Pp. 8. (London: H.M. Stationery Office, 1959.) 1*s*. 9*d*. net.

Other Countries

Bulletins de la Société Royale de Zoologie d'Anvers. No. 13: Reseau Arteriel Coronarien des Cervicornes. Par Pierre P. van Straeten. Pp. 27. No. 14: Sclerose et Atherosclerose du Res Arterial Coronarien chez des Mammiferes et Oiseaux Morts en Jar Zoologique. Par M. Vastesaeger, P. Gillot, R. Parmentier et J. M telmans. Thrombose Coronarienne Ayant Entraine la Mort chez Panda (Ailurus Fulgens). Par Marcel M. Vastesaeger, Paul E. Gi et J. Mortelmans. Pp. 55. (Anvers: Société Royal de Zoolc d'Anvers, 1959.)

Biochemical and Biophysical Research Communications, Vol. 1, Nc (July 1959). Published monthly. Pp. 44. Subscription rates: volume, 6 issues)—Institutional subscribers 12 dollars; 85*s*. Private subscribers certifying that the volume will be for personal only, 6.50 dollars; 46*s*. (New York and London: Academic Pr Inc., 1959.)

Publications of the United States Naval Observatory. Second Ser Vol 17, Part 6: Polarization of Starlight in the Galaxy. By Jc S Hall. Pp. iii+275–342+plates 4–6. (Washington, D.C.: Gove ment Printing Office, 1958.)

U.S. Department of Health, Education and Welfare: Public Hea Service. National Library of Medicine. *Index Medicus*, Vol. 1, Nc (January 1960). (Formerly *Current List of Medical Literature*.) 282. (Washington, D.C.: Government Printing Office, 1960.) 2 dollars.

Canada: Department of Mines and Technical Surveys. Geolog Survey of Canada. Bulletin 54: Helicopter Operations of the Gec gical Survey of Canada. By Officers of the Geological Survey of Cana Pp. xii+60+7 plates. (Ottawa: Queen's Printer, 1959.) 75 cents.

Canada: Department of Mines and Technical Surveys. Publicati of the Dominion Observatory, Ottawa. Vol. 22, No. 3: Bibliograp of Seismology, Items 10310–10513. January–June 1958. By W. E. Smith. Pp. 1+61–83. (Ottawa: Queen's Printer, 1959.) 25 cents.

United States Department of Agriculture: Agricultural Resea Service. Agricultural Information Bulletin No. 210: Availability Water to Crops on Saline Soils. By L. A. Richards. Pp. ii+10. (Wa ington, D.C.: Government Printing Office, 1959.) 10 cents.

Jamaica. Annual Report of the Ministry of Agriculture and La for the year ended 31st December, 1957. Pp. i+81. (Kingsto Government Printer, 1959.) 4*s*.

Ospedali d'Italia Chirurgia, Vol. 1, No. 1 (Novembre 1959). 188. Abbonamento annuo: Italia 6,000 lire (ordinari); 10,000 (sostenitori). Estero 18 dollars. Fascicolo separato: Italia 800 l Estero 2 dollars. (Firenze: *Ospedali d'Italia Chirurgia*, Edizi Scientifiche Salpietra, Via M. Buonarroti, 17, 1959.)

Ministére de l'Agriculture de la Province de Quebec. Le Conseil Recherches Agricoles. Recherches Agronomiques. Monographie No. Les Bacteries Lactiques et les Laits Fermentés. Par Prof. Édou Brochu, René Riel et Prof. Claude Vézina. Pp. xi+225. Somma des Résultats, 1957–1958. Pp. 63. (Quebec: Ministere de l'Agricult de la Province de Quebec, 1959.)

Rockefeller Foundation. The President's Review, including a Qu ter Century of the Natural Sciences. By Warren Weaver. (From Rockefeller Foundation Annual Report, 1958.) Pp. viii+168+ plates. (New York: Rockefeller Foundation, 1959.)

Au Service de l'Agriculture Congolaise. l'Institut National po l'Étude Agronomique du Congo Belge (INEAC). Son But, Son P gramme, Ses Réalisations. Cinquième édition. Pp. 168. (Bruxelle Institut National pour l'Étude Agronomique du Congo Belge, 1959.)

United States Department of Commerce: Coast and Geode Survey. Technical Bulletin No. 9: Gravity Measurement Operatic in the Field. By Lieut.-Commander Hal P. Demuth. Pp. ii+ (Washington, D.C.: Government Printing Office, 1959.) 15 cents.

National Science Foundation. Ninth Annual Report for the Fis Year ended June 30, 1959. Pp. xvii+274 (12 plates). (Washingt D.C.: Government Printing Office, 1960.) 1 dollar.

Danish Atomic Energy Commission. Report on the Activities the Danish Atomic Energy Commission for the period from 1 Ap 1958 to 31 March 1959. Pp. 85. (Copenhagen: Danish Atomic Ener Commission, 1959.)

Hamburger Sternwarte in Bergedorf. Jahresbericht fur das Ja 1958. Pp. 7. A Finding List of Stars of Spectral Type F2 and Earl in a North Galactic Pole Region. By Arne Slettebak and Jürgen Stoc Pp. 24. Warner and Swasey Observatory. Luminous Stars in t Northern Milky Way, 1. By J. Hardorp *et al*. Pp. 40. (Hambu Bergedorf: Hamburger Sternwarte, 1959.)

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare Londo

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Offic

THE BALANCE OF FUNDAMENTAL AND APPLIED RESEARCH

THE ninth annual report of the (U.S.) National Science Foundation (see p. 362 of this issue) is the first to appear since the appointment of Lord Hailsham as Minister for Science; and although there is no institution in the United Kingdom which corresponds to the Foundation, it may be taken for granted that Lord Hailsham is likely to consider very carefully activities on which, in two years, the United States has increased its expenditure from some 40 million dollars to nearly 140 million dollars. Some of this work is parallel with that of the Department of Scientific and Industrial Research in Great Britain; but the latter's expenditure of £500,000 in research grants and approaching £1 million on studentships and fellowships looks small against the National Science Foundation's awards of some 46 million dollars in grants for fundamental research, with nearly 16 million dollars more for research facilities and 13 million dollars in graduate fellowships. Moreover, it is clear from the foreword of its chairman, Dr. Detlev Bronk, that the Foundation is tending to assume functions that the University Grants Committee discharges in Britain and that, like that Committee, it is succeeding notably in strengthening the universities in their true functions of research and teaching without encroaching on their freedom.

Nor is this the only contribution to education which the National Science Foundation is making. It was already concerned with the quality and the extent of science teaching in the schools and in the universities of the United States before the National Defense Education Act of 1958 widened its responsibilities in this field, and in three years its expenditure for such purposes has more than trebled. On a much greater scale than the Department of Scientific and Industrial Research in Britain, it is concerned with the dissemination of scientific information, and the current report attests not so much the magnitude of the resources which are made available for such purposes in the United States as the vision and vigour with which these purposes are pursued by the National Science Foundation.

Probably to the British reader, however, the most suggestive part of the report is that which, following the stimulating statement of the director, Dr. A. T. Waterman, surveys the re-appraisal and re-organization of the status of science in the United States during 1958–59. In that section, as in Dr. Waterman's statement, the essential factors which determine the resources available for research and development and condition their deployment are shown, and it is possible to distinguish how far the institutions devised for one particular set of national circumstances react on those performing other functions. The National Science Foundation is an institution peculiar to the United States, and the fact that it performs certain functions, such as the award of fellowships or research grants or the administration of science fellowships for the North Atlantic Treaty Organization which in Britain are executed by the Department of Scientific and Industrial Research or the University Grants Committee, does not imply that either of these bodies should necessarily be modified on the model of the National Science Foundation. It does, however, suggest that the comparative scale or scope of operations might be studied.

Dr. Bronk stresses particularly the way in which, during the past ten years, the support of science has become generally recognized in the United States as a proper and necessary function of the Federal Government. This is attested by the increase, in that period, of the budget of the National Science Foundation from 3·5 to 155 million dollars, while at the same time the universities have been receiving more assistance than ever from individuals, private foundations and industry. If Dr. Bronk's assumption that the Foundation has stimulated this increased and more widespread support of science is sound, it may be worth while for the Minister for Science in Great Britain to consider rather closely exactly how the Foundation functions, more particularly since it is incontestable that the Foundation has notably succeeded in strengthening American universities without in any way encroaching on their prerogatives or deflecting their policies.

Dr. A. T. Waterman's statement, however, is designed to discourage any facile optimism. Science, he observes, is increasingly an instrument of both national and international policy, and for all that has been done, there is still in the United States an alarming dearth of trained teachers, especially for secondary schools, and no prospect that the requisite number will be forthcoming. Indeed, he suggests that the United States has not yet come to grips with the major problem; and his further comment that the cultivation and staffing of a professional group can be realized adequately only if the career is a rewarding one from the point of view of salary, prospects and prestige, as well as the deeper satisfactions that go with the opportunity to serve, is one that bears vitally on the recommendations of the Crowther Report. It is above all the supply of trained teachers that determines the practicability of raising the school-leaving age, and when full weight is given to the argument of the Crowther Committee in regard to timing, the urgency and priority lie on increasing the number of teachers.

Dr. Waterman makes a further comment on the man-power situation. In spite of the surveys made by the Advisory Council on Scientific Policy's Standing Committee on Scientific Man-power, the studies of the National Science Foundation provide the United States with considerably fuller information about the situation in the United States than is available about the position in Great Britain. About a quarter of American scientists and engineers are engaged in research and development, and Dr. Waterman points out that this pool of talent is the limiting factor in the national research and development effort, and its competence determines the effectiveness of the nation's undertakings. Its size and quality, moreover, are only increased or improved as a result of long-term operations, and there are definite limits to the extent to which the special skills and the fields that will be important in the future can be forecast.

This last is a factor to be weighed when considering whether or not to embark on new fields such as that of space research, and Dr. Waterman is emphatic as to the need for carefully selecting the fields of research, particularly in applied science, in which even a nation with such immense resources as those of the United States can wisely engage. He regards the establishment of priorities, particularly in fields involving highly expensive equipment or installations, as fundamentally a matter for Government; and it was for this purpose that the Federal Council on Science and Technology was recently established. The functions of that body correspond broadly with those of the Advisory Council on Scientific Policy in Britain, and it should be a first objective of the Minister for Science to see that the Advisory Council is effectively placed to co-ordinate the interests and responsibilities of the various Government bodies with research and development programmes, to identify research needs and to advise him on the more effective utilization of our scientific and technological resources and the planning and administration of the programmes needed.

What stands out particularly from the report of the National Science Foundation is the way in which the educational and research aspects are interlocked and co-ordinated policies are now being concerted. Dr. Waterman, for example, advocates a man-power policy which endeavours to identify talented students in order to ensure that those with aptitude for science and engineering receive the appropriate professional training, more especially in fundamental science. The close relation between teaching and research leads him to emphasize the economic limits on research, and the way in which fundamental research, on which the United States is spending only some 8 per cent of its total expenditure of 10,000 million dollars on research and development, is the main limiting factor on development. Dr. Waterman makes the further observation, which also Lord Hailsham should note, that failure to provide full support may seriously impair the effectiveness of a project.

Dr. Waterman's main argument is for more generous support of fundamental research in the United States and for a more careful scrutiny of the effort devoted to applied research. The question of priorities is equally important in Britain, though it may well be that it is the effort in applied research that should be increased. Be that as it may, it is as essential as in the United States that the programme that is evolved should be supported by an informed body of public opinion, and that the resources placed at its disposal should be adequate in the first instance and not liable to be curtailed from year to year.

This will become the more important if there is any considerable extension of the system of research institutes, to which Sir Harry Melville referred in an address on scientific research in British universities given at Newcastle upon Tyne on September 22. At present the system is limited to nuclear physics, where the Department of Scientific and Industrial Research has been financing in some six universities the construction and largely the maintenance of particle accelerators which are now housed, maintained and operated in a central institute or institutes for the benefit of more than one university, so as to facilitate economic operation, as has been done at the European Organization for Nuclear Research in Geneva. Similarly, the National Institute for Research in Nuclear Science, where a proton synchrotron of an energy of 7 GeV. is under construction, has not a wholly permanent staff, and its work derives inspiration from the university staff who work there.

Much has still to be done to work out the most satisfactory arrangements for such institutes, but Sir Harry Melville stated that about 27 per cent of university expenditure on research in the United States is used in this way, and that experience has established definite benefit to the universities from such an association. The mounting costs of research equipment may well encourage similar developments in other fields, and it is as desirable that the implications, administrative as well as financial, of such a system of special institutes in association with the universities should be fully examined before some urgent problem leads to the establishment of procedures that are unsound. The report "Strengthening American Science", issued in December 1958 by the President's Science Advisory Committee (see *Nature*, 183, 1215; 1959) showed that this and other problems of financing university research and the relations between Government and universities are receiving close attention in the United States by minds as sensitive to the essential issues as are the University Grants Committee and the Advisory Council on Scientific Policy in Britain.

On the balance of scientific research, the National Science Foundation indicates some important developments. The Foundation has now assumed responsibility for research on the modification of weather, and in March 1959 announced grants for this purpose totalling 1·13 million dollars. At the same time it announced the establishment of an Antarctic Research Programme to continue scientific activity based largely on certain programmes of the International Geophysical Year. There have also been calls from the scientific community for increased effort in particular critical fields. For example, a group on medical research has urged systematic increase in Federal support for medical research from 330 million dollars in 1957 to about 900 million dollars in 1970, with at least a doubling of the number of research workers. A Committee on Oceanography has recommended doubling the support of fundamental research in the marine sciences during the next ten years at a cost of a further 650 million dollars, about half of this coming through the National Science Foundation. A report on atmospheric research envisaged an institute established and operated by a university committee and financed through the National Science Foundation at a capital and operating cost over six years of some 70 million dollars, as well as further encouragement and support of research in atmospheric physics in existing university departments. President Eisenhower, moreover, has already recommended the financing by the Federal Government of the construction of a large new electron linear accelerator over six years at a cost of some 100 million dollars. The statement also recommended further support of research in high-energy physics by the Atomic Energy Commission, the National Science Foundation and the Department of Defense, and that support for the construction and operation of high-energy accelerators should be increased to 135 million dollars by 1963.

It is not only the scale of effort in the United States that is changing. The Federal organization to meet the scientific needs of the nation is more fluid, and proposals have been made for the creation of departments of science and technology or of science, and for a commission to examine such proposals. It appears, however, that such measures as the establishment of the Federal Council for Science and Technology and the appointment of Dr. W. R. Brode as science advisor to the Secretary of State, following the earlier appointment of a Special Assistant for Science and Technology to the President himself, have largely provided what is needed to support the National Science Foundation, and these arrangements should be given full opportunity to function before decisions are taken as to the need for, or value of, some further centralized agency. Dr. Brode has already expressed deep concern with these questions of organization, but while he is obviously not entirely satisfied that the recent changes provide all that the United States needs, he seems disposed to advocate further study of the organization of science and scientific policy rather than immediate action.

The two points in the work of the National Science Foundation that appear to deserve most careful attention in Britain are the work being done to extend and improve the quality of education in science and technology, and the means by which the balance of research is fostered or varied. On the first, it is not the scale of educational effort that should be noted: Sir Harry Melville has forecast expenditure by the Department of Scientific and Industrial Research on studentships and fellowships of £4 million or more in a few years, probably on some 3,000 awards, or 30–40 per cent of the present total number of research students in the universities, with a further £1–2 million on research grants. It is rather the other measures adopted by the Foundation to assist teachers of science and technology to improve their standard of teaching, to assist the schools to improve their equipment and particularly to make the studies of new techniques and methods of presentation, which could make even the existing supply of teachers more effective.

Here very little has yet been done. The National Science Foundation obviously has a considerable advantage in being able to undertake such studies side by side with its efforts to assist students to take up courses in science and technology and to undertake research; but the Minister for Science is well able to deal with the situation on appropriate lines in Britain. He has the authority to secure whatever co-ordination may be desirable between the work of the Agricultural Research Council, the Medical Research Council, the Overseas Research Council and the Department of Scientific and Industrial Research in such matters as the award of research grants, fellowships or studentships. Further, he would seem to be the most appropriate person to explore the possibility of increasing co-operation with industry and elsewhere.

Very great stress was laid on this by Sir Harry Melville from two points of view. First, Sir Harry emphasized the importance of increasing support for the universities of Britain from other sources so as to prevent their dependence on financial support from the State becoming overwhelming. At the same time, he is convinced that in carrying the main responsibility for fundamental research, the universities should also be responsible for seeing to its balance and the closing of any gaps that may occur. Secondly, he urged that multiple sources of support provided an insurance against mistaken decisions and the refusal of support to a worthy project. The soundness of that view is to be seen to some extent in the existence of differing opinions as to the importance and value of space research, and it might become more important as efforts are made to extend the amount of applied research undertaken in Britain.

Mr. Aubrey Jones, former Minister of Supply, has frankly advocated the establishment of a Minister for Technology rather than a Minister for Science, and rests his argument largely on the prospective reduction of defence expenditure relative to national income. He does not believe that, with defence expenditure little more than 7 per cent of the national income and the defence scientific effort approaching 50 per cent of the total scientific effort of Britain, the rate of technological advance is likely to be maintained. While he thinks that the economic burden of armaments is exaggerated, he suggests that a prime responsibility of the Minister for Science is to find a substitute for the technological role taken by armaments in a free society.

If this contention is sound, clearly the Defence Research Policy Committee and the Advisory Committee on Scientific Policy may require to work much more closely together. Here again it would seem that the Minister for Science is best placed to supply the necessary guidance and to deal with those factors, such as excessive secrecy and departmentation, which may hinder the free exchange of views and information. The problem of communication indeed requires to be attacked with far more energy, vision and urgency than is apparent in recent references to it in reports from the Advisory Council. There is indeed much to be done to prepare the way for the difficult decisions that cannot long be postponed regarding the balance of research effort, both fundamental and applied, in Britain; and the deployment of our trained man-power in defence, industry, teaching and elsewhere, and the measures to be taken to ensure that the supply is adequate in quality and in numbers. The National Science Foundation's report, although prepared mainly for American readers, indicates numerous points calling for fresh thought and even inquiry in Britain, and it is to be hoped that it will be carefully studied by the Minister for Science and his advisors, the Parliamentary and Scientific Committee and professional associations of scientists and technologists, who are able to assist in forming that intelligent public opinion required to sustain public policy.

APPLIED RADIATION CHEMISTRY

Chemische Reaktionen ionisierender Strahlen (Radiation Chemistry)

Herausgegeben von Prof. Hermann Mohler. Pp. 299. (Aarau und Frankfurt am Main: Verlag H. R. Sauerlander und Co., 1958.) 30.80 D.M.

A SIGNIFICANT diminution in the cost of atomic power could be achieved if the energy at present 'lost' as radiation were used to achieve large-scale chemical production or processing. In many countries, private and government laboratories exist to explore the possibilities of applied radiation chemistry, and already a number of processes have been, or are being, used commercially. Hitherto the use of radiation in the chemical industry has been very small, primarily because radiation merely generates in chemical systems reactive species such as ions and/or free radicals which in most cases can be produced in a more controlled manner by more conventional chemical means. This fact and certain inherent disadvantages in the use of radiation are likely to limit its successful application to fields where chemical methods are either non-existent or very difficult to apply. The book under review has been written in the belief that the time has now come when the chemical technologist should know something of the principles and applications of radiation chemistry.

The book originated in a course of lectures in the University of Basle in 1956, and some of the authors contributing to this book took part as lecturers. After a brief definition of the subject, the first half of the book is concerned with a discussion of the necessary background knowledge of radioactivity, followed by an account of radiation sources (parts of which read like a technical sales brochure) and dosimetry, with a minor chemical digression (pages 54–68) in which a sketchy account of some radiation chemical mechanisms is given. The latter part of the book deals with the interaction of radiation and matter and presents somewhat cursory accounts of selected radiation-induced reactions in solid, liquid and gaseous phases, and concludes with two chapters, rather surprisingly in English, entitled "The Effects of Atomic Radiation on Polymers" and "Radiation-induced Reactions of Potential Industrial Importance".

The book displays several of the disadvantages of composite authorship. For example, in the whole of the last chapter the phrase 'radiochemical reaction' is given a meaning quite different from that commonly accepted and from that carefully specified by the editor and writer of the introduction. Again, there is a great unevenness in level of treatment; the chapter on polymers, though by an expert, is almost at the level of popular science exposition, whereas that on dosimetry is a good deal more profound. These defects are minor in comparison with several distorted and often erroneous notions about radiation chemistry which the book contains. The stated origin of the hydroxyl radicals in irradiated water (p. 63), the mechanism of formation of H_3O^+ on electron impact on water vapour (Table 4·08, p. 194), and the mechanism of the reduction of ceric ions (p. 152), all contain inexcusable errors which are not printing slips. The complete omission of ion-molecule reactions and the inadequate treatment of the competition between diffusion and combination of radicals, both matters of central importance, are serious deficiencies. When one reads phrases such as the following about the oxidation of sulphur dioxide by oxygen in aqueous solution, "Attention will have to be given to the effect of trace metals, for example, iron and copper, on the reaction" (p. 251), or "There is no published information to indicate to what extent chain reactions play a part" (p. 249), one marvels how the author of this chapter can have overlooked the classical works of Bäckström and others. Any chemist or chemical technologist using the Fricke dosimeter to determine doses or dose-rate who uses the *G* values for this system given on pages 156 and 161 must be content with values which will be 6–7 per cent too high.

Apart from the dropping of an 'h' from Shrivenham, the book is well printed and produced.

F. S. DAINTON

THE THEORY OF DAMS

The Theory of Storage

By Prof. P. A. P. Moran. (Methuen's Monographs on Applied Probability and Statistics.) Pp. 111. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1959.) 13*s*. 6*d*. net.

MANY of the individual problems of applied probability have a very respectable antiquity; thus queueing theory began with Erlang in 1908, what we now call birth-and-death processes were first studied by Galton and Watson in 1873, and the use of probabilistic models in physics and astronomy can be traced back to much earlier dates than these. But it was not (in Great Britain at least) until just after the Second World War that the full range of possibilities was widely recognized; during the past fifteen years the subject of applied probability has grown to such an extent that it now rivals in importance its elder sister, the statistics of experimentation. That the publishers of this new series of monographs recognize this fact is clearly shown by the general title which they have given to the series, by the individual titles of the five volumes so far announced (only one of these is concerned with statistics as ordinarily understood), and by their happy choice of Prof. M. S. Bartlett as general editor of the series.

In the monograph reviewed here Prof. P. A. P. Moran of the Australian National University, Canberra, writes on the theory of storage systems in which either the input or the output is of stochastic character. Most space is given to problems of the first type ("The Theory of Dams"); here a random input of water feeds a reservoir or a system of reservoirs subject to overflow and release rules of various types, and one is interested both in the conditions for statistical equilibrium and the statistical distributions which characterize it, and also in transient phenomena such as the risk that the reservoir will run dry within a given time period when the initial conditions are known. This is a very recent branch of applied probability, and can be said to be Prof. Moran's peculiar creation, for apart from some exceedingly interesting pioneer work by Hurst practically all the mathematical papers devoted to the subject have been written by Moran himself or by those influenced by him. The programme of research opened up by Moran in 1954 is still very far from complete; much more remains to be done on systems with a (random) continuous input, very little is known yet about the behaviour of networks of reservoirs, and a satisfactory treatment of correlated inputs is still lacking (as it is also in queueing theory, although recent work by Dagnall, Winsten, and Wishart has shown that significant progress can be made if the problem is suitably formulated). Those familiar with the earlier literature will be very grateful to the author for this timely survey of what has been done and of what remains to be done; others will be equally grateful for the possibility which this book offers them of joining in a very active programme of research.

D. G. Kendall

QUANTUM EFFECTS ON A MACROSCOPIC SCALE

Liquid Helium

By Prof. K. R. Atkins. (Cambridge Monographs on Physics.) Pp. x+312. (Cambridge: At the University Press, 1959.) 60*s*. net.

The strange behaviour of liquid helium at low temperatures has been the subject of much work and thinking for some time. Ever since Kamerlingh Onnes succeeded in liquefying helium some fifty years ago, work has been going on with this single substance; more and more new phenomena have been discovered and a new field of experiments and theory has been established. At first, the difficult techniques for obtaining the necessary low temperatures meant that the work was concentrated in a few laboratories which became famous in this field. With the more recent methods these low temperatures are easier to obtain, and much work is going on in many places all over the world. The subject is still in rapid development. A new monograph which tries to select the essential features in such a vast field of experiments and theoretical thinking is very welcome. At the same time, it is a somewhat bold enterprise to write a monograph on such a rapidly progressing subject. A few points were already out of date by the time that the book was printed.

The wide variety of strange phenomena connected with liquid helium led slowly towards a pattern of basic facts. Some of these are by now essentially understood, others are not, and many more are perhaps still to be discovered. Theoretical ideas and experimental discoveries proceeded hand in hand in a fruitful co-operation. There are many striking examples of this interaction between theory and experiment. The concept of elementary excitations which move around in the superfluid background was introduced by Landau and is essential for the understanding of many properties of liquid helium. These excitations, phonons and rotons, characterize the low-lying excited states of the system. Landau's predictions about the excitation spectrum have been recently confirmed by neutron-scattering experiments. The elementary excitations form the 'normal component' of the liquid, which together with the superfluid component leads to a 'two-fluid' theory from which many features of the hydrodynamic and thermal behaviour of liquid helium can be understood. Other features which are less well understood are related to the formation of vortices. According to the ideas of Onsager and Feynman, the strength of these vortices has quantized values, a prediction which has found experimental verification in the past few years.

Quantum properties play an important part in the whole behaviour of liquid helium, and some manifestations of these are on a macroscopic scale. The Bose statistics obeyed by the helium-4 atoms seems also to be essential for the superfluid behaviour of helium. The helium-3 isotope which obeys Fermi statistics does not show superfluidity. Though many features of liquid helium are understood, much progress is still needed in a detailed theoretical description. The phenomena are related to the collective behaviour of a large number of particles, and the wave mechanics of such a system is of considerable mathematical complexity. But a better understanding of the collective behaviour of helium atoms may be of significance also in connexion with other similar problems of physics.

The book under review succeeds in a fair selection of the relevant experimental facts in making a good systematic treatment. This will be of value both to the expert and for reference. Some parts in the theoretical sections are perhaps not of the same standard, and especially the author's estimate of the theoretical achievements seems to be slightly over-optimistic. The book covers a lot of ground, it makes pleasant reading, and will be enjoyed not only by the specialists but also by those who look merely for orientation in this rather exciting subject.

J. G. Valatin

FRESHWATER INVERTEBRATES

A Guide to Freshwater Invertebrate Animals

By Dr. T. T. Macan. Pp. x+118. (London: Longmans, Green and Co., Ltd., 1959.) 11*s*. 6*d*. net.

The importance of freshwater biology for scientific, economic and educational purposes has greatly increased in recent years and the many biologists, both amateur and professional, now interested in the subject, will be grateful to T. T. Macan for writing an attractive, straightforward and well-illustrated "Guide to Freshwater Invertebrate Animals".

The line drawings, of which there are more than two hundred, are simple, clear and attractively finished and make up for some of the carelessness in the choice of words. To anyone unfamiliar with the conventions applied in describing mollusc shells the definition of a sinistral shell will mean very little: "if it be held upright with the aperture towards the observer the aperture is to the observer's left". Readers requiring a definition of sinistral in this context are the very ones least likely to know the meaning of 'upright'. Fortunately most of the ambiguities and other obscurities can be resolved by reference to a figure or to an opposing couplet in the key; but this takes a little time, and the distractions they evoke are further aggravated by expressions like "Swimming quick" which may be a grammatically appropriate antithesis to "Swimming laboured", but could easily have been avoided.

Apart from these minor blemishes the "Guide" is a pleasure to use. The practice of giving the dimensions of the specimens figured in millimetres rather than giving the magnifications is commendable and will save much mental arithmetic. It is, however, unfair to expect all the readers for whom the book is intended to know that the length of an insect, for example, does not include in its measurement any appendages projecting at either end.

Most authors of taxonomic keys become slaves to the system, and for the sake of uniformity attempt to find simple characters to separate large groups which are too complex for this to be done satisfactorily. It is for this reason that most keys require the reader to inquire into the most obscure and insignificant details, particularly in the early stages of the key, where the groups to be separated are the most complex. This is very discouraging until the student learns by experience how to bypass the difficulty by recognizing the major groups by sight rather than by resolving the alternatives presented in the key. Dr. Macan avoids this trouble in a delightfully simple way: where to persist in the format of a key would lead to the use of impracticable alternative questions he abandons the format and substitutes a straightforward explanatory paragraph. By way of compensation, perhaps, the author makes use of the key format for his references to further literature. The number of species of freshwater invertebrates in Great Britain is far too great for them all to be dealt with in a single work, so in many places the key inevitably ends in a family or other group name rather than a genus or species, and here where the investigator wants it is a reference to further literature on the group. Macan's "Guide" is thus more than a key to the invertebrates, it is also a master key to other keys.

J. P. HARDING

DOWSING—FACT OR FICTION?

Water-Witching U.S.A.

By Evon Z. Vogt and Ray Hyman. Pp. xi+248. (Chicago: University of Chicago Press; London: Cambridge University Press, 1959.) 37*s.* 6*d.* net.

THE difficulties of popularizing science are well known; they are probably greatest in fields such as psychology and sociology, where most readers are quite unaccustomed to the possibility of a scientific approach. The book under review shows what can be done even in a field that superficially might seem rather unlikely. In turning to dowsing or 'water witching', the writers, of course, have the advantage that most lay readers will have some interest in the problem and will at least have heard of the claims made for this 'science'. Their account is well written, well documented, critical in the best sense and, above all, intensely readable. It can be recommended to anyone interested in the subject as a model of popularization, and few people will lay down the volume without having learned a few new facts at least from the authors' wide-ranging discussion.

In their book they pass from the reasons for dowsing, through its history, to a consideration of the question of whether it does in fact work or not. As they point out, there is fairly universal agreement that the stricter the controls become which are imposed on the dowser, the less frequently does his score deviate from the chance-level. In this, there is a striking parallel to other sets of beliefs, such as those associated with mediums, clairvoyants, phrenologists, graphologists, and Freudian psychotherapists. The unbiased reader will be unlikely to disagree with their conclusion that there is no scientific basis for water divining, and that recourse to it and belief in it are both based on psychological causes which are independent of reason and scientific proof. Particularly good in this connexion is their discussion of scientific methodology applied to problems of this type; even those least aware of modern psychological methodology could scarcely fail to follow their description step by step of the reasons why controlled experiments are necessary, and the way in which such experiments should be carried out.

The authors go on to discuss psychological theories which might account for the muscle twitches of the dowser, including a discussion of the famous 'talking horses' and other so-called 'parapsychological' phenomena. Here again, the discussion is lucid, well supported by strictly experimental findings, and altogether convincing. Their main point in bringing in these apparently extraneous facts is this. Modern psychology has demonstrated the truth underlying Carpenter's ideo-motor theory, to wit, that a person's thoughts tend to be mirrored in certain small incipient muscle movements or twitches. These can be used as signs or signals by a clever medium. By the same token, they can also, when amplified by the forked twig held by the water diviner, lead to an unconscious indication of the diviner's thoughts about the likelihood of water-bearing properties of a particular piece of ground—notions themselves in many cases derived from his personal familiarity with the neighbourhood, or even semi-scientific knowledge of geological indications.

The book ends with some chapters on the kind of people who undertake dowsing, the kind of people who employ dowsers, and the reasons why they do so. The facts discussed there are derived from the United States only, where dowsing appears to be much more prevalent than in Britain. The interested reader might like to consider whether the descriptions furnished by Vogt and Hyman of the typical dowser and his employer fit in with national stereotypes about the United States and Britain; it would certainly be interesting to have some similar facts about dowsing in the latter. Even without this, however, most readers will find this an interesting, enjoyable and well-written book, which will tell them all they need to know about 'water witching'.

H. J. EYSENCK

British Industrialists

Steel and Hosiery, 1850–1950. By Charlotte Erickson. (The National Institute of Economic and Social Research. Economic and Social Studies, Vol. 18.) Pp. xxi+276. (Cambridge: At the University Press, 1959.) 40*s*. net.

THIS book gives the results of a survey of the social origins and careers of about 1,000 managing partners and executive directors in the hosiery industry of the Nottingham area and in the heavy-steel industry during the past one hundred years. It is thus in the first place a historical study, but the work was planned on the assumption that important differences might exist in the recruitment of management by different industries, depending upon their age, traditions, structure and organization. It does not claim more than to present some empirical data on the social origins of business leaders and on the use made of the natural ability of able individuals, and makes no attempt to construct principles for the selection of leaders.

Nevertheless, as Prof. T. S. Ashton points out in his foreword, this admirably produced volume contains material highly relevant to present issues. It gives some background for present-day thinking about the selection of leaders and about training for management that should be carefully weighed in planning the expansion of higher technological education at the least. These studies bear closely on such questions as what constitutes the best education and experience for business leadership, the relative place of education and of experience, the appropriate age of appointment of directors, as well as retirement. Such questions cannot be dealt with in averages without regard to the particular individual's rate of development and retention of powers, but they need consideration, and this book demonstrates the practicability of obtaining evidence and shows how it can be obtained. Moreover, the two industries actually chosen offer the possibility of some tentative inferences about the growth of the impersonal corporation upon the selection of business leaders in Great Britain. Indeed the book may well gain in value as further studies on such lines are made in other industries and the results become available for comparison.

R. BRIGHTMAN

The Study of Man

The Lindsay Memorial Lectures, 1958. By Prof. Michael Polanyi. Pp. 102. (London: Routledge and Kegan Paul, Ltd., 1959.) 7*s*. 6*d*. net.

THESE lectures form a most valuable companion to the author's "Personal Knowledge", in which he goes far towards rejecting the objectivity of science in that, as a discipline, it is commonly thought of as detached and impersonal. An individual, even passionate, element is essential. The three discourses are entitled (1) "Understanding Ourselves", (2) "The Calling of Man", (3) "Understanding History". This emphasis upon understanding rather than upon prediction (the usual goal in theoretical studies) marks the writer as a true epistemologist. The importance of such an outlook to-day lies in its capacity to offset at least some of the evils of specialization without becoming merely dilettante in the process.

The author is now ready to do something well worth the attempt, namely, to transpose much of Gestalt-psychology into a theory of knowledge. Why this has not happened before is largely because its devotees were too passive, and inclined to under-estimate the personal element. In this, and in many other ways, Prof. Polanyi shows himself an artist, not least when he insists that those to whom the internal splendours of mathematics are a closed book have no knowledge of the subject.

It remains to see all this in the light of the late Lord Lindsay's outlook on education, and his early efforts on behalf of the University College of North Staffordshire in particular. He would have delighted in the liberalism which makes the act of knowing an urge to service.

F. I. G. RAWLINS

Russian–English Glossary of Solid State Physics

Edited by I. Emin. Pp. iii+90. (New York: Consultants Bureau, Inc., 1958.) 10 dollars.

Russian–English Glossary of Optics and Spectroscopy

Pp. iv+78. (New York: Interlanguage Dictionaries Publishing Corporation, 1959.) 10 dollars.

THESE two glossaries are of about the same size, the same format and edited by the same editor, but are published by different organizations. They represent very useful compilations of Russian terms belonging to the respective branches of physics, but although each glossary contains some 4,000 terms the user of these glossaries, as of any other specialized technical compilation, will often find certain terms missing. This applies to all specialized glossaries for the obvious reason that there are no hard and fast separations between specialized and general terms in science. Thus, for example, a very important Russian term of a French derivation 'etalon', meaning 'standard', such as 'standard sample' or 'standard measure', also the term 'brus' or 'brusok' meaning 'bar', or again names of certain chemical compounds or common minerals, are all missing from these compilations. The price of each of these glossaries is rather high.

S. I. TOMKEIEFF

Outline of Human Genetics

By Prof. L. S. Penrose. (Contemporary Science Series.) Pp. xii+146. (London: William Heinemann, Ltd., 1959.) 12*s*. 6*d*. net.

THIS is an excellent and lucidly written introduction to human genetics for the general reader. As one would expect, the treatment is well balanced and the factual basis correct and up to date. Of particular interest is the last chapter ("Eugenics and Dysgenics"), in which the author, himself the Galton professor of eugenics in the University of London, gives many good reasons for a conservative attitude towards practical measures in this field.

H. GRÜNEBERG

Die Cactaceae

Handbuch der Kakteenkunde. Von Curt Backeberg. Band 3: Cereoideae (Austrocactinae). Pp. iii+1361–1926+tafel 108–160. (Jena: Gustav Fischer Verlag, 1959.) 85 D.M.

THIS further volume of Herr Backeberg's colossal new handbook to the Cactaceae (*Nature*, 184, 1010; 1959) continues the account of the subfamily Cereoideae as far as the end of the 'sippe' Austroechinocacti of the subtribe Austrocactinae. Among the larger genera included are *Lobivia* (72 species), *Gymnocalycium* (58) and *Parodia* (36). As before, the volume is copiously illustrated.

A BASIS FOR A GENERAL SYSTEM OF INSECT MIGRATION AND DISPERSAL BY FLIGHT

By C. G. JOHNSON
Rothamsted Experimental Station, Harpenden

WHENEVER the start of a 'mass migration' of insects has been described—and this is very rare in spite of a voluminous literature—the insects have nearly always been making either their first flight as new adults or one very soon afterwards. This fact is usually mentioned only incidentally and has been observed intentionally in very few insects[1–15]: it has never been brought forward as a general principle, though it may provide a central feature for a long-needed, general system of insect migration and dispersal.

Studies of insect migration have usually been preoccupied with special qualities of the flight such as persistence, long distances travelled, collective flight or apparent control over the direction of displacement; and migration is usually defined in these terms[1–15]. But no matter how spectacular these behavioural qualities may be, they are so variable that definitions based on them as to what is or is not 'migration' or what is 'active' migration and what is 'passive' dispersal, become arbitrary, controversial and unsatisfactory when applied to all the types of insect which are said to migrate.

I suggest that the only common feature which is obvious at present in the mass migrations of insects in general is the active exodus flight by new adults from the breeding site followed by one or more flights, varying in character from species to species, to a new breeding site. This is what I shall mean by migration. I shall take mass migrations as the starting point for analysis.

Records of Post-teneral Migration Flights

I have so far found no exceptions to my conclusion that mass migrations begin in the first place either as first flights at the end of the teneral period or soon afterwards.

The examples supporting the conclusion are given in Table 1 and refer to recognized migrants like *Vanessa cardui*, *Ascia monuste*, locusts and dragonflies and to less spectacular ones; to organized drifters like aphids, and to Isoptera and crepuscular or nocturnal chironomids, which normally fly a very short distance but which can also be said to migrate in the above sense of the word. These examples include insects of several orders and cover a wide range of flight speed, duration and orientation.

The teneral period is taken here as beginning at emergence from the last immature instar and ending at full flight-worthiness, although pigmentation may be incomplete as in dragonflies. It varies inherently from about 1 hr. (*Vanessa cardui*)[16,17] to several days (locusts)[4,18,19]; its length is affected by temperature, as with any developmental process[20].

Perspectives in Migration Studies in the Light of the Post-teneral Flight

A recognition of the principle of post-teneral exodus flight brings new order and interesting speculation to the subject.

(1) *Periodicity of the first flight.* The daily synchronization of mass flights is not primarily behavioural, as with birds. Except in ants and termites it is caused by rhythms of emergence from the last immature instar, and by variation in the teneral period with changing temperature, in association with light and temperature thresholds for take-off[8–13]. Flight peaks may be repeated daily or within the day: total numbers migrating each day follow the curve for seasonal alate population change[47]. Seasonal synchronization may be caused by breaking of diapause[48]. Such periodicities are fundamental to the mass migration process.

This synchronized flight by individuals without apparent effect on each other is often called 'swarming'. This term is also used to describe aggregations by mutual attraction, which is quite a different process.

(2) *Possibility of teneral or post-teneral 'conditioning'.* The initial orientation of the insect in flight is probably 'imprinted' during the teneral period, or determined at take-off. The analogy with flight of bees comes to mind. Distances flown (within 24 hr.)

Table 1. EXAMPLES OF EXODUS FLIGHT IMMEDIATELY AT THE END OF THE TENERAL PERIOD
Recognized migration asterisked

- Exopterygota
  - Odonata
    - Of general occurrence (refs. 21, 22)
    - * *Macrogomphus annulatus* (Selys) (Gomphidae) (ref. 23)
    - * *Anormogomphus kiritschenkoi* (Bartenef) (ref. 23)
    - *Gomphus vulgatissimus* (L.)
    - * *Lindenia tetraphylla* (Van der Lind.) (ref. 23)
    - *Anax imperator* Leach (Aeshnidae) (ref. 15)
    - * *Anax guttatus* (Burm.) (Aeshnidae) (ref. 23)
    - *Anax junius* Brauer (Aeshnidae) (ref. 28)
    - *Aeshna mixta* Latr. (Aeshnidae) (ref. 24).
    - * *Hemianax ephippiger* (Burm.) (Aeshnidae) (ref. 23)
    - * *Orthetrum trinacria* (Selys) (Libellulidae) (ref. 23)
    - * *Sympetrum striolatum* Charp. (Libellulidae) (ref. 25)
    - * *Sympetrum fonscolombii* (Selys) (Libellulidae) (ref. 24)
    - * *Pantala flavescens* Fabr. (ref. 23)
    - * *Lestes malabarica* Fraser (Lestidae) (ref. 23)
  - Orthoptera
    - * *Schistocerca gregaria* Forsk. (Acrididae) (refs. 4, 19)
  - Isoptera
    - All species (ref. 26).
    - *Drepanotermes silvestri* Hill (ref. 27)
    - *Hamitermes perplexus* Hill (ref. 27)
  - Hemiptera
    - * *Blissus doriae* Ferr. (Het: Lygaeidae) (ref. 29)
    - * *Dysdercus sidae* Montr. (Het: Pyrrhocoridae) (ref. 30)
    - * *Aphis fabae* Scop. (Hom: Aphididae) (refs. 6, 8, 9, 31)
- Endopterygota
  - Lepidoptera
    - * *Catopsilia crocale* Ca. (Pieridae) (ref. 32)
    - * *Catopsilia pyranthe* L. (Pieridae) (ref. 33)
    - * *Ascia monuste* L. (Pieridae) (refs. 13, 14, 34)
    - * *Vanessa cardui* L. (Nymphalidae) (refs. 16, 17)
    - *Vanessa californica* Bdv. (Nymphalidae) (ref. 35)
    - * *Loxostege sticticalis* L. (Pyraustidae) (ref. 36)
    - *Hemileuca oliviae* Ckll (Lasiocampidae) (ref. 37)
    - There are very many references to migrations by *apparently* newly emerged butterflies and moths (ref. 1)
  - Diptera
    - * *Aedes taeniorhyncus* (Wied.) (Culicidae) (refs. 10–13)
    - *Chironomus brevibucca* (Kieff.) (Chironomidae) (ref. 38)
    - There are many references suggesting post-teneral exodus flights in mosquitoes (ref. 39)
  - Hymenoptera
    - *Diprion polytomum* (Htg.)? (Diprionidae) (ref. 40)
    - Generally in ants (ref. 41)
  - Coleoptera
    - Several *Dendroctonus* spp. (Curculionidae) (ref. 42)
    - * *Anthonomus grandis* Boh. (Curculionidae) (ref. 43)
    - *Euthyrrhinus meditabundus* Fabr. (Curculionidae) (ref. 44)
    - * *Diabrotica duodecimpunctata* Fabr. (Chrysomelidae) (ref. 45)
    - *Promecotheca opacicollis* Gestro (ref. 46)

possibly depend on the time of day when flight maturity and take-off occur, that is, on the period remaining before flight is stopped by darkness or falling temperature. Too long an enforced wait before take-off, leading to sexual maturation or fertilization, apparently inhibits migration altogether in *A. monuste*[13] and *Hemileuca oliviae*[37]. Reversal of positive phototaxis with changes in temperature (and humidity)[49–51] may influence take-off behaviour and subsequent flight.

Thus, variation in initial orientation and flight duration, or whether the exodus flight will occur or not, could be expressed collectively according to the daily periodicity.

(3) *Take-off flight*. The individual take-off flight at the exodus appears to be very similar for several insects of different orders. It is often described as a vigorous flight upwards (positive phototaxis)[7,13,30,34,52] or at a steep angle, to about 20 ft. when turbulent transport determines speed and direction or the insects stop climbing and are reported as flying off in the same direction[10–12,15–17,30].

Some species may fly off without delay (aphids, *V. cardui*); others (locusts, *A. monuste*) first make a few, relatively short preliminary flights.

(4) *Duration of migration*. This is partly a species characteristic, probably evolved in relation to survival. Locusts and some Lepidoptera may continue to fly intermittently for many days, covering great distances; others fly for only a few hours (aphids) or even minutes (some Isoptera) before migration ends or flight ceases permanently (Isoptera: some aphids). The exodus flight, however, and sometimes its continuation, appears always to be of relatively great vigour.

(5) *Migratory and other flights*. At present it is not clear if the exodus flight and its more or less immediate continuation are different in quality from other flights which occur later: it is claimed that they are, soundly I think, for Lepidoptera[1–3] and mosquitoes[10–14] at least. But with some insects it is not possible to be certain about this. It seems to me that it is best to make the chronological distinctions first, and that the failure to do this has greatly blurred the migration picture.

(6) *Aggregation*. Insects may aggregate at take-off (locusts) or afterwards (*Danaus plexippus*)[53] or at hibernation or æstivation (for example, Coccinellids). This is a special feature, secondary to synchronization of flight by simultaneous maturation when individuals fly away together but apparently without affecting each other.

(7) *Hibernation and æstivation*. I presume that they are exodus flights which end in hibernation or æstivation, followed later by so-called 'return migration' towards former breeding sites.

(8) *The 'return flight'*. The 'return' flight has been considered a necessity without which a species would lose its breeding sites[3]. This assumes that all the females of the original population transfer to places unsuitable for breeding: this has not been proved. Direction, as well as distance, from the original source vary and migration is dispersive (as compass diagrams show[1–3]); some insects may remain behind[13,37]. The habitat may thus be replenished from within or from directions other than that of the main exodus[54]; there is, however, often a seasonal bias in different directions. The analogy with birds should not be pressed too far.

(9) *Causes of migration*. Current lack of food or space is often said to cause migration, but I postulate that to make the original exodus is the normal individual action of many new flight-mature insects, irrespective of the size of the population, the immediate food supply or space. Shortages of food or space may cause insects to move; such shortages often coincide with a mass exodus, but they are not necessarily cause and effect. Exodus flights are, no doubt, made also by individuals from the smallest possible populations but pass unnoticed. I see migration as an evolved adaptation rather than as a current reaction to adversity.

(10) *The adult as a migrant stage*. The idea that the adult represents a stage the primary function of which is dispersal fits in with my conclusions; for a primary function would be expected to occur as soon as possible once the adult stage is reached, when the insect is fresh.

(11) *Migration and reproduction*. The exodus flight having evolved for recolonization, it therefore precedes oviposition; in fact, in *Aphis fabae*, larviposition is delayed until induced by flight[55], and this may well be the general tendency.

(12) *Migration and dispersal*. The initial exodus flight appears to be generally very active and continuing into the migratory flights lead to dispersal except where they end in aggregations. It remains to find the proportion of the aerial 'plankton' concerned with 'deliberate' post-teneral flights as distinct from being caught up 'accidentally' at other times; but I suspect that post-teneral exodus is the rule with many more species than we realize, though it may be unobstrusive. Insects which do not migrate may well be the exceptional ones.

Conclusions

Mass migratory flights, as commonly recorded, appear to be made primarily by newly emerged adults at the end of the teneral period after moulting from the previous instar and as soon as the insects have full capacity for flight. Commonly, it is the first flight of the new adults, but in some species a number of relatively short flights lead to the exodus flight, which, continuing, becomes dispersive, and takes the insects to new breeding sites, from which new adults of another generation migrate. Exodus flights appear to be made usually by individuals without reference to each other except in special cases (for example, locusts).

This principle does more than repeat that insects leave their breeding places; it says when they migrate, and why they may do so collectively. It distinguishes migration flights chronologically in the first place before attempting to distinguish them behaviourally.

Migration from hibernating or æstivating aggregations of insects also occurs more or less *en masse*, but this is not a general feature; the resemblance to bird migrations (in that a change in behaviour occurs in adults with a previous, different behavioural history) has probably distracted attention from the original post-teneral migration which I postulate is common to all.

The chronology of mass migration now seems more clear: experimental work on migration in many insects might now be planned without waiting for the hitherto unpredictable phenomenon in the field.

This might apply especially to problems of orientation: and to the possible relation of endocrine balance to the active and persistent character of many migratory flights following emergence.

Note added in proof: Since writing this article I have seen P. B. M. Allan's paper (*Entom.*, 75, 147; 1942) in which he, like Piepers (1890), expresses opinions applying specifically to Lepidoptera, which are similar to the views developed above.

[1] Williams, C. B., "The Migration of Butterflies" (London, 1930).

[2] Williams, C. B., "Ann. Rev. Ent.", 2, 163 (1957).

[3] Williams, C. B., "Insect Migration" (London, 1953).

[4] Kennedy, J. S., *Phil. Trans. Roy. Soc.*, B, **235**, 163 (1951).

[5] Kennedy, J. S., and Stroyan, L. J., "Ann. Rev. Ent.", **4**, 139 (1959).

[6] Moericke, V., *Z. Angew. Ent.*, 37, 29 (1955).

[7] Johnson, C. G., *Biol. Rev.*, **29**, 87 (1954).

[8] Johnson, C. G., and Taylor, L. R., *J. Exp. Biol.*, **34**, 209 (1957).

[9] Johnson, C. G., Taylor, L. R., and Haine, E., *Ann. App. Biol.*, **45**, 682 (1957).

[10] Provost, M. W., *Mosquito News*, **12**, 174 (1952).

[11] Provost, M. W., *Mosquito News*, **13**, 196 (1953).

[12] Provost, M. W., *Mosquito News*, **17**, 233 (1957).

[13] Nielsen, E. T., *Bull. Ent. Res.*, **49**, 305 (1958).

[14] Nielsen, E. T., and Nielsen, A. T., *Ent. Medd.*, **26**, 386 (1952).

[15] Corbet, P. S., *J. Anim. Ecol.*, **26**, 1 (1957).

[16] Skertchly, S. B. J., *Nature*, **20**, 266 (1879).

[17] Egli, O., in Loeliger, R., Centre d'observation pour les migrations de papillons, Zurich. Circulaire No. 24, 3 (1950).

[18] Uvarov, B. P., *Bull. Ent. Res.*, 12, 135 (1921).

[19] Gunn, D. L., *et al.*, *Nature*, **156**, 628 (1945).

[20] Taylor, L. R., *J. Exp. Biol.*, **34**, 189 (1957).

[21] Longfield, C., "The Dragonflies of the British Isles" (London, 1937).

[22] Tillyard, R. J., "The Biology of Dragonflies" (Cambridge University Press, 1917).

[23] Fraser, F. C. (private communication).

[24] Fraser, F. C., *J. Soc. Brit. Ent.*, **2**, 133 (1943).

[25] Fraser, F. C., *Ent. Mon. Mag.*, 81, 73 (1945).

[26] Ratcliffe, F. N., Gay, F. J., and Greaves, T., "Australian Termites" (Melbourne, 1952).

[27] Hill, G. F., *Bull. Ent. Res.*, **12**, 363 (1922).

[28] Root, F. M., *Canad. Ent.*, **44**, 208 (1912).

[29] Sajo, K., in Webster, F. M., *U.S. Dept. Agric. Bur. Ent.*, *Bull.* No. 69 (1907).

[30] Ballard, E., and Evans, M. G., *Bull. Ent. Res.*, **18**, **45** (1928).

[31] Muller, H. J., and Unger, K., *Zuchter*, **22**, 206 (1952).

[32] Piepers, M. C., *Natuurk. Tijdschr. Ned.-Ind.*, 50, 198 (1890).

[33] Manders, N., *Trans. Ent. Soc. Lond.*, Pt. **4**, 701 (1904).

[34] Nielsen, E. T., and Nielsen, A. T., *Amer. Mus. Novit.*, No. 1471 (1956).

[35] Webster, F. M., *Canad. Ent.*, **45**, 117 (1913).

[36] Melnichenko, A. N., *Bull. Plant Protection*, Leningrad, 1st Ser., No. 17, 5 (1936).

[37] Ainslie, C. N., *U.S. Dept. Agric. Bur. Ent.*, *Bull.* No. 85, Pt. 5, 59 (1910).

[38] Fryer, G., *Bull. Ent. Res.*, **50**, 1 (1959).

[39] Horsfall, W. R., "Mosquitoes: Their Bionomics and Relation to Disease" (London, 1955).

[40] Balch, R. E., *J. Econ. Ent.*, **32**, 412 (1939).

[41] Imms, A. D., "A General Textbook of Entomology" (London, 1957).

[42] Hopkins, A. D., *U.S. Dept. Agric. Bur. Ent.*, *Bull.* No. 83, Pt. 1, 169 (1909).

[43] Gaines, J. C., *J. Econ. Ent.*, **25**, 1181 (1932).

[44] Hill, G. F., *Bull. Ent. Res.*, **12**, 63 (1921).

[45] Smith, C. E., and Allen, N., *J. Econ. Ent.*, **25**, 53 (1932).

[46] Kowalski, J., *Ann. Épiphyt.*, **4**, 286 (1917).

[47] Johnson, C. G., *Ann. App. Biol.*, **39**, 525 (1952).

[48] Corbet, P. S., *Nature*, **174**, 655, 777 (1954).

[49] Perttunen, V., *Ann. Ent. Fenn.*, **24**, 12 (1958).

[50] Perttunen, V., *Ann. Ent. Fenn.*, **25**, 65 (1959)

[51] Perttunen, V., and Lahermaa, M., *Ann. Ent. Fenn.*, **24**, 69 (1958).

[52] Peake, F. G. G., *Bull. Ent. Res.*, **43**, 317 (1952).

[53] Lugger, O., *Proc. Ent. Soc. Wash.*, **1**, 256 (1890).

[54] Wiltshire, E. P., *Trans. Roy. Ent. Soc. Lond.*, **96**, 163 (1946).

[55] Johnson, B., *Animal Behaviour*, **6**, 9 (1958).

BINDING OF A HEPATOCARCINOGEN TO THE STRUCTURAL LIPOPROTEIN OF RAT LIVER: ITS BEARING ON THE IMMUNOLOGICAL THEORY OF CANCER

By J. W. WESTROP and PROF. H. N. GREEN

Cancer Research Unit, University of Sheffield

THE outstanding relevance of specific protein binding by carcinogens to the immunological theory of cancer has been stressed repeatedly since the theory was first proposed[1]. The concept that this specific binding is to a cytoplasmic tissue-specific lipoprotein complex, detectable as tissue-specific antigen, has been steadily developed since that time[2] and there is considerable evidence in its favour.

In hepatocarcinogenesis, central importance has been attached recently to azo-dye binding in the microsomal fraction[3,4]. Since it is known that this fraction, as obtained by differential centrifugation of liver homogenates, includes the cell membrane and ergastoplasm (endoplasmic reticulum + ribonucleic acid granules) it becomes important to decide whether binding of azo-dye to these structures is a factor in the binding found in the fraction as a whole.

Bruemmer and Thomas described a method[5] of obtaining a 'ghost cell' preparation from calf liver and showed it to be an insoluble lipoprotein with a similar chemical composition to an insoluble lipoprotein obtained by Smith *et al.*[6] by differential centrifugation of homogenates. It is thought to represent the structural substance of the cell, that is, the endoplasmic reticulum. Using this method[5], we have obtained a ghost cell preparation from the livers of control rats and rats injected with azo-dye, and confirmed that it is an insoluble lipoprotein. We have also shown, by analysis[7] for bound dye, that firm binding to the protein of this lipoprotein does in fact occur. It is seen (Table 1) that in acute experiments, binding by the hepatocarcinogen, 3′-methyl-4-dimethylaminoazobenzene, is relatively considerable. On the other hand, using the feebly carcinogenic 4′-methyl-4-dimethylaminoazobenzene and the non-carcinogenic 2-methyl compound, no more than a possible trace of bound dye in the ghost cell substance was found. A repeat experiment did, however, show some, though less, binding with both compounds. Under these experimental conditions the binding is not therefore specific to a carcinogen. Feeding of 4-dimethylaminoazobenzene for a long period resulted in the production of enlarged and grossly abnormal livers showing early neoplastic changes. No bound dye was detected in the ghost cell preparation from these livers.

The yield of ghost cell substance, expressed as percentage of fresh liver, from all the rats injected with azo-dye was strikingly reduced. Only in the case of the repeat experiment with 4′-methyl-4-dimethylaminoazobenzene and the 2-methyl compound could this reduced yield be ascribed, and even then only partially, to decreased cellularity of the liver as indicated by the concentration of liver deoxyribonucleic acid. In the other experiments, and notably

Table 1. FIRM BINDING TO THE 'GHOST CELL' SUBSTANCES IN LIVERS OF RATS TREATED WITH AZO-DYE

Exp. No.	Treatment	No. of rats	Time killed	Bound dye: Absorbance/50 mgm. protein	
				Total liver	Ghost cell substance
1	3'-Me-DAB	8	41 hr.	0·183	0·129
2	3'-Me-DAB	6	48 ,,	0·176	0·085
3	4'-Me-DAB	2	48 ,,	0·024	Trace ?
4	2-Me-DAB	1	48 ,,	0·129	Trace ?
5	4'-Me-DAB	7	48 ,,	0·063	0·028
	2-Me-DAB	4	48 ,,	0·122	0·067
6	DAB	3	15 months	—	0·003

Exps. 1–5: Intraperitoneal injection, 20 mgm./100 gm. body weight in arachis oil. Similar numbers of control rats injected with arachis oil only

Exp. 6: Fed 0·06 per cent 4-dimethylaminoazobenzene in stock diet. Similar numbers of controls fed stock diet only.

Absorbance is $\log_{10} I_0/I$, 1 cm. at 520μ for 4-dimethylaminoazobenzene (DAB), 525μ for 2-methyl-4-dimethylaminoazobenzene (2-Me-DAB) and the 3'-methyl compound (3'-Me-DAB), 580μ for 4'-methyl-4-dimethylaminoazobenzene (4'-Me-DAB).

with the 3'-methyl compound, a reduced concentration of liver deoxyribonucleic acid did not accompany the reduced yield of ghost cell substance.

It may perhaps be significant that there was a reduction in ghost cell substance in the 'neoplastic' livers resulting from long-term feeding with 4-dimethylaminoazobenzene. The livers from dye-fed rats were about twice the size of the controls, which might reflect a very low content of ghost cell substance in the neoplastic cell itself. Incidentally, the higher yield of ghost cell substance in this experiment was due to a less rigorous application of the extraction procedure in a first trial of the method. The reduced yield of ghost cell substance from the livers of rats injected with 3'-methyl-4-dimethylaminoazobenzene was accompanied by a reduced concentration of ribonucleic acid in the liver, which was most apparent when the animals were killed 48 hr. after injection of the dye. Since much of the cellular ribonucleic acid is associated with the endoplasmic reticulum to form the ergastoplasm, it would appear that dye injection has produced a loss in both components. This acute loss does not appear to be related to carcinogenic potency.

During the course of the present work, it was reported[4] that following feeding to rats, 3'-methyl-4-dimethylaminoazobenzene was firmly bound to the liver ergastoplasm and exclusively to the 'insoluble residuum' fraction thereof. It seems to us probable that this fraction and our ghost cell preparation represent the same cellular substance, that is, the structural lipoprotein of the endoplasmic reticulum, and that we have confirmed in another, possibly more direct, way that binding of carcinogenic azo-dye to this substance occurs. It is also stated in the report[4] already mentioned that single massive doses of dye may decrease the activity of (liver) glucose-6-phosphatase, an enzyme located in the 'insoluble residuum' fraction. If this is due to loss of endoplasmic reticulum, it would be in line with our finding of a diminished yield of ghost cell substance.

Table 2. EFFECT OF AZO-DYES ON THE YIELD OF 'GHOST CELL' SUBSTANCE AND CONCENTRATION OF NUCLEIC ACIDS IN RAT LIVER

Treatment	Dry liver/wet liver (per cent)	Yield ghost cell substance (per cent)	Composition of ghost cell substance			Liver nucleic acid conc.: change in dye group vs. control	
			Phosphatide (per cent)	N (per cent)	P (per cent)	RNA (per cent)	DNA (per cent)
3'-Me-DAB	23·2	0·30	—	—	—	−17·2	+14·1
Control	23·0	0·83	13·7	10·5	0·90		
3'-Me-DAB	25·0	0·25	7·9*	8·8	0·89	−35·5†	+3·0†
Control	25·7	0·93	10·2*	10·0	0·87		
4'-Me-DAB	24·2	0·52	—	11·9	0·91	+12·4	+7·3
Control	24·5	—	—	—	—		
2-Me-DAB	22·0	0·45	—	—	—	−18·5	+17·2
Control	25·8	1·31	10·3	9·2	0·95		
4'-Me-DAB	24·0	0·65	9·8	10·6	0·83	−6·7	−27·9
2-Me-DAB	22·6	0·26	11·1	9·7	0·83	−10·1	−20·4
Control	23·6	1·14	8·9	8·4	0·81		
DAB	—	1·58	13·1	10·5	9·94		
Control	—	2·45	10·0	9·3	0·83		

* Alcohol extractable only.

† Corresponding figures for additional groups treated similarly were −30·1 and +11·0 respectively.

Our results indicate that binding occurs in the region where tissue-specific antigen(s) is located. A liver microsomal sub-fraction containing a large proportion of the microsomal protein and phospholipid and thought to be a lipoprotein forming an integral part of the endoplasmic reticulum was shown by Vogt[8] to contain all, or nearly all, the tissue-specific antigen. Our preliminary results indicate that the major portion of firmly bound dye in the microsomes after injection of 3'-methyl-4-dimethylaminoazobenzene is in this fraction which contains nearly all the microsomal phosphatide (now completely confirmed in each of four experiments). This, together with the earlier findings, make it highly probable that tissue-specific antigen is involved in the binding process. The question of specificity must remain open until we know whether there is a big quantitative difference between carcinogens and non-carcinogens either in immediate binding, or in the time it persists, or both. However, present results, together with preliminary work on a transplantable hepatoma, indicate that the microsomal lipoprotein complex responsible for binding may be lost during carcinogenesis, since no binding occurred in the late stages of the process nor in the hepatoma. Failure of carcinogenic dye to bind with the soluble protein fraction from chemically induced hepatoma[9], whereas it shows firm binding in normal liver, may be secondary to the deficiency of tissue-specific antigen postulated by us. According to Hultin[3], primary binding is in the microsome fraction, followed by the release of metabolic products into the cytoplasmic fluid, which are then trapped by soluble protein components. If this is so, then in the absence of microsomal binding so-called 'specific' binding to the soluble protein fraction would not occur.

We have for some years[2], on the basis of much varied work, maintained that the cancer cell lacks in some degree cytoplasmic tissue-specific antigen which results in a loss of immunological identity as a tissue. This results in failure of certain (for example, 'scavenger') cells to recognize displaced cells, and in cancer cells lacking the receptors to recognize humoral (for example, hormonal) controls. The cancer cells can therefore no longer be fully integrated into an organized tissue or into the whole organism. The mechanism of loss of tissue-specific antigen doubtless varies greatly, but in chemical carcinogenesis immune attack on haptene-bound tissue-specific antigen may be important[3]. Even if this is not so, the basis of the immunological theory would not be affected.

We have previously suggested[10] that the tissue-specific antigens are membranous lipoprotein complexes and indicated how their loss could account for known alterations in the surface properties of the cancer cell. The concept that cellular affinities (that is, the forces binding like cells to like) are mediated through antigens on cell surfaces is supported by the work of Spiegel[11], who prevented re-aggregation of marine sponge and amphibian embryonic cells by treatment with specific surface-active antibodies. The fact that exposure to a carcinogen has a somewhat similar effect on marine sponge cells[12] favours the idea that surface antigens are involved in carcinogenesis. We are now getting a clearer picture of the site and nature of such antigens and indications of how carcinogenic chemicals and agents of many different kinds interact with them and cause their loss[13].

There is evidence that the ergastoplasm is concerned with the synthesis of proteins peculiar to that cell, and ideas suggesting that differentiation and structure are controlled by self-replicating particles located in the ergastoplasm and linked to nuclear genes by it, have some experimental support[14]. The present findings provide evidence that carcinogens are able to bind firmly to the cell framework. It remains to be seen whether there is in this respect a quantitative, or even qualitative, difference between carcinogens and related non-carcinogens. If there is, and absence of such binding in cancer tissue is confirmed, the idea that deficiency of tissue-specific antigens and neoplasia are synonymous terms will receive further support.

[1] Green, H. N., *Brit. Med. J.*, ii, 1374 (1954).

[2] Green, H. N., *Ann. N.Y. Acad. Sci.*, **68**, 268 (1957); "Cancer", 3, edit. Raven (Butterworth, London, 1957); Ciba Foundation Symposium on Carcinogenesis, 131 (1959).

[3] Hultin, T., *Exp. Cell. Res.*, **13**, 47 (1957).

[4] Fiala, S., and Fiala, A. E., *Brit. J. Cancer*, **13**, 236 (1959).

[5] Bruemmer, N. C., and Thomas, L. E., *Exp. Cell Research*, **13**, 103 (1957).

[6] Smith, J. T., Funches, A., Barak, A. P., and Thomas, L. E., *Exp. Cell Research*, **13**, 96 (1957).

[7] Miller, E. C., and Miller, J. A., *Cancer Res.*, **7**, 468 (1947).

[8] Vogt, P., *Nature*, **182**, 1807 (1958).

[9] Gelboin, H. V., Miller, J. A., and Miller, E. C., *Cancer Res.*, **18**, 608 (1958).

[10] Green, H. N., and Wilson, R., *Nature*, **182**, 1054 (1958).

[11] Spiegel, M., *Ann. N.Y. Acad. Med.*, **40**, 337 (1954–55).

[12] Kennedy, G. K., 36th Ann. Report, Brit. Emp. Cancer Comp., p. 386 (1958).

[13] Green, H. N., *Acta Unio contra Cancrum* (in the press).

[14] Brachet, J., "Biochemical Cytology", 36–47 (Acad. Press Inc., New York, 1957).

THE BIOCHEMISTRY OF THE EYE*

By DR. ANTOINETTE PIRIE

Nuffield Laboratory of Ophthalmology, Oxford

BIOCHEMICAL processes in the tissues of the eye are as diverse as in any other organ, and the functions of transmission of, and sensitivity to, light add special complexities. Size and shape must be controlled rigidly in order that the eye can act as an optical instrument, the tissues must be transparent, which means that they must be avascular, and the light-sensitive pigments in the retinal cells must be backed by the light-absorbing melanin of the choroid. Cornea, lens and vitreous body are light transmitters and focusers; the retina is the light-receiving and light-sensitive part of the eye.

Cornea and Lens

Recent experiments have shown that the clarity of the cornea depends upon its metabolism, which regulates the ionic balance. If respiration of the epithelium of the cornea is inhibited by fitting a type of contact lens, the epithelial cells swell and water accumulates in the fibrous stroma, thus making the cornea optically imperfect. Presence of oxygen beneath the contact lens prevents this swelling. Similar swelling occurs if the cornea is cooled or stored anaerobically or in the absence of glucose, but can be reversed when the tissue is re-warmed in presence of oxygen and glucose. A degree of swelling that might be unnoticeable in another tissue can distort the optical perfection of the cornea.

The cornea consists of three parts—epithelium, collagenous stroma and endothelium. The stroma is, in most animals, the largest part, but the epithelium has the most active metabolism. The cornea is avascular and oxygen is supplied by diffusion from the air, and, together with other nutrients, from the aqueous humour and surrounding tissues. The metabolism of glucose by the corneal epithelium appears to be similar to that of other tissues. The Q_{O_2} is 6–8, which is comparable to liver; cytochrome oxidase can be demonstrated histologically and cyanide inhibits respiration almost completely. Anaerobic glycolysis and some aerobic glycolysis occur. The enzymes of the citric acid cycle are present and glucose is also directly oxidized by the pentose phosphate pathway.

Glucose breakdown is the main source of energy in both cornea and lens. The relative importance of different paths of glucose breakdown has been studied in both tissues by Kinoshita and Wachtl using glucose labelled with carbon-14 on C_1 or C_6 or uniformly labelled on all carbons. In these avascular tissues anaerobic glycolysis is, as one might expect, the main path. The corneal epithelium glycolyses 65 per cent of all glucose metabolized and oxidizes 35 per cent, most of it by direct oxidation through the pentose phosphate route. The lens, which is much less active metabolically than the cornea, glycolyses almost all glucose used. The citric acid cycle is almost inactive in lens and any oxidation of glucose takes place by direct oxidation of C_1 through the pentose phosphate path. This oxidation is accompanied by reduction of triphosphopyridine nucleotide, and systems which can re-oxidize this coenzyme have been sought in both cornea and lens. Kinoshita found that the corneal epithelium contains a lactic dehydrogenase that will use reduced triphosphopyridine nucleotide, reducing pyruvic to lactic acid, and that addition of pyruvate anaerobically to cornea stimulates direct oxidation of glucose. Such a system may also be active in lens. Both tissues also contain a high concentration of reduced glutathione and glutathione reductase, which uses reduced triphosphopyridine nucleotide as coenzyme; but no system oxidizing glutathione has yet been found.

---

* Substance of two lectures given in University College, London, on February 29 and March 7, 1960.

The corneal stroma consists of fine uniformly arranged collagen fibres embedded in a matrix of mucopolysaccharides and mucoproteins. As these substances occur in the cornea unmixed with other fibrous proteins or with blood vessels it seems a suitable tissue in which to study collagen and mucopolysaccharide formation. Experiments have shown that repair of collagen in the cornea requires ascorbic acid. Three mucopolysaccharides are present—keratosulphate, a polymer of N-acetylglucosamine, galactose and sulphate, chondroitin sulphuric acid, a polymer of N-acetylgalactosamine, glucuronic acid and sulphate and the non-sulphated polysaccharide chondroitin. Cornea, both *in vivo* and *in vitro*, will incorporate sulphur-35 labelled inorganic sulphate into mucopolysaccharides. The uptake is much reduced in scorbutic guinea pigs.

The lens cells are derived from embryonic ectoderm. A small clump of cells grows into the optic cup, rounds itself off and becomes detached from the outer surface. By the time the human embryo is 2 cm. long this little clump has surrounded itself with a capsule which is impermeable to cells and to proteins, and the lens exists for the rest of life cut off from blood vessels and nerves, suspended radially in the eye by the suspensory ligament and bathed by the aqueous and vitreous humours. The adult lens has a dry weight of 35 per cent and nearly all of this is protein. The protein of the lens is not species specific. Common antigens are present in the lenses of all mammals examined, and man and animals can form antibodies to their own lens proteins. Escape of protein from a cataractous lens occasionally leads to development of sensitivity to lens protein and this can cause an intraocular allergic reaction. Until recently the lens was thought to contain only three major proteins, but with advance in electrophoretic techniques thirteen protein fractions have been separated and five fractions crystallized.

Senile cataract occurs throughout the world in man and animals but the biochemical changes are not known. A form of experimental cataract in which some of the biochemical changes are known is that produced in young rats by feeding high concentrations of galactose or xylose or by inducing diabetes with alloxan. R. van Heyningen has found that enzymes are present in the normal lens which will convert glucose to fructose by way of sorbitol. Sorbitol, present in traces in normal lens, accumulates in the lens of the diabetic rat, and the corresponding polyols, dulcitol and xylitol, accumulate in the lens of the rat fed galactose or xylose. The concentration of dulcitol may reach 2 gm./100 gm. lens after 1–2 days on a diet of 35 per cent galactose before any sign of cataract has appeared.

Cataract due to excess galactose also occurs in man. Some babies cannot metabolize galactose, do not thrive on milk and, among other signs of illness, may develop cataracts. Kalckar has found that galactosæmia is an inborn error of metabolism and that these babies do not have the enzyme galactose-1-phosphate uridyl transferase in their tissues, and their red blood corpuscles contain galactose-1-phosphate. Schwarz and Golberg found traces of galactose-1-phosphate in the fully cataractous lenses of galactose fed rats, and Lerner found that lenses from a galactosæmic infant had a low galactose-1-phosphate uridyl transferase activity. Whether block of galactose breakdown at the dulcitol-level with early high accumulation of dulcitol or block of the further metabolism of galactose-1-phosphate causes lens opacity to develop is still not clear.

Such cataracts are very rare in man, but senile cataract is still listed as the largest single cause of blindness in the world as a whole, in spite of the fact that the blindness can be relieved by surgical removal of the cataractous lens.

The Vitreous Body

The vitreous body fills the space between the lens and retina and can be considered as an extremely tenuous connective tissue. Although it is 99 per cent water it is a surprisingly stable jelly-like structure which does not dissolve when suspended in saline. A fibrous insoluble residue was described by Mörner in 1894, who suggested that it might be collagen, and this was confirmed using chromatographic and X-ray analysis. Electronmicrograms show very fine uniform fibres which occasionally show a cross-striation of 640 Å., in the posterior part of the vitreous body, while coarser fibres are present near the lens where the vitreous body is very firmly attached to the retina and outer coats of the eyeball. When the fibrous part is separated by centrifugation or filtration a clear viscous fluid remains, the vitreous humor, from which hyaluronic acid was first isolated by Meyer and Palmer in 1934. The stability of the vitreous body depends on the network of collagen fibres permeated by polymerized hyaluronic acid. The concentration of hyaluronic acid in the vitreous of cattle is about 400 mgm./l., and the concentration of fibrous protein 150 mgm./l., yet together, these large molecules, even in these low concentrations, form a surprisingly stable structure.

The Retina

The retina, like the brain from which it is derived embryologically, has a very active metabolism. The Q_{O_2} is about 10, and glycolysis proceeds both aerobically and anaerobically. Oxidation of glucose takes place by the pentose phosphate path and by the citric acid cycle, judged by formation of carbon dioxide from glucose labelled with carbon-14 on C_1 or C_6. But in studies of yields of radioactive lactic acid, carbon dioxide or other intermediates the fact that retina will actively incorporate carbon dioxide into malate must be remembered. Addition of pyruvate to retinal tissue stimulates direct oxidation of glucose presumably through stimulation of reactions which re-oxidize reduced triphosphopyridine nucleotide, thus supplying triphosphophyridine nucleotide for glucose oxidation. Such reactions could be the formation of malate from pyruvate plus carbon dioxide catalysed by the malic enzyme or reduction of pyruvate to lactate catalysed by a lactic dehydrogenase.

Attempts have recently been made to correlate the high rate of retinal glycolysis with maintenance of light sensitivity, and to determine metabolic changes when the retina is illuminated. Injection of iodoacetate in many species of animals causes an almost immediate fall in the electrical response of the retina to light and this is followed by a progressive fall in glycolysis with degeneration of those cells in the retina which contain light-sensitive pigments. But further work has shown that iodoacetate inhibits other processes in the retina besides glycolysis. No change has been found in respiration, in adenosinetriphosphate, deoxyribonucleic acid or ribonucleic acid when the retina is illuminated.

The main biochemical study of the retina has always been study of the light-sensitive pigments themselves. This brief review can discuss only one class, namely, those which are contained in the rod cells of vertebrate retinas and are thought to be the basis of vision in dim lights where colours are not appreciated. These pigments, the rhodopsins and porphyropsins, are lipoproteins with carotenoid chromophores, the carotenoid being retinene A_1, the aldehyde of vitamin A_1, or retinene A_2, the aldehyde of vitamin A_2. It is interesting that the first connexion between vitamin A and visual pigments came from study of human and experimental night blindness and that later biochemical work showed the vitamin to be a part of the pigment molecule. Rhodopsin can be isolated from the rod cells by extraction with digitonin with which it forms a soluble complex. It is a red pigment which fades to a yellow when exposed to light. This red pigment was first seen in the frog retina by Boll in 1876, who noticed that it faded in light but was re-formed if the live animal or separated eye was left in the dark.

The breakdown of rhodopsin by light and its re-formation in darkness has been studied by examination of changes in the absorption spectrum. Mammalian rhodopsin has an absorption maximum at 500 mμ, which is also the wave-length of light to which the mammalian eye is most sensitive. Change in absorption at 500 mμ measures change in rhodopsin. The primary action of light can be studied by determining change at very low temperatures, − 70° C., where thermal reactions are stopped. Such experiments show that light does not, strictly speaking, bleach rhodopsin but only changes the point of maximal absorption very slightly to the blue. Subsequent reactions which occur in light or in the dark cause more profound changes with release of retinene. Recent work of Wald and Hubbard has suggested that the retinene present in rhodopsin is a particular 11-*cis* stereoisomer and that the action of light is to change this isomer to the all-*trans* form while leaving it still attached to the protein. Vitamin A and retinene in other parts of the body are the all-*trans* isomers, but the pigment epithelium in mammalian eyes and the eyes of some marine crustaceans contain 11-*cis* retinene. The mechanism of formation of this isomer in the eye is not clear. Wald found it less effective than the all-*trans* isomer in promoting regeneration of rhodopsin in the retina of the vitamin A-deficient rat.

Examination of the density of rhodopsin in the living eye has shown that visual sensitivity is not related directly to rhodopsin concentration. Bleaching half a per cent of the total rhodopsin reduces sensitivity three-thousand-fold. Probably neural factors as well as pigment concentration are involved.

Apart from the light-sensitive pigments of the visual cells there are other pigments in the eye that modify the light stimulus received. For example, there is a yellow pigment, probably the carotenoid xanthophyll, at the macula, where vision is most acute in the human eye. This absorbs about 60 per cent of all incident blue light. The retinal pigment epithelium or choroid of many fish, amphibians and at least one reptile contains fluorescent pterins, and similar parts of the eyes of other species of fish and some mammals are rich in riboflavin. The most extreme example is the eye of the lemur, *Galego crassicaudatus*, in which there is a layer of crystals of riboflavin immediately behind the visual cells. This mirror will both reflect light and, through its fluorescence, will transform short-wave blue light to light of longer wave-length (520 mμ) to which rhodopsin is more sensitive.

Many animals have elaborated mirrors behind their retinas or on their irises. Carnivores have a layer of crystals of zinc cysteine ; and in the silver fox the zinc concentration of this part of the eye may reach 16 per cent of the dry weight. This is also the basis of the eye shine of dogs and cats. Fish and amphibians lay down crystals of guanin as a mirror in their eyes as in their scales (fish silver), while lemurs have crystals of riboflavin. The biochemical processes whereby these substances are concentrated to such an extent that they crystallize have yet to be investigated.

The study of both the specialized and the general biochemistry of eye tissues is only just beginning to expand. It is a fascinating study, and should lead to a clearer understanding of normal and abnormal processes in the eye as well as giving information which is interesting in connexion with the metabolism of other tissues.

OBITUARIES

Prof. H. W. B. Skinner, F.R.S.

HERBERT SKINNER, Lyon Jones professor of physics in the University of Liverpool, died suddenly in Geneva on January 20, at the age of fifty-nine, leaving a wife and daughter. His death was a great shock to a wide circle of friends and colleagues, for he was well known and liked far beyond his own University.

He was educated at Rugby and Trinity College, Cambridge, and worked under Rutherford at the Cavendish Laboratory until 1927, when he joined Tyndall at Bristol. He was elected to the Royal Society in 1942 in recognition of his work on the soft X-ray spectroscopy of metals.

Early in the War, Skinner worked on radar at the Telecommunications Research Establishment, which was a remarkably successful amalgamation of academic, industrial and Government scientists working in close liaison with the communications industry and the Royal Air Force. Skinner was one of the bright spirits of this enterprise and certainly contributed much to its success. He left in 1943 to join the atomic weapons work under the Department of Scientific and Industrial Research, and went to California as a senior member of the British group working with E. O. Lawrence and his colleagues on the electromagnetic separation of uranium isotopes.

Skinner returned to act as deputy to Sir John Cockcroft, who was still in Canada, in setting up the Atomic Energy Research Establishment at Harwell. He and a few colleagues began the creation of a great research laboratory from an empty R.A.F. station on the edge of the Berkshire Downs. Looking back now, it is remarkable that such impressive progress was made in those early years, when conditions were so difficult. Skinner's contribution, first acting in Cockcroft's absence and later as one of his able lieutenants, was a most important one. His particular personal creation was the General Physics Division which, organizationally, could have no logical justification but was a reflexion of his own wide interests and was extremely productive. Under his personal supervision came the synchrocyclotron, cloud chamber and nuclear emulsion work, synchrotrons, linear accelerators and electronics instrumentation, X-ray and neutron diffraction, isotope separation and mass spectrometry, and, later, extra-mural work on plasma physics. All this work prospered and, with the growth of Harwell, some found homes in new divisions.

Four years later, when chief physicist at Harwell, Skinner was appointed to succeed Sir James Chadwick at Liverpool. There he had further opportunity to exploit his talent for construction, because Chadwick, having created a flourishing school of nuclear physics around one of the first cyclotrons in Europe, had undertaken the construction of a new research laboratory centred on a 156-in. synchrocyclotron. This large project was in an early and critical stage, but was brought to a highly successful conclusion with the help of Chadwick's former colleagues and new men brought in by Skinner. Unlike Chadwick, Skinner was not primarily a nuclear physicist, and he appointed J. M. Cassels as professor of experimental physics. Liverpool became the home of a powerful school of high-energy physics, and the research work more than kept pace with the general growth in the universities. The small cyclotron, together with a Cockcroft–Walton generator, enabled the traditional nuclear physics school at Liverpool to grow in size and output to such good effect that one of Skinner's last acts was to undertake the installation of a tandem electrostatic generator for further expansion in this field. This machine is still being manufactured, and it is tragic that Skinner will not see it installed. A new and impressive building, the Chadwick Physics Laboratory, for teaching and research was completed recently under his guidance.

Skinner was active in the work of the European Organization for Nuclear Research (CERN) and was the senior British consultant in the 600-MeV. synchrocyclotron project. He was chairman of the CERN Panel of the Department of Scientific and Industrial Research, concerned with British participation in CERN'S work, and served on the Nuclear Physics Sub-Committee. He remained keenly interested in atomic energy, and was a consultant to the Atomic Energy Authority and a member of the *Nimrod* Project Committee. The National Institute for Research in Nuclear Science has good reason to be grateful for his advice and help on numerous occasions, and he was an active and provocative member of several committees of the Institute. He brought his laboratory into the national Liquid Hydrogen Bubble Chamber project sponsored by several British universities.

Herbert Skinner was devoted to physics and to physicists, and was generous with his time and energies. He hated red tape and sometimes alarmed administrators. Unconventional, persistent in argument and often disconcerting in management, he was also sincere, gentle and kind to an extent not always understood by his critics. He and his wife Erna were generous in hospitality, and their home was often crowded with guests. The affairs of physicists are duller without him.

T. G. Pickavance

Prof. Marcel Schein

On February 20, at the height of his scientific career, Marcel Schein died in Chicago, Illinois. With him disappeared a most brilliant, able and imaginative scientist whose work is destined to leave an enduring mark in the physics of our century.

Marcel Schein was born in Tresten, Czechoslovakia, on June 9, 1902. After studying in Prague, Vienna, Würtzburg and Zurich, he received a doctorate in physics at the University of Zurich in 1927. His first academic appointment was that of assistant in physics in that University. Between 1929 and 1930 he spent a year in Chicago on a Rockefeller Fellowship. He then returned to Zurich as a *docent*, a position which he held until 1935, when he was appointed professor of physics at the University of Odessa. In 1938, Marcel Schein went to settle permanently in the United States, at the invitation of Prof. A. H. Compton. He joined the University of Chicago where he remained until his death, holding various positions until, in 1946, he was appointed professor in the Department of Physics and in the Institute of Nuclear Studies. In 1927, while in Zurich, he married the former Hilde Schoenbeck, who was working as a Ph.D. candidate in the Physics Department. From this marriage he had a son, Edgar, who is now on the faculty of the School of Industrial Management at the Massachusetts Institute of Technology.

In the early years of his scientific career, Marcel Schein made some valuable contributions to the physics of X-rays. He is best known, however, for his work in cosmic rays, which he began after moving to Chicago in 1938. At that time it was known that the primary radiation consisted, at least to a large extent, of positively charged particles. The possibility that these particles might be protons had been suggested; however, there was no direct experimental evidence to support this assumption. Indeed, the prevailing view was still that primary cosmic rays were for the most part positive and negative electrons. During 1938–41, Marcel Schein conducted a series of balloon experiments in which he studied the physical properties of cosmic-ray particles in the highest layers of the atmosphere and was able to show that these particles did not behave in at all the way that high-energy electrons were known to behave. He concluded that electrons did not appear in any appreciable amount among primary cosmic rays, and that the incoming radiation consisted most likely of protons[1].

These experiments remain one of the milestones of cosmic-ray research. However, they were only the beginning of Marcel Schein's work in this field of science. Soon his interest became focused on the most energetic particles present in the primary cosmic radiation and on the remarkable and unbelievably intricate processes that occur when these particles strike atomic nuclei. Marcel Schein was a pioneer in the study of nuclear interactions at energies far exceeding those provided by man-made machines. At the time of his death, he had just returned from an expedition to the Caribbean where, in an effort to extend further and improve the experimental data on high-energy interactions, he had flown the largest stack of nuclear emulsions ever used in any experiment. This stack, which is now being processed, will undoubtedly contain invaluable data the analysis and interpretation of which will keep many physicists busy for a number of years.

Marcel Schein was keenly interested in international scientific collaboration. He travelled extensively in foreign countries, providing great stimulation through his lectures and his informal contacts with scientific workers. He participated most actively in practically all major international conferences dealing with subjects within his field of interest. His last experiment, which I mentioned before, was a truly international venture, with a large number of laboratories, both in the United States and abroad, participating in the analysis of the experimental results.

Marcel Schein was, in many ways, a remarkable man. For him science was a passionate search for the new and the unknown, involving all his scientific skills, as well as his deepest emotions. His sharp mind, his keen intuition, his irresistible enthusiasm and his intense personality will be long remembered by his many friends, pupils, and professional associates in all parts of the world. BRUNO ROSSI

---

[1] Schein, M., Jesse, W. P., and Wollan, E. O., *Phys. Rev.*, **59**, 615 (1941).

Prof. G. P. Mazumdar

PROF. G. P. MAZUMDAR died suddenly on November 21. He was born on February 18, 1894, at Gopalnagar in the District of Pabna, North Bengal (now in East Pakistan), the third son of Kali Charan Mazumdar, a wealthy landlord and Zeminder of the district. After obtaining his B.Sc. at the University of Calcutta in 1913, he joined the teaching staff of the Botany Department, Presidency College, Calcutta. He later obtained his B.A. (1916) and M.Sc. in botany (1915), standing first in order of merit, and in 1917 the B.L. degree from the same University. He was eventually appointed a professor of botany in the Bengal Educational Service in the Presidency College, Calcutta, and from 1928 became one of the postgraduate lecturers in botany at the University of Calcutta. In 1938 he went on study leave to England to work on plant anatomy in the University of Leeds under the late Prof. J. H. Priestley and obtained the degree of Ph.D. in 1940. He retired from the Government service in 1949; but his services were soon requisitioned by the Government of West Bengal for the organization of honours teaching in botany in the Government College, Darjeeling. In December 1951 he was appointed professor of botany and head of the Biology Department, University of Dacca, in East Pakistan, and retired in October 1954. While in Pakistan, he acted as the chairman of the Commission of Courses of the Karachi University and presided over the Section of Biology at the annual session of the Pakistan Association for the Advancement of Science in January 1955. In 1945 he presided over the Section of Botany at the thirty-second Indian Science Congress. He also presided over the Section of Technical Sciences at the All-India Oriental Conference some few years back. He was elected a Fellow of the Indian Academy of Sciences, Bangalore, and National Institute of Sciences of India (1945). He was for a long time connected with the Indian Association for the Cultivation of Science, now at Jadavpur, Calcutta, both as a member and a treasurer. He was also member of other Indian learned societies.

Prof. Mazumdar published a large number of scientific papers in numerous journals throughout the world and several scientific Bengali primers, especially in botany. His writings for children on scientific subjects and botany in Bengali have evoked admiration. He also dealt with botany in ancient India in several books and papers. His "Vanaspati" earned for him the Griffith Memorial Prize of the University of Calcutta in 1925. His "Upavana Binoda" (dealing with horticulture in ancient India) was published in 1938. He published other works on the history of botany. The Asiatic Society awarded him the P. Bruhl Memorial Medal in 1955 for his outstanding researches in botany.

R. M. DATTA

NEWS and VIEWS

Botany at Cambridge: Prof. G. E. Briggs, F.R.S.

ON September 30, Prof. G. E. Briggs will retire from the professorship of botany in the University of Cambridge. Since he succeeded Prof. F. T. Brooks in 1948, he has maintained the notably wide range of teaching and research in the Botany School and has fostered expansion in several branches of the subject. The Department has flourished under his direction, and has benefited greatly from his example of easy friendliness. As a physiologist he has always believed in the value of a quantitative and critical approach both in teaching and research, and his lectures were planned not only to show this but also to indicate the weaknesses of many currently accepted generalizations. He is a brilliant teacher, and for those undergraduates and research students who could rise at least part-way towards his high standard, his lectures and supervision provided a never-to-be-forgotten education. His researches on enzyme kinetics, on growth and photosynthesis early brought him a world-wide reputation as a critical and original thinker. More recently he has entered a new field of research, the biophysics of the plant cell, and his success in this work has drawn to him a flourishing group of research students. In 1952 he became president of St. John's College, but he never allowed the duties of this post to curtail the time he gave to the Botany School.

Prof. H. Godwin, F.R.S.

DR. H. GODWIN, reader in Quaternary research at Cambridge, who has been appointed to succeed Prof. Briggs, is known to a large number of former Cambridge students as an able and enthusiastic teacher of botany at all levels. Outside Cambridge, he may be best known for his large book on the Quaternary history of the British vegetation. His first research was, in fact, in pure plant physiology with Dr. F. F. Blackman, but from early days the inspiration of A. G. Tansley led him to work at Wicken Fen and eventually ecology took up his whole time. Study of fluctuating water-level in the peat and of the effects of this and of cutting reeds on fen vegetation soon directed his attention to the history of this vegetation in the immediate past, and to actual changes in this locality rather than general seral development. Thus he naturally dug in the peat for visible plant remains, and was soon using the methods of pollen analysis worked out not long before by von Post in Sweden. He gradually developed his own blend of the study of pollen, other plant remains and local ecology. He has now a considerable and well-equipped research school. Latterly their work on the more recent peats have been telling such consistent stories that his school have pushed their studies back into the Late Glacial and into the more extensive wilderness of the various Interglacials.

Organic Chemistry in the University of New South Wales : Prof. S. J. Angyal

The newly created chair of organic chemistry in the University of New South Wales (formerly the New South Wales University of Technology) has been filled by the appointment of Dr. S. J. Angyal, formerly associate professor in the University. Prof. Angyal was educated in Hungary and migrated to Australia at the beginning of the War. As lecturer in the University of Sydney, he carried out research on the Sommelet reaction. In 1952, as Nuffield Dominion Travelling Fellow, he spent a year in Sir Alexander Todd's laboratory in Cambridge. He was visiting professor in the University of California in Berkeley in 1957. In the following year he was awarded the H. G. Smith Memorial Medal by the Royal Australian Chemical Institute. Prof. Angyal takes great interest in stereochemistry, and has made important contributions to the chemistry of the inositols. At present he is engaged in work on the application of conformational analysis to carbohydrate chemistry.

Radio Research in Britain : Dr. J. A. Saxton

Dr. J. A. Saxton has been appointed deputy director of the Radio Research Station, Slough (Department of Scientific and Industrial Research), in the grade of deputy chief scientific officer. This appointment is opportune, as he will serve for a period of six months under the present director, Dr. R. L. Smith-Rose, before the latter is succeeded by Mr. J. A. Ratcliffe on October 1 (see *Nature*, February 6, p. 353). Dr. Saxton joined the scientific staff of the Radio Division of the National Physical Laboratory in 1938, and has been responsible for carrying out a considerable programme of research in the propagation of very short radio waves over the ground and through the troposphere. He has studied the electrical properties of gases, water vapour, and water, at very high radio-frequencies, and applied the results to an understanding of the refraction of radio waves transmitted through the lower atmosphere. During 1945, and again in 1950, he was seconded to the United Kingdom Scientific Mission in Washington for liaison duties in radio physics and engineering; and he has made extensive visits in the United States and Canada in connexion with research in radio wave propagation and allied problems. He has been an official delegate of the United Kingdom at meetings of the International Scientific Radio Union (U.R.S.I.) and the International Radio Consultative Committee (C.C.I.R.) in London, Geneva, The Hague, Boulder (Colorado) and Los Angeles. Dr. Saxton has attended senior staff courses at the Administrative Staff College, Henley, and at Peterhouse College, Cambridge. For the past five years. he has been a senior principal scientific officer, and head of a division of the Radio Research Station, and so is well qualified and experienced for the new post of deputy director of the Station.

Atoms for Peace Awards for 1959 and 1960

Drs. Leo Szilard, professor of biophysics in the University of Chicago, and Eugene P. Wigner, Thomas B. Jones professor of mathematical physics, Princeton University, are to share the 1959 Atoms for Peace Award; and Dr. Walter H. Zinn, formerly director of the Argonne National Laboratory, and now vice-president of Combustion Engineering, Inc., and Dr. Alvin M. Weinberg, director of the Oak Ridge National Laboratory, will share the 1960 Award. All have been active in the development of nuclear reactors. Each will receive a gold medallion and will share equally in the combined honorarium of 150,000 dollars. The Awards will be presented at a ceremony to be held at the National Academy of Sciences, Washington, D.C., on May 18. In making the announcement, Dr. James R. Killian, jun., chairman of the Trustees of Atoms for Peace Awards, said:

"The Trustees believe the development of the nuclear reactor is one of the great advances in man's capability for using atomic energy for peaceful purposes. It gives the world a new source of energy with which to meet the growing requirements of modern society for power to run its machines. As a source of radioisotopes, it is now providing science and industry with new possibilities in research and control, as well as with new products. The transformation of a highly complex, theoretical concept of 1939 to the multitude of reactors operating to-day in research and in commercial establishments is a major achievement of modern science and engineering. The men who are selected for recognition by this Award have been leaders in that transformation. Dr. Szilard and Dr. Wigner, both working in the area of nuclear physics, were early advocates of a concerted effort to study the possibilities of nuclear chain reactions. Their interest and concern resulted in the well-known letter of the late Albert Einstein to President Roosevelt which noted that "the element uranium may be turned into a new and important source of energy in the immediate future". These two men held an influential place in the work which resulted in the first nuclear chain reaction and in the subsequent applications of that significant development. Dr. Zinn and Dr. Weinberg participated in the early work and have continued to make important contributions in the field of reactor design and in the administration of research and development efforts in this area."

The Atoms for Peace Award was established as a memorial to Henry Ford and his son, Edsel, in response to President Eisenhower's 1955 appeal at Geneva for international efforts to develop nuclear energy for peaceful purposes. It is granted "solely on the basis of the merit of contribution, wherever found in the world and without regard for nationality or politics".

Ballistic Missile Early Warning Station at Fylingdales Moor

The debate in the House of Commons on March 25 on Mr. T. Driberg's motion that to establish a ballistic missile early warning station on Fylingdales Moor is contrary to the spirit of the National Parks and Access to the Countryside Act, 1949, is chiefly of interest for the reply of the Under-Secretary of State for Air, Mr. W. J. Taylor. Mr. Driberg argued that unless the National Parks Commission was consulted in advance, consultation meant nothing, and he also alleged that some scientific opinion held that the station could not be equipped with a system of radar detection capable of identifying ballistic missiles with certainty. Mr. Taylor repeated the assurance given by the Secretary of State for Air on March 3 that no alternative area was available in Britain and said there was to be very full discussion of the detailed proposals between representatives of the Air Ministry, the National Parks Commission and the Council for the Preservation of Rural England, and while the siting of the radars themselves could not be modified, he hoped that by careful choice of design and attention to landscaping details, the appearance of the completed station should be such that the disturbance to the natural landscape would be generally acceptable. On the certainty of detection, Mr. Taylor said that the opinion quoted was not sustained by the advice of the distinguished scientists who had advised the Government on the project and that in the view of those scientists the system would work. He was informed that there was no difficulty in distinguishing between ballistic missiles and artificial satellites and that the possibility of confusion between a missile trajectory and an ionization trail was so remote that for practical purposes it could be ignored. The Government was satisfied that this system of radar detection was capable of identifying ballistic missiles with very great precision and, moreover, the station was complementary to other methods of obtaining information about hostile intentions and provided the last stage of tactical warning.

Development of Ballistic Missiles

On April 13 the Minister of Defence, Mr. H. Watkinson, in the House of Commons, and the First Lord of the Admiralty, Lord Carrington, in the House of Lords, announced that the Government has been considering the future of the project for developing the long-range ballistic missile *Blue Streak* and has been in touch with the Australian Government about it. The vulnerability of missiles launched from static sites, and the practicability of launching missiles of considerable range from mobile platforms have now been established, and in the light of military advice, the Government has concluded, and the Australian Government has fully accepted, that Britain should not continue to develop, as a military weapon, a missile that could be launched only from a fixed site. The Government is now considering whether the *Blue Streak* programme can be adapted for the development of a launcher for space satellites, and a further statement will be made as soon as possible. There are many other projects for which the range at Woomera will be needed, and a substantial programme of work for that range for some years to come at least is expected.

In reply to further questions Mr. Watkinson said that the cost of the project to date has been about £65 million and that of completing it would be between £500 and £600 million. None of the expenditure would be wasted if it was decided to go ahead with *Blue Streak* as a launcher for a space satellite. The Americans are investing an immense sum of money in space research, both for its military and its scientific and industrial value, and at present Britain could only get into space by the American offer to launch British satellites. *Blue Streak*, in conjunction with *Black Knight*, which has a record of firings practically 100 per cent perfect, is a possible space launching-vehicle, and this combination may give us experience of the utmost military and scientific value.

New Nature Reserve in Scotland

Strathy Bog, an area of 120 acres in the County of Sutherland, has been declared a nature reserve by the Nature Conservancy; this brings the total number of national nature reserves in Scotland to 24 with a total area of 101,809 acres. The new reserve is the least-disturbed part of a vast area of bogland which covers the flat or gently undulating moorlands of this district. The ground is extremely wet, with standing water in the pools throughout the year, and *Sphagnum* moss is prominent in the vegetation, giving a generally spongy surface. In a rich assemblage of bog-plants there are cotton-grasses, sundews, bog asphodel, dwarf birch and bearberry. The area shows certain unusual structural features. Part of the Bog is covered with elongated pools lying parallel to each other, giving the impression that the surface has torn repeatedly under tension caused by the rather fluid mass of underlying peat tending gradually to slide down-hill. Such bogs may thus eventually break up and dry out even when unaffected by human disturbance.

The Nature Conservancy also announces additions to the nature reserve at Rannoch Moor. The original area was 3,485 acres in the north-east corner of the Moor of Rannoch. The new area comprises 200 acres covering a stretch of Loch Laidon and a small area of 19 acres at the southern end of the existing reserve.

International Communications and Scientific Journals

With the rapid growth of new journals the problem of presenting these journals in a form which will make their contents available to readers in other countries becomes more and more acute. To help English-speaking peoples, an increasing number of editors in countries oversea are preparing copies of their journals translated into English. Although this practice is highly commendable from the point of view of English-speaking readers, the journals often fail to make the impact they might because of the inadequacies of the translation. It is extremely difficult to translate the highly technical language of one country into that of another, and, unless special precautions are taken, a translation may produce effects which are not quite what the original research worker had intended. Recent English versions of journals which emanated from France, Czechoslovakia and Japan all indicate that the translations have been carried out by natives of those countries who 'know English well'. Before publication they would have been well advised to submit their publications to English-speaking men of science who also have a good working knowledge of the foreign language concerned. In this way the circulation value of their journals would be considerably enhanced, and many ludicrous statements would be eliminated. Another solution to what is admittedly a most difficult problem might be greater use of an auxiliary language like Interlingua or Esperanto. A world-wide conference to discuss the matter could be of benefit to men of science everywhere.

Abstracting Scientific Information

The Review of the International Council of Scientific Unions for July 1959 contains an article by Prof. E. A. Boutry, secretary of the International Council of Scientific Unions Abstracting Board, describing the work of the Board, its story, ideas, methods and aims, which merits wide reading by scientific workers. Prof. Boutry points out that owing to the rapid increase of the bulk of published scientific information, the probability that printing a paper in a periodical will suffice to ensure that the scientific information it contains will reach the appropriate scientific worker has steadily decreased in recent decades and is likely to continue doing so, nor have editors of abstracting periodicals any certain means of procuring all the literature they should review or learning of its existence. Needless repetition and duplication hamper the work of abstracting periodicals and no mechanical or automatic methods can improve the quality of the literature published or reviewed, or reduce useless duplication. Looking to the future, Prof. Boutry makes various proposals. Authors, he suggests, should voluntarily accept and comply with certain rules in writing their manuscripts. Particularly he advocates submission with the paper of an author's abstracts in two versions, one of which should be written in English or French, composed in accordance with the "Guide for the Preparation and Publication of Synopses" (Unesco). He also deprecates publication of incomplete and incorrect "Letters to the Editor". Editors are asked to agree voluntarily to see that these practices are followed and to waive copyright in respect of such abstracts for members of the Board, while national committees of science and national scientific societies are asked to help in tracking and listing serial or non-periodical publications in their countries and to discourage excessive printing of non-periodical publications.

Carnegie Trust for the Universities of Scotland

The fifty-eighth annual report of the Carnegie Trust for the Universities of Scotland covers the year ended September 30, 1959, in which investment policy has absorbed an exceptional amount of the time of the Executive Committee (pp. iii+73. Edinburgh: Carnegie Trust for the Universities of Scotland, 1960). The new investment policy has substantially improved the income of the Trust, which reached a record high level of £176,564 in consequence. The largest single payment was £33,000 to the University of Glasgow towards the cost of the new arts building, while Edinburgh received £20,000 towards the cost of its new Staff Club. During the year there were on the books two Fellows, three senior scholars and 68 scholars of whom 30 were new appointments, and annual expenditure on the research scheme reached a record level of nearly £27,000. Counting mathematics and geography as arts subjects, forty of the awards were in arts and thirty-three in science; and 22 of the latter were to chemists, including biochemists. Under the new regulations, which discouraged applications from students benefiting from the improvement of local authority bursaries in 1957, while the number of beneficiaries fell from 1,430 in 1957–58 to 568 in 1958–59, the average payment per beneficiary rose from less than £15 to £30 and the total expenditure on fees only fell from £21,500 to just over £17,000. Appendixes to the report include the memorandum of evidence submitted to the Anderson Committee on Grants to Students and the usual reports on the work of Fellows and Scholars and on research grants other than travel grants as well as a list of publications since September 30, 1958, by Fellows, Scholars and recipients of grants. It is noted that three out of the six scholars who have completed their third year of work in chemistry have undertaken post-graduate research in the United States or Canada, but that information suggests that at least half such British research graduates in chemistry eventually return. Assistance given to the Scottish Dictionaries Joint Council was consolidated into an annual grant of £5,000 until 1963 and assistance to Scottish learned societies towards the cost of publications has been restricted to the present level of £2,500 per annum.

Instrument Abstracts

A useful journal for all who work with instruments is compiled by the British Scientific Instrument Research Association (No. 1, Vol. 1, January 15, 1960). It contains details of a wide range of publications in instrument technology with abstracts of many of them. Besides a general section there are sub-sections on astronomy, atomic physics, biology and medicine, chemistry, control, data handling, electricity, electronics, fluid mechanics, geophysics and meteorology, heat, light, magnetism and electromagnetism, materials and design, mechanics, navigation, sound, surveying, and telecommunications. The publications listed have been taken from many countries including France, Germany, Holland, United States and the U.S.S.R. *Instrument Abstracts* is published monthly by Taylor and Francis, Ltd., Red Lion Court, Fleet Street, London, E.C.4. The annual subscription is £4.

U.S.S.R. and the International Geophysical Year

A series of publications concerning various activities in the U.S.S.R. during the International Geophysical Year has been issued. Included are: a classified bibliography of 616 items covering all branches of activities in the U.S.S.R. during the International Geophysical Year ("Bibliographical Index of Literature in Russian Language for 1958." Pp. 63. Moscow: Publ. Acad. Sci. U.S.S.R.); a report on thirteen fulfilled plans of observations, four reports and some articles dealing with geophysical researches carried out with rockets in the United States (Information Bulletin No. 7. Pp. 114. Moscow: Publ. Acad. Sci. U.S.S.R.); a collection of twelve articles dealing with geomagnetism and ionosphere investigations ("Magneto-Ionosphere Disturbances". Pp. 75. Moscow: Publ. Acad. Sci. U.S.S.R.). In each case the text is in Russian; however, there is also a contents in English.

Russian for Scientists

A very slender pamphlet by Prof. J. W. Perry, entitled "Scientific Russian Without Tears", has been issued recently. Unfortunately it is far too short to be of much value to a novice and far too elementary for an advanced student of the Russian language (pp. ii+26. (Reprinted from *The Chemical Bulletin.*) (Chicago: Chicago Section, American Chemical Society, Inc., 1959.) 1 dollar). Its only possible use is as an auxiliary to a normal dictionary in the case of a scientist trying to read Russian scientific literature, but in this case a dictionary of scientific terms would obviously be better. It is "Without Tears" for the simple reason that the majority of words included are international, for example, atom, vector, canal, parameter, etc., and only a knowledge of the Cyrillic alphabet is necessary to read them in Russian. A novice who is struggling with the intricate cases and tenses of the Russian language and cannot ask for a glass of water is invited to read sentences like "rubber similar to isoprene and other unsaturated hydrocarbons takes up bromine". The examples given in this book are mainly from the field of chemistry and physics. Scientists should not content themselves with only picking up a scientific jargon. Unless they know the fundamentals of the language they may misread a scientific article rather than read it. Once they have mastered ordinary Russian, the only additional book they will need is a suitable dictionary.

Films and Film Strips in Teaching

The steady success of the educational films and film-strips produced by Gaumont–British Instructional Films, Ltd., now called Rank Precision Industries, Ltd., was due to clear recognition that they could never be more than aids to learning. The place of the teacher was accepted as paramount and all films and film-strips produced were deliberately designed to support the teacher rather than supplant him. As a result of this policy, Rank Precision Industries, Ltd., is now recognized as a valuable partner by the teaching profession in providing a wide range of both still and moving films. The latest film catalogue describes more than six hundred films in their separate categories with information about their content, running-time, suggested age-group, classification and hire- and purchase-prices. Besides films produced by Gaumont British Instructional, details are given of films produced by Encyclopædia Britannica Films, United World Films, and other organizations. In the film-strip catalogue more than three hundred strips are listed under eighteen subject categories; many of the films are in colour. Both catalogues are attractively produced and can be obtained from the Gaumont-British Film Library, Aintree Road, Perivale, Middlesex.

'Araldite' in Aircraft Research Models

For aerodynamic research, model aircraft of great accuracy and strength are required. A paper, published for the Royal Aircraft Establishment, Bedford, by the Ministry of Supply as Technical Note No. *A.D.W.*6, describes the making of models with shells consisting of 'Araldite' glasscloth laminate. It includes the results of bending tests on 'Araldite' glasscloth panels performed by the Royal Aircraft Establishment, Bedford. These tests show properties of laminates made with various 'Araldite' resins, glasscloth reinforcements and fillers. 'Araldite' epoxy resins, manufactured by Ciba (A.R.L.), Ltd., are extensively used in industry as adhesives, and for casting, laminating, tooling and surface coating. They were chosen by the Royal Aircraft Establishment, Bedford, for model-making because with glasscloth they give laminates with a very high strength/weight ratio. Several models of each type were required and the cold-laminating technique used resulted in these models being identical and of great dimensional accuracy. It is a feature of 'Araldite' epoxy resins that they cure with negligible shrinkage. A description of 'Araldite' and the uses to which it has been put at Bedford has been given by E. J. R. Thomas, of the Wood and Plastics Department (Ciba (A.R.L.), Ltd. Technical Notes No. 206 (February 1960): Model-Making with 'Araldite'. Pp. 12. Duxford: Ciba (A.R.L.), Ltd., 1960).

Measurement of Wind Speeds near a Tornado

An observation has been made of the speed of debris particles whirling round a tornado funnel from enlargements of the separate pictures of a cine film. The maximum value was 212 m.p.h. The observation was made in a tornado which struck Dallas, Texas, on April 2, 1957. On enlargement of the film at the Kansas City Research Unit of the U.S. Weather Bureau it proved possible to identify individual particles of debris whirling round the tornado and compute their tracks and speeds. The observations are reported in the October 1959 issue of the *Monthly Weather Review*.

The Neolithic Revolution

Recently, a British Museum (Natural History) publication entitled "The Neolithic Revolution" has appeared (Pp. vi+60+18 plates. London: British Museum (Natural History), 1959. 5*s*.). The author, Sonia Cole, is well known for her work on certain aspects of African prehistory. The discovery by early man of the possibilities of agriculture and the breeding of animals in captivity produced profound changes not only in his well-being, but also in his outlook on life. This neolithic revolution necessitated communal life, and for the first time man had to live close to his fellow man—not always an easy matter. Food could now be stored and a much larger population could survive. It is not too much to say that we can describe the prehistoric folk prior to these discoveries as our forerunners, those that come after them as our early ancestors. This well-illustrated work discusses such problems as the origins of grain cultivation, the domestication of animals—that is to say, breeding in captivity, not merely taming; flint mining and forest clearance; transport—particularly necessary when a further stage in civilization was reached and the village developed into the town; crafts and buildings.

Fishery Research Training Grants

The Development Commissioners have announced that, in association with the Ministry of Agriculture, Fisheries and Food and the Scottish Home Department, they will award postgraduate training grants in fishery research tenable from October 1. These training grants are intended to enable selected candidates to undergo a specified course of training to fit them for the investigation of problems in marine or freshwater science. Candidates must be British subjects and should be graduates with honours in science of a British university or possess equivalent qualifications. The value of the awards will be £420–£270 per annum depending on where the research training is carried out. Further information can be obtained from the Secretary, Development Commission, 3, Dean's Yard, Westminster, London, S.W.1. Applications should reach the Commissioners on or before May 20.

The British Textile Institute

The Textile Institute celebrates its golden jubilee this year, and in its awareness of the importance of science in the textile industry the theme of the annual conference will be "Fibre Science". The meeting will be held in London during May 30–June 3. The conference will be opened by Sir Harry Melville, who will speak on the impact of modern chemistry on industry in general. Other speakers will include Prof. J. B. Speakman (University of Leeds), Prof.

M. J. Lighthill (Royal Aircraft Establishment, Farnborough), the Rt. Hon. Douglas P. T. Jay, M.P., Prof. D. T. Jack (University of Durham), Prof. W. T. Astbury (University of Leeds), Prof. R. Meredith (Royal College of Science and Technology, Glasgow), Prof. R. Nicholson (Royal College of Art), Prof. Janey Ironside (Royal College of Art) and Sir Walter Puckey (chairman, Automation Consultants and Associates, Ltd., and of Management Selection, Ltd.). Further information can be obtained from the Golden Jubilee Conference Organizer, Textile Institute, 10 Blackfriars Street, Manchester 3.

Advisory Committee on Scientific Work of the Infestation Control Laboratory

THE Minister of Agriculture, Fisheries and Food has appointed the following committee to advise and report annually on the programme of experimental and research work of the Infestation Control Laboratory of the Ministry: Prof. J. B. Cragg, professor of zoology in the University of Durham (*chairman*); Mr. H. R. Hewer, reader in zoology, Imperial College of Science and Technology; Dr. T. Moran, director of research for the Research Association of British Flour Millers, St. Albans, Herts; Mr. F. Rayns, director of the Norfolk Agricultural Station, Sprowston, Norwich; Prof. H. G. Sanders, chief scientific adviser (agriculture), Ministry of Agriculture, Fisheries and Food; Prof. V. C. Wynne-Edwards, professor of natural history, University of Aberdeen. The secretary of the Committee is Miss Y. Larthe. Assessors to the Committee are: Mr. A. S. Fortune, chief inspector, Department of Agriculture for Scotland; Dr. R. A. E. Galley, director of the Tropical Products Institute, Department of Scientific and Industrial Research; Mr. G. V. B. Herford, director of the Pest Infestation Laboratory, Slough, Bucks; Mr. G. G. Samuel, Agricultural Research Council; Dr. E. B. Worthington, deputy director-general (scientific), Nature Conservancy.

Announcements

H.M. THE QUEEN has conferred the Order of Merit on Sir Cyril Hinshelwood, Dr. Lee's professor of chemistry in the University of Oxford and president of the Royal Society. Lord Radnor, chairman of the Forestry Commission since 1952, has been appointed a knight of the Order of the Garter.

DR. RICHARD O. ROBLIN, vice-president for research and development of the American Cyanamid Company, who is known for his work on sulphadiazine and sulphamerazine, has been elected president and director of the Cyanamid European Research Institute in Geneva; Dr. Mario Scalera, assistant to the general manager of the Central Research Division of Cyanamid, has been elected a vice-president of the Institute. The Institute, which last year acquired eight and a half acres of land for its laboratories in Geneva's Cologny section, will be devoted to long-range, basic research in the chemical and related fields.

THE Trustees of the Rockefeller Foundation have authorized a grant of 30,000 dollars to the Marine Biological Association of the United Kingdom for the purchase of research equipment for use in the Plymouth laboratory.

THE Latin American school of physics is to be held this year at the Centro Brasileiro de Pesquisas Físicas, under the auspices of Conselho Nacional de Pesquisas do Brasil, Academia Brasileira de Ciências, Campanha de Aperfeiçoamento de Pessoal de Nível Superior, Pan American Union and Unesco, during June 27–August 7. Further information can be obtained from J. Leite Lopes, Centro Brasileiro de Pesquisas Físicas, Av. Wenceslau Braz, 71 Rio de Janeiro, Brazil.

THE thirtieth annual report of the University Research Committee, University of Birmingham, gives a summary of departmental research progress during the academic year 1958–59. Lists of papers published during the year and of titles of those approved for higher degrees during the period are included in each departmental report, arranged alphabetically by authors (pp. 123. Birmingham: The University, 1960). A selected list of general works and further writings by members of the University staff is appended, arranged under faculties.

THE International Atomic Energy Agency is issuing a world list of institutions concerned with atomic energy (Gen./Pub. No. 3). The list is being issued at irregular intervals as a series of publications; each publication covering a Member State of the Agency. The list is intended to facilitate the exchange of information on nuclear energy between scientists, engineers, research workers and administrators in Member States. Copies can be obtained from the Scientific and Technical Information Division, International Atomic Energy Agency, Kärntner Ring, Vienna.

AN international conference on Powder Metallurgy is to be held at the Hotel Beltmore, New York City, during June 13–15. Further information can be obtained from Mr. Kempton H. Roll, Metal Powder Industries Federation, 60 East 42nd Street, New York 19.

THE sixth Commonwealth Mycological Conference will be held during July 15–22 at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1. Further information can be obtained from the Director, Commonwealth Mycological Institute, Ferry Lane, Kew, Surrey.

THE thirteenth symposium in biology at the Brookhaven National Laboratory on Protein Structure and Function will be held during June 6–8. Further information can be obtained from Dr. D. E. Koshland, jun., Department of Biology, Brookhaven National Laboratory, Upton, L.I., New York.

THE second annual conference of the British Computer Society, Ltd., is being held during July 4–7 at the Sun Pavilion, Harrogate, Yorkshire. Further information can be obtained from Miss D. E. Pilling, Electronic Computing Laboratory, The University, Leeds 2.

THIS year the Charité (Faculty of Medicine), Humboldt University, Berlin, celebrates its 250th anniversary, and functions will be held in conjunction with the 150th anniversary of the University. Further information can be obtained from Dr. Dagobert Müller, secretary of the Committee for Preparations of the 250th anniversary of the Charité, Berlin, N.4, Schumannstrasse 20–21.

ERRATUM. In announcing the award of the J. Lawrence Smith Medal of the U.S. Academy of Sciences to Dr. E. J. Öpik (see *Nature*, April 23, p. 280), it was stated that Dr. Opik is director of the Armagh Observatory; he is, in fact, a research associate of the Observatory, the director of which is Dr. E. M. Lindsay.

THE NATIONAL SCIENCE FOUNDATION, WASHINGTON

As in last year's report, rather more than half the ninth annual report of the (U.S.) National Science Foundation*, covering the year 1959, is occupied by appendixes listing the members of the National Science Board, its staff, committees and advisory panels, the grants for basic research and other purposes, grants for the International Geophysical Year programme, fellowship awards and publications, together with the financial report. About a quarter of the remainder deals with the re-appraisal and re-organization of the status of science in the United States, 1958–59, including a brief account of the two reports, "Strengthening American Science" and "Education for the Age of Science", coming from the President's Science Advisory Committee. This section, and the Chairman's foreword and the Director's statement, are discussed separately (see p. 341 of this issue); the remaining parts of the report, which review the activities of the Foundation itself, are reviewed here.

The significant increase in the support given by the Foundation to basic research in the United States from 25 million dollars in 1958 to almost 65 million dollars in 1959, should be noted first; this includes some 15·5 million dollars for research facilities, of which 12·3 million dollars were in support of facilities in mathematical, physical and engineering sciences. Support in the biological and medical sciences covers a wide range in developmental and environmental biology, systematic and regulatory biology. In genetic biology it is directed towards elucidating the nature of genetic material, the laws governing the transmission of hereditary traits, and the mechanisms controlling and determining the expression of hereditary characters; in metabolic biology, towards the mechanisms of protein synthesis and growth and specific metabolic factors which inhibit growth; in molecular biology, towards the investigation of the structure, synthesis and reactivity of peptides and proteins; and in psycho-biology, to the support of quantitative techniques in physiological and experimental psychology as these develop from mathematics and mathematical statistics.

In mathematical, physical and engineering sciences, a new programme for atmospheric sciences was established, under which the weather modification programme is now handled. Grants in chemistry were chiefly in organic and physical chemistry, while in the Earth sciences, support for oceanography was increased. In the engineering sciences, special reference is made to two grants in plasma dynamics, while the physics programme continued to place major emphasis on high-energy physics, particularly cosmic rays, and increasing attention was given to low-temperature research. Many of the facilities of the National Radio Astronomy Observatory are now approaching completion or actually in operation, and construction of the Kitt Peak National Observatory was started in 1959, where besides a 36-in. and an 84-in. reflector for stellar observations, it is proposed to instal a solar telescope with a parabolic mirror 60 in. in diameter and a focal length of 300 ft.

An Office of Social Sciences was established during the year to support research and related activities in social science disciplines, for which grants during the year totalled 853,000 dollars, including anthropological sciences, sociological sciences, economic sciences and the history and philosophy of science. The Antarctic Research Programme, which received 2·3 million dollars, is supported on a geographical basis and an interdepartmental committee has been set up by the Foundation to examine proposals and programmes of the various agencies and the broad programme suggested by the Committee on Polar Research of the U.S. National Academy of Sciences.

Among the significant research developments of the year to which the report directs attention are the sunspot photographs obtained with the *Stratoscope I* 12-in. balloon-borne solar telescope; the resolution of the galactic nucleus Sagittarius *A* with the new 85-ft. Tatel radio-telescope at Greenbank, West Virginia; the use of a new technique of testing for perception of visual depth to throw light on native and learned factors in the perception of distance; the synthesis of a pituitary hormone of 13 amino-acids linked in a specific sequence resembling adrenocorticotrophic hormone in structure; the identification of a catalytic factor from blood which can transform 1,000–10,000 times its own weight of soluble fibrin into the insoluble form; the discovery of a mollusc thought to be extinct for nearly 300 million years; the establishment of migrations of *Sequoia* from tropical swamps 60 million years ago through adaptation to drier and cooler climates; and the development of a tetrahedral anvil which can generate pressures up to 100,000 atm. at 3,000° C.

During the year the Foundation sponsored and provided partial support for 41 scientific conferences and symposia and awarded 419 grants, totalling 330,000 dollars, to enable scientists to attend international meetings. Fellowship awards totalled 3,937, amounting to about 13·1 million dollars, and with those assisted under the research grants programme, the number of scientists assisted during the year was about 6,000. Of the fellowships, 965 were in the biological and medical sciences, 2,857 in the physical sciences (chemistry, 730; geological sciences, 195; engineering sciences, 558; mathematical sciences, 689; physics, 663), and 59 in the social sciences. Of the total, 1,100 were pre-doctoral, 194 post-doctoral and 83 senior post-doctoral; 302 science faculty fellowships were awarded for improving the quality of science teaching, as well as 628 summer fellowships to secondary school teachers of science and mathematics, 580 summer fellowships for graduate teaching assistants, and 1,050 co-operative graduate fellowships of 2,200 dollars for 12 months. The plans for improving the quality of science teaching by assisting teachers in secondary schools to extend their knowledge of science and of new developments comprise four main programmes on which 33·25 million dollars were expended in 1959. The summer institutes programme provided stipends to

---

* National Science Foundation. Ninth Annual Report for the Fiscal Year ended June 30, 1959. Pp. xvii+274 (12 plates). (Washington, D.C.: Government Printing Office, 1960.) 1 dollar.

20,000 participants. Besides teachers in secondary schools and colleges attending 348 'courses' varying in length from 4 to 12 weeks, 515 teachers and supervisors in elementary schools received training in 12 summer schools; technical school personnel were provided for in two experimental summer programmes and 546 college teachers of science and mathematics attended 20 summer conferences dealing with special fields of science and mathematics. Under the Academic Year Institute programme, providing a year's study in science and mathematics for secondary school teachers, awards were made to 32 colleges and universities, and it is estimated that the 1959–60 programme will support more than 1,500 teachers; while opportunities for further study in out-of-school hours will be provided to about 9,000 secondary school teachers under the In-Service Institutes programme. Special projects in science education on which nearly 9 million dollars was expended cover visits of scientists to secondary schools, the provision of a travelling science library of carefully selected books for high schools, a travelling science demonstration lecture programme for secondary schools and support for summer training of secondary school students. The State Academies of Science, the College Programme and Teacher Improvement Programmes provide for visits by scientists, and foster the participation of undergraduates in research, supplementary training for science teachers and eight special field institutes covering advanced training in highly specialized subjects. On the Course Content Improvement Programme, a further 6 million dollars was expended on projects in elementary and secondary schools and in colleges; this included supplementary teaching aids such as films and television. Activities under the International Science Education Programme initiated during the year include the improvement of science curricula and the training of teachers and also measures to assist science students and scientists to engage in international educational programmes.

The Scientific Man-Power Programme, on which 780,000 dollars was expended in 1959, besides maintaining the National Register of Scientific and Technical Personnel, initiated surveys of scientific and technical employment in private industry and State Governments, of scientific and technical personnel in colleges and universities, and of scientists and engineers in Federal Government employment engaged in research, and pilot studies of the demand for scientists and engineers in several industries. Reports were completed on the knowledge of foreign languages of American scientists in 1954–55, on scientists and engineers in American industry in January 1957, and on employment and other characteristics of American scientific man-power during 1954–55. The measurement and appraisal of the national research and development effort is a major responsibility of the Foundation, and its Office of Special Studies has now completed its surveys of the year 1953–54; its present programme of statistical surveys proposes a detailed survey of each sector every four or five years, summary data only being collected in the intervening years. During the year, a survey was made of expenditure on scientific research and development in the fiscal years 1958, 1959 and 1960, and a survey of scientific research and development expenditure and man-power in colleges and universities during 1957–58 is now being conducted, following the publication of the report on the 1953–54 survey.

During the year, further responsibilities for improving the availability of research information to scientists were assigned to the Foundation by the National Defense Education Act, 1958, and accordingly the Office of Science Information Service and the Federal Advisory Committee on Scientific Information have been established. For the dissemination of scientific information, 146 grants totalling 3·8 million dollars were made for such purposes as documentation research, the international exchange of scientific information, the support of scientific publications and information services and the dissemination of unpublished research information such as unpublished Government research reports. Studies of the flow of information among scientists and of the scientific activity of chemists were completed during the year and five mechanical translation projects are at present supported, as well as the effort of 28 professional societies and academic institutions in providing translations of 35 Russian scientific and technical periodicals and 18 books and monographs. A Foreign Technical Information Centre has been established in the Office of Technical Services of the Department of Commerce, where scientific and technical translations prepared by Government agencies are collected, and their availability is announced. Support of scientific publications covered the issue of *Physical Review Letters*, an experiment in rapid low-cost publication of short, up-to-the-minute articles on physical research, support for the *Journal of Geophysical Research* and a grant to enable *Biological Abstracts* to extend its coverage; while grants in support of information services include one to the Bio-Sciences Information Exchange, administered by the Smithsonian Institution, and continued support to the Office of Critical Tables of the U.S. National Academy of Sciences.

THE PUBLIC AND THE BROADCASTING PROGRAMMES IN BRITAIN

THE British Broadcasting Corporation has issued a report on an inquiry carried out at the end of 1958 by its Audience Research Department*. Its first chapter describes the public and the facilities which are available for listening and viewing, comparing the public which depends solely on sound broadcasting with that which has television as well, and also contrasting viewers who can receive B.B.C. television only, with those who can also receive Independent television. The following three chapters deal successively with listening in the evening, viewing in the evening and listening in the day-time, contrasting the amount of listening or viewing, the selectiveness of listeners or viewers and the distribution of their patronage. A fifth chapter discusses the tastes of listeners and viewers as they emerge when people have a chance to express their views in respect of a range of categories of programme output, and includes a comparison of the tastes of men and women of different age groups and different educational levels. Each chapter ends with a summary of its main findings, but a concluding section of the report entitled "Highlights and Reflections" attempts to view the results as a whole.

---

* British Broadcasting Corporation. The Public and the Programmes: an Audience Research Report on Listeners and Viewers, the time they devote to listening and viewing, the Services they patronize, their Selectiveness and their Tastes. Pp. 71. (London: British Broadcasting Corporation, 1959.) 3*s*. 6*d*.

At the present time there are three distinct publics. The first, 'Band 1/3', which can receive both B.B.C. and Independent television and also sound broadcasting (now about half the population), is gradually swallowing up the other two: 'Band 1', which can receive B.B.C. television and sound (now about 20 per cent), and the 'sound only', which cannot receive television (now about 30 per cent). About 15 per cent had very high frequency receivers, and three-quarters of these are in television homes. The 'sound only' public is somewhat older and of a slightly higher educational level than the 'sound and television' public, and on average families in this group are a good deal smaller than 'sound and television' families. The 'Band 1' public also was somewhat older and of a rather higher educational standard than the 'Band 1/3' public.

The typical viewer watches television in winter for approaching two hours each evening, and this means that at peak hours not far short of half the adult population is watching television. The typical listener has his radio on for not much more than half an hour a night and will usually be doing something else at the same time. In television homes sound broadcasting is used very little in the evening, and after 6 p.m. it is catering primarily for people who have no television set. The vast majority of its day-time audiences, particularly in the early morning period and on Sundays, consists of people who have television sets. The inquiry showed that most people exercised their opportunity to choose between different programme services; those who did so, both viewers and listeners, outnumbering single-service loyalists by about two to one; but those who settled for one service were by no means homogeneous in either choice or tastes. There was an abnormally high proportion of discriminating listeners among those who limit their listening to the Home Service, and an abnormally high proportion of discriminating viewers among those who, though they could view Independent television, rarely did so.

A relation was noted between the amount of time people devote to listening or viewing and the services they patronize. The more time a person spends in listening the greater the proportion of that time he is likely to give to the Light Programme; similarly, the more he views, the greater is likely to be the proportion of his time spent in viewing Independent television. The inquiry showed that the less a person listens or views the more likely he is to be selective, and the more selective he is, the more likely he is to prefer the kinds of programme characteristic of the Home Service and the B.B.C. television than of the Light Programme and Independent television. Again, the older a listener is, the less likely he is to enjoy feature films, crime series, or westerns. Sex is sometimes predictive, women being more likely than men to be 'heavy' consumers of both sound and television in the evening. Science features on television, ranging sixteenth out of eighteen categories in popularity with the public, were not unpopular with men but were unpopular with women and most unpopular with viewers over sixty. Their popularity increases with each step up the educational level, and most often the individual's behaviour, attitudes and tastes tend to be associated with the age when his full-time education ceased, and/or 'occupational status', frequently reinforced by information about the newspapers he reads. Again and again the report demonstrates that the higher the individual's cultural level, the less he tends to listen or view, the more likely he is to be selective and to take an interest in serious types of programmes. Whatever measure of 'cultural level' is used, the population appears as a sharply tapering pyramid, and, accordingly, the more a type of broadcasting output or service depends for its custom upon people who have enjoyed cultural advantages or want something more than the undemanding relaxation, the more numerically restricted its audience is likely to be. So far as science is concerned the inquiry indicates that nearly all effective viewing is on B.B.C. television and hence anything that prejudices B.B.C. television as against Independent television would be liable to prejudice the use of television in the presentation of science to the public.

AUTOMATION AND ITS HUMAN REPERCUSSIONS

THE mental health problems of automation were examined recently by a World Health Organization study group (Study Group on the Mental Health Problems of Automation. (World Health Organization Report, Series No. 183.) Pp. 30. Geneva: W.H.O.; London: H.M. Stationery Office, 1959). It is not automation in the form of automatic co-ordination of machine tools on production lines, nor in the form of automatic control over manufacturing processes, that is liable to bring about the most revolutionary changes in mechanized work, but the rapid and automatic processing of an increasing range of technical and business information by the electronic digital computer.

Emotional reactions to automation range from unreasonable hopes of a rapid rise in living standards to fears of upheavals in conditions of employment and of difficulty in adaptation to the new machines. These reactions are of an anticipatory nature and are not based on actual experience. In the meantime, workers in automated undertakings are already suffering from physiological and psychological strain.

Because of its nature, automated work may have psychological consequences: for example, if the manual activity of a worker who has been accustomed to assess his work on the basis of his physical effort is reduced, he will feel himself less useful and suffer from a sense of inadequacy; if contact with the machine or with the object on which he is working is eliminated or reduced, he will see his task in a more abstract form and this may lead to anxiety; if his responsibility is increased his job may become more of a strain.

What kind of strains are imposed upon the worker ? First, there is the nervous strain caused by the need of unremitting attention to signals of varying perceptability, often separated by long intervals. The less the physical activity of such a worker and the greater the number of indicators to be watched, the more the nervous tension to which he will be exposed. In these circumstances particular importance will be attached to working conditions, such as temperature, sound-proofing, lighting, and the position of the operator and the machines. By preventing the operator from communicating with others, automated work tends to isolate him both physically and mentally. This feeling of isolation may be heightened by the background noise made by the machines.

In addition to its direct effects upon the workers' mental health, automation will undoubtedly have indirect social consequences. Families may, for example, be affected by the increased mobility of labour. The most serious difficulties indirectly affecting mental health are, however, liable to arise in connexion with the organization of the work itself. If automation calls for more shift work (as appears likely), this will certainly be opposed by the workers and their families.

Automation may provide certain satisfactions ; for example, in an entirely automated plant, each operator becomes more or less his own master ; the gap lessens between the factory worker and the office worker, and changes of occupation in middle age should be easier.

Efforts to mitigate the harmful effects of automation on mental health should be based on information and education. Education will be all the more effective if it is directed primarily towards those in key positions, that is to say, managers, engineers, trade-union leaders and the medical profession, particularly works doctors.

EMPLOYMENT OF WOMEN IN BRITAIN

THE Institute of Personnel Management has published under the title "Working Wives" a survey of facts and opinions concerning the gainful employment of married women in Britain carried out in co-operation with Mass Observation, Ltd., by Viola Klein during the autumn months of 1957, when out of 12,820,000 married women in Great Britain nearly 4 million were gainfully employed (Occasional Papers, No. 15. Pp. 63. London: Institute of Personnel Management, 1960. 7*s.* 6*d.*). Thus, in about one out of every three households the wife contributes by her earnings to the family income, but the apparent steep rise in the employment of married women since 1951 is due to the Population Census seriously underrating the number of married women in employment, particularly part-time. The outstanding impression gained by the survey is that women's lives to-day are dominated as much as ever by their role—actual or expected—as wives and mothers, and all other occupations are subordinated to their responsibility for home and family. The growth in the number of married women going out to work is due to the smaller size of their families and the general reduction in housework through the modernization of household techniques, combined with a striving to improve their standards of living. It is not widely assumed that married women should have jobs, although among the more highly educated single women in the sample nearly one third wished to continue their careers after marriage ; this is nearly double the percentage in the next occupational group of women willing to continue in employment not merely temporary. The taking up of employment by married women appears to result from unforeseen though not unforeseeable circumstances, and men appear to be less conservative in their outlook in these matters than they are usually assumed to be.

Slightly more than one half the married women in employment have part-time jobs, which may be in the region of 4–30 hr. per week. The sample also showed that two-thirds of the women in part-time employment are engaged in unskilled or semi-skilled work, and that shorthand typing is the occupation least likely to offer any scope for the married woman who wishes to supplement her income by part-time employment. In some smaller occupational groups, such as teachers, nurses, social workers, a shortage of trained staff has opened the doors to part-time employees, and though the problems involved have not yet received the attention they deserve, more opportunities may well be offered here in the future for married women to combine a career with having a family. Women, in fact, it is concluded, are an essential and distinctive part of our man-power resources.

EXPLORATIONS OF THE GALÁPAGOS ISLANDS

THE Galápagos Islands have recently attracted widespread attention as a result of the Darwin centenary and the measures at present being taken to preserve and study their flora and fauna. The Galápagos Islands have been one of the principal fields of endeavour of the California Academy of Sciences since its first expedition there during 1905–6, and its collections from the archipelago are unsurpassed. It is therefore appropriate that the Academy should publish a short history of the islands by the late Joseph Richard Slevin, for more than fifty-three years associated with its Department of Herpetology, and a member of the original expedition, who for half a century maintained an active interest in the islands and published a number of scientific and popular papers about them (Occasional Papers of the California Academy of Sciences. No. 25: The Galápagos Islands : a History of their Exploration. By Joseph Richard Slevin. Pp. x+150. San Francisco : California Academy of Sciences, 1959).

This publication gives a description of the islands, their geology, climate, and fauna, but it is mainly concerned with their history. An immense amount of literary research has gone into it, and the author has ransacked the archives of America and Europe to bring together the information that he has skilfully welded into a fascinating account of the islands from their discovery to the present day. He has consulted the original log-books of the early explorers, official reports from naval officers of many nationalities engaged on surveying, and the letters and logs of whalers and tortoise-oil hunters. There can be few records of visits to the islands that he has not seen, and his illustrations range from reproductions of Cowley's drawings made in 1684 to photographs of many interesting nineteenth-century ships that worked there, and of living giant tortoises and of the devastation of broken carapaces left by the oil hunters. The paper concludes with a notice of all the scientific expeditions that have been at the Galápagos, sections on the giant tortoises and the preservation of the fauna, and a select bibliography. Slevin could have wished for no better monument.

L. HARRISON MATTHEWS

THE AUSTRALIAN DEFENCE STANDARDS LABORATORIES

THE annual report of the Defence Standards Laboratories of the Department of Supply, Australian Defence Scientific Service, for the year ended June 30 1959, the staff of which numbered 621 at the end of the year, compared with 637 at July 1, 1958, includes lists of senior and professional staff, papers published, and committees on which the Laboratories' staff have served*. The Laboratories, besides providing a scientific advisory service to those concerned with development, manufacture, inspecting, procurement, storage and use of defence material, have a recognized function of research, both in relation to their scientific advisory function and in advising and assisting the defence services on the development of new and improved materials, methods and equipment. The range of the Laboratories' activities may be illustrated by mentioning a few of the investigations on which some notes are given in the report.

In chemistry these include studies of the pore structure and other physical characteristics of brown coal and copra charcoals, the oxidation of phosphorus in the decomposition of cast iron by acid, determination of minute amounts of ammonia by Nessler's reagent and of small amounts of tin, and of the dyeing of textiles. In metallurgy the study of chromium and chromium base high-temperature alloys continued, as well as of the production of pure chromium, the processing, properties and structure of chromium and chromium alloys and also on titanium alloys. In physics, further experience was gained in the technique of electron spin resonance, the use of X-ray diffraction in studying the structural changes in the ageing of titanium–chromium alloys, and on the stabilization of a.c.-line voltages. A stable electric arc was developed, and further work carried out on precise load measurement and the determination of gamma-ray source strengths. Miscellaneous work included improvements in electrophotography such as improved particulate photoconductor coatings of acceptance to charge on the surface, uniformity, sensitivity and spectral response, and the study of thin selenium films for xerography.

---

* Commonwealth of Australia. Annual Report of the Defence Standards Laboratories for the year ended 30th June, 1959. Pp. iv+75. (Maribyrnong, Vic.: Defence Standards Laboratories, 1959.)

HETEROGENEITY OF LECITHINS LABELLED WITH PHOSPHORUS-32

By DR. F. D. COLLINS
Biochemistry Department, University of Melbourne

SINCE the first use of phosphorus-32 in 1937 [1] for the study of phospholipid metabolism an immense amount of work has been done using this isotope; but in every case the results have been limited by the analytical methods used to separate the very complicated mixture of naturally occurring phospholipids. In the early work, for example, lecithin was isolated as the ethanol-soluble material, but this was far from pure. In more recent years the use of chromatography on alumina[2,3] or silicic acid[3] has yielded lecithins which analysed correctly in that the molar ratio of phosphorus : choline : fatty acid plus fatty aldehyde was equal to 1 : 1 : 2. In addition mild alkaline hydrolysis[4,5] of lecithin has been shown to yield glyceryl–phosphoryl–choline, which could be isolated and purified by paper chromatography. The use of these procedures enabled the mean specific radioactivity to be determined but took no account of the possible effects of the different fatty acids and fatty aldehydes that were present. Because of the absence of methods for fractionating the lecithins it has had to be assumed that any variation between lecithins was not large enough to invalidate comparisons of the specific radioactivities between the lecithins and other phospholipids. The following experiment shows that quite large variations in specific radioactivity can exist between different lecithins.

A rat (310 gm.) was injected intravenously with 0·8 mc. of labelled sodium dihydrogen phosphate in 0·1 *M* sodium chloride and 0·001 *M* sodium dihydrogen phosphate and killed after 90 min. The liver lipids were extracted, dinitrophenylated and methylated as described by me[6], and then divided at −18° into an acetone-soluble and an -insoluble fraction. The acetone-insoluble materials were free of dinitrophenyl-containing lipids, and countercurrent distribution (120 transfers) in carbon tetrachloride–chloroform–methylene chloride–methanol–

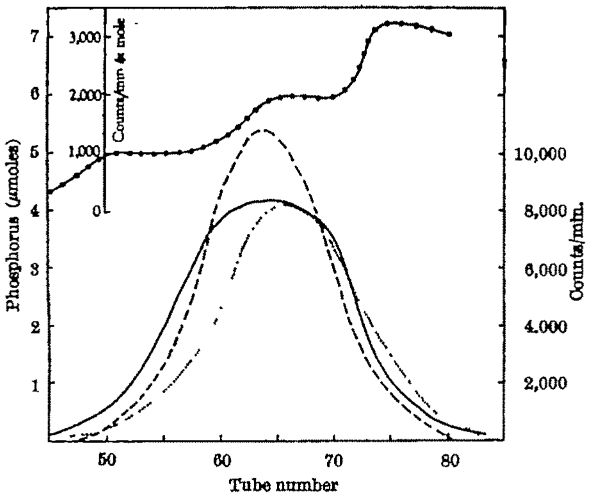


Fig. 1. Counter-current distribution of lecithin in carbon tetrachloride–methanol–water. —, phosphorus (μmoles); . . ., counts/min.; – – –, theoretical curve (phosphorus μmoles); · – · – ·, specific radioactivity counts/min./μmole

water (25 : 15 : 10 : 40 : 10 by volume) showed that lecithin (partition coefficient = 0·20) constituted 81 per cent of this fraction. The contents of the tubes containing the lecithin (mean specific radioactivity 1,750 counts/min./μmole) were combined and redistributed (120 transfers) in carbon tetrachloride–methanol–water (62 : 35 : 3·15 by volume) and the distribution obtained is shown in Fig. 1.

The theoretical distribution of 76 μmoles of a pure material with a partition coefficient of 1·15 is shown, and it will be seen that the experimental curve is broader and lower than that which would be expected for a pure compound. The curve for the radioactivity is skew, and the plot of the specific radioactivity shows a stepwise curve increasing in the more polar direction; the mean specific radioactivity is 1,690 counts/min./μmole but varied between 600 and 3,250 counts/min./μmole.

The lecithins were divided into three fractions obtained by combining the contents of the tubes as shown in Table 1. Each fraction was submitted to mild alkaline hydrolysis[4,5] and the water-soluble products subjected to paper chromatography in phenol–water (saturated). In each case a phosphate spot was detected[7] with an R_F of 0·90–0·95 which corresponded to glyceryl–phosphoryl–choline. The spot was cut out, extracted with water and the specific radioactivity of the phosphorus determined. The ether-soluble material remaining after the mild alkaline hydrolysis was further hydrolysed by heating with N potassium hydroxide in ethanol for 1 hr. The unsaponifiable material was extracted with diethyl ether from the alkaline digest and discarded. The mixture was then acidified and the fatty acids extracted with diethyl ether. The uptake of hydrogen of the fatty acids in the presence of a platinum catalyst was measured as an indication of the degree of unsaturation with the results shown in Table 1.

Table 1. COUNTER-CURRENT DISTRIBUTION OF LECITHIN

After distribution in carbon tetrachloride–methanol–water the contents of the tubes shown below were combined and analysed

Fraction	*A*	*B*	*C*
Tube Nos.	44–59	60–70	71–83
Phosphorus (μmoles)	21·4	40·0	13·1
Specific radioactivity (counts/min./μmole phosphorus)			
Calculated from graph	1,000	1,750	2,520
From isolated glyceryl-phosphoryl-choline	985	1,930	2,750
Absorption of hydrogen (ml. at S.T.P.) per 100 mgm. fatty acids	6·89	9·14	Insufficient for analysis
Apparent 'partition coefficient'	0·85	1·22	1·73

There was close agreement between the specific radioactivity measured on the intact lecithin and the isolated glyceryl–phosphoryl–choline. Fraction *B* was more unsaturated than *A* but unfortunately there was insufficient material for the examination of fraction *C*. Synthetic dimyristoyl lecithin had a partition coefficient of 0·9 in carbon tetrachloride–methanol–water while the mid-points of fractions *A*, *B* and *C* correspond with partition coefficients of 0·85, 1·22 and 1·73 respectively. These results indicate that the saturated fatty acids predominate on the non-polar side of the distribution and the unsaturated ones on the more polar portion. Thus one can conclude that lecithins containing the more unsaturated fatty acids exchange more rapidly with inorganic-phosphate.

A preparation of a mixture of phosphatidyl ethanolamine and phosphatidyl serine (after dinitrophenylation and methylation) from the same animal as that used for the lecithin referred to above showed a similar skew distribution of radioactivity both in carbon tetrachloride–methanol–water (62 : 35 : 3·15 by volume) and in petroleum ether (b.p. 110–120°) : methanol. The specific radioactivity ranged from 10,600 to 16,500 counts/min./μmole phosphorus with the highest values on the more polar side of the distribution. The fatty acids were not examined and in this instance there was about 80 per cent phosphatidyl ethanolamine and 20 per cent phosphatidyl serine, but previous work had shown that there is little or no separation of these two phospholipids in the solvent system used. In spite of these limitations it is very likely that this skew distribution is also due to the partial segregation of phospholipids with differing fatty acid compositions.

The two examples given here show a range of specific radioactivity but their means still differ significantly. However, in other cases the results may not be so clear cut and some of the conclusions reached by the use of radiophosphorus may have to be revised. It will be necessary to fractionate each phospholipid in order to study the correlation between fatty acid composition and the turnover of the lipid-phosphorus.

Chromatography on silicic acid can be used[8] but counter-current distribution of the purified phospholipids provides a means in which the separations can be precisely controlled.

I am indebted to Dr. K. W. Zimmermann, Commonwealth Scientific and Industrial Research Organization, Melbourne, for the determination of hydrogen uptake of the fatty acids.

[1] Artom, C., Sarzana, G., Perrier, C., Santangelo, M., and Segre, E., *Nature*, 139, 1105 (1937).
[2] Lea, C. H., Rhodes, D. N., and Stoll, R. D., *Biochem. J.*, 60, 353 (1955).
[3] Hanahan, D. J., Turner, M. B., and Jayko, M. E., *J. Biol. Chem.*, 192, 623 (1951).
[4] Dawson, R. M. C., *Biochim. Biophys. Acta.*, 14, 374 (1954).
[5] Benson, A. A., and Maruo, B., *Biochim. Biophys. Acta.*, 27, 189 (1958).
[6] Collins, F. D., *Biochem. J.*, 72, 281 (1959).
[7] Hanes, C. S., and Isherwood, F. A., *Nature*, 164, 1107 (1949).
[8] Hanahan, D. J., Dittmer, J. C., and Warashina, E., *J. Biol. Chem.*, 228, 685 (1957).

MECHANISM OF THE GASTRIC SECRETION OF HYDROGEN IONS

By PROF. SPYRIDON G. A. ALIVISATOS

Mount Sinai Medical Research Foundation and Hospital, Chicago Medical School

THE experimental work and theories proposed for the formation of hydrochloric acid in the stomach were reviewed by Heinz and Öbrink[1]. Secretion of gastric acid appears to be dependent on aerobic metabolic processes; but glycolysis may also contribute to a small extent. The probable participation of various enzyme systems in the acid-producing mechanism was also discussed[1]. Such systems would eventually couple with the above-mentioned energy-yielding processes. Of the two ionic species involved, both the hydrogen and the chloride ions seem to be actively secreted, but the latter cannot be responsible for the essential part of acid formation[1,2]. Recently, Heinz and Durbin[3] accumulated more evidence for the existence of an independent 'hydrogen ion pump' in the stomach mucosa. However, at present there is no enzyme system that could be identified with any degree of certainty with this 'pump'.

The stimulating effect of histamine on the gastric secretion was first discovered by Popielski[4]. This effect is independent of the nervous system and, most probably, is due to a direct action of the drug upon the parietal cells of the gastric mucosa[5]. A steady concentration of histamine should be maintained in the body in order to achieve a steady state of elevated secretion of acid in the stomach (references in ref. 1).

Diphosphopyridine nucleotide (coenzyme I), which is an 'onium'-bearing compound, may undergo in the presence of a suitable enzyme[6] either hydrolysis or imidazolysis of its nicotinamide–ribose bond[7]. Both these processes are accompanied by the liberation of a hydrogen ion. The latter is, in a sense, forcibly ejected during the reaction, since both enzymic processes, namely, hydrolysis and imidazolysis, occur at neutrality, while protonation of either nicotinamide or the imidazolytic products of coenzyme I (for example, the histamine dinucleotide[8]) occurs at much lower *p*H values (for a thermodynamic evaluation of this question see ref. 9).

S-adenosyl-methionine, a sulphonium-bearing compound, may also undergo imidazolysis, as inferred from the *in vivo* work of Schayer *et al.* (references in ref. 10), a preliminary report of Brown *et al.*[11] and our unpublished studies (S. G. A. Alivisatos *et al.*, in preparation).

The above-mentioned observations led recently to the hypothesis that the immediate mechanism for hydrogen ion production in the stomach mucosa may involve the degradation of an 'onium' structure similar to that present in coenzyme I or in S-adenosylmethionine. Hydrolysis or, alternatively, histaminolysis (imidazolysis) of this structure would yield the necessary hydrogen ions (Fig. 1). In view of the relatively large quantities of hydrogen ions secreted in the stomach, these processes should be reversible, provided that the required energy from aerobic or glycolytic metabolic sources would be available. Overall reversibility, however, would undoubtedly involve different routes. In general, restoration of the 'onium' structure would probably proceed through phosphorolytic pathways involving nucleoside triphosphates (Fig. 1). In addition, while direct reversibility in hydrolysis would be very unlikely, imidazolysis could possibly be to a limited extent reversible, depending on the *p*K′ value for the protonation of the imidazolytic product and on the *p*H range of activity of the enzyme(s). Such 'direct' reversibility could, perhaps, explain anomalies of 'back-diffusion' of hydrogen ions observed in histamine-stimulated stomach pouches (references in ref. 1).

According to this hypothesis, the stimulatory effect of histamine in gastric secretion would be due to its higher affinity, as compared to the affinity of water, for the enzyme-substrate intermediate. This would be in accord with the observation that, at neutrality, histaminolysis of coenzyme I predominates and proceeds to quantitative yields when the ratio of this imidazole to water is about one to 50 (ref. 12). By analogy with the intracellular distribution of the diphosphopyridine nucleotidase of rabbit erythrocytes[13], the enzyme(s) catalysing the reaction(s) postulated above may reside in the mucosal (secretory) side of the membrane of those cells of the stomach mucosa that are responsible for the hydrogen ion secretion (probably the parietal cells; however, see ref. 1).

The previously mentioned necessity of a steady histamine concentration in the body fluids as a prerequisite for a steady elevation of the hydrochloric acid secretion-rate in the stomach[1] pointed towards a perhaps small but continuous 'leak' of the hypothetical imidazolytic product. Accordingly, my first experimental approach was a trial to study the fate of histamine in the isolated stomach. It was hoped that this might lead to conclusions with respect to the nature of the postulated 'onium'-bearing structure. For this purpose, stomachs of white mice were excised and washed as described by Davenport *et al.*[14]. A glucose-containing Krebs–Henseleit type saline also described by Davenport[15] was used, after gassing with oxygen, for the washings and as an incubation medium. The washed stomachs were filled with this saline ('stomach contents', approximately 0·7 ml. per stomach) and both cardiac and pyloric ends were tied with silk thread. The liquid-inflated stomachs were then incubated at 37° C. with shaking, immersed in saline[15] ('nutrient medium', approximately 8·0 ml. per stomach). Throughout the incubation period of 60–90 min., a continuous stream of oxygen was bubbled through the 'nutrient medium'. In preliminary experiments it was found that under these conditions mice stomachs would produce about 3·7 μequiv. of acid per ml. per hr. When 2(ring) carbon-14-labelled histamine was included in the 'stomach contents' (4·0 μmoles per ml.; 4·75 curies per mole) acid production rose over that of the control (hista-

Table 1. FRACTIONATION SCHEME AND DISTRIBUTION OF RADIOACTIVITY IN FRACTIONS OBTAINED FROM STOMACHS AND INTESTINES OF EXPERIMENTAL ANIMALS AFTER *in vitro* INCUBATION WITH A 2(RING) CARBON-14-LABELLED HISTAMINE CONTAINING SALINE

Specimen	I. Incubation medium	II. Organ contents (including organ walls)			
		(*a*) Material soluble in water : ethanol : ether (1 : 1 : 25)			(*b*) Material insoluble in water : ethanol : ether (1 : 1 : 25)
		1. Water	2. Ether	3. Insoluble	1. 0·2 *N* HCl fraction*
1. Stomachs, mouse	5·7	76·0	1·0	4·0	14·0
2. Stomachs, mouse	6·3	82·2	0·2	0·1	10·9
3. Stomachs, mouse	44·0	34·7	2·0	0·4	18·7
4. Stomachs, frog	45·0	44·5	0·2	0·1	10·2
5. Intestines, mouse	67·5	14·1	9·1	0·1	8·0
6. Intestines, frog	35·3	16·6	2·7	0·8	44·3

Each experiment comprised 4–5 stomachs or intestines. The figures represent per cent counts per min. of those originally added. Total radioactivity recovered in each experiment was about 95 per cent (mean value).

* The insoluble residue that could not be extracted with water (Fraction IIb_2) was not tested for radioactivity.

mine omitted) by about 30–50 per cent. Mouse intestinal fragments (ileum) were excised, washed and utilized in a similar manner. In experiments with frogs (*Rana pipiens* and *Bufo bufo bufo*) the saline[15] was diluted with water to 2/3 and incubations were carried out at room temperature. Frog stomachs (only the mucosal layers) were prepared as described by Davies[16]. Frog intestinal fragments (muscularis included) were prepared as above. At the end of the incubation, the 'nutrient medium' was acidified with 0·1 *N* hydrochloric acid to *p*H 2·0, while the liquid-inflated stomach (or intestine) was dropped in a mortar containing a dry-ice ether mixture. Three minutes later the ether was removed by decantation and kept aside, while the solid-frozen organ was pulverized with a pestle. A volume of ethanol equal to the volume of the 'contents' was then added to the moist powder and mixed. Afterwards, the previously used ether was recombined slowly under continuous stirring and the mixture was centrifuged at 1·5 × $10^3 g$ for 15 min., in the cold. The supernatant (water : alcohol : ether = 1 : 1 : 25) was evaporated to dryness under reduced pressure and the residue was extracted as indicated in Table 1 (*a*). The precipitate of this centrifugation (Table 1 (*b*)) was further extracted with 0·2 *N* hydrochloric acid. Attempts to solubilize the remaining residue by more drastic means have been, up to now, unsuccessful. Table 1 indicates the percentage radioactivity present in the various fractions. Evidently a considerable portion (5–6 per cent) of the total radioactive material penetrated through the stomach walls from the 'contents' towards the 'nutrient medium' (Nos. 1 and 2, Table 1). This material differed considerably in its migratory properties from histamine (1, Table 2). In experiments with frog stomachs (mucosal layer) and intestinal fragments (mouse or frog) increased physical porosity of the wall, often identifiable during the washings, contributed to the passage of larger quantities of unaltered histamine. This was also the case in a few experiments with mouse stomachs (Nos. 3–6, Table 1).

The various fractions of Table 1 were separately condensed to a small volume and used in paper chromatographic[12,17–19] and paper ionographic[6,9,12] studies. Results from an experiment with mouse stomachs are summarized in Table 2. They are expressed in terms of relative movements with respect to histamine. The migratory properties of a few imidazole derivatives are also included in Table 2. In general, during incubation with the stomach, a number of histamine derivatives were formed. In some instances as many as five distinct radioactive peaks could thus be registered (IIa_1, System *B*, Table 2). Although some of these peaks could represent artefacts formed during the fractionation procedures, notable differences observed between the products formed in the stomach and those in the intestine (not included in Table 2) strongly support the view that most of those peaks correspond to *bona fide* catabolic changes of the histamine molecule. Unchanged histamine was also present in most of the fractions, often representing the major peak (Table 2).

Ionographic studies at *p*H values ranging from 3·0 to 9·0 showed that cationic groups were predominant in almost every derivative. Many of these substances were devoid of any anionic group. How-

Table 2 CHROMATOGRAPHIC AND IONOGRAPHIC PROPERTIES OF ISOTOPICALLY LABELLED SUBSTANCES PRESENT IN FRACTIONS OBTAINED FROM MOUSE STOMACHS BY THE PROCEDURE OUTLINED IN TABLE 1

Fraction (see Table 1)	Chromatographic systems*				Ionography† at *p*H 3·5
	A	*B*	*C*	*D*	
I	*1·35*‡ 0·34	*1·06*	*0·83* 0·37	*0·99*	*0·62*
IIa_1	*0·99* 0·61 0·42	*0·99* 0·68 0·55 0·40 0·28	*0·99* 0·55 0·39	*1·02* 0·78 0·68 0·52	*0·98* 0·78 0·61 0·49
IIa_2	1·66 *0·96* 0·50	*0·86* 0·43	1·04 0·96 *0·70* 0·42	*0·69* 0·46 0·29	*0·98* 0·45
IIb_1	*0·94* 0·64 0·28	*0·97* 0·72 0·34	*0·88* 0·38	*0·99* 0·73 0·41	*0·99* 0·61 0·03
Acetyl (side chain)-histamine	1·48	1·10	1·70	1·25	0·49
l-Histidine	0·59	1·44	0·27	0·65	0·45
Imidazole	1·37	1·34	1·86	1·20	0·90
Imidazole-(4 or 5)-acetic acid	0·79	0·23	0·35	0·89	0·22
N(ring)-methyl-histamine	1·15	1·07	0·98	1·07	0·98
$2C^{14}$-(ring) labelled histamine (R_F values)	0·53	0·62	0·44	0·68	1·00

* *A*, *n*-propanol/0·05 *M* acetic acid, 60/40 (ref. 12); *B*, *n*-butanol/ethanol/conc. ammonia, 80/10/30 (ref. 17); *C*, *iso*propanol/pyridine/water, 2/2/1 (ref. 18); *D*, pyridine/water, 65/35 (ref. 19). All proportions are volume per volume. Movements of the various substances were divided by the movement of histamine in the corresponding system, and the ratios (relative movements) are given in the table. These relative movements may be converted to R_F values by multiplying by the R_F values of histamine given above.

† Ionographic movements are expressed relative to the movement of histamine, the migration of which towards the negative pole was always taken as unity.

‡ Italic figures represent the major radioactive peak (up to 70 per cent of the total counts present in the fraction).

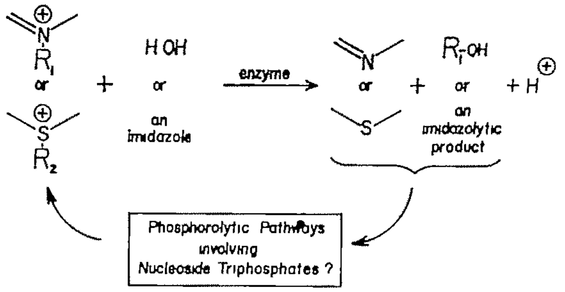


Fig. 1. Proposed mechanism of hydrogen ion production in the stomach mucosa. The postulated 'onium' structure could be an integral part of either a relatively small molecule or a large entity, possibly a lipoprotein embedded in the mosaic of the cell membrane (mucosal or secretory end). A similar intracellular distribution could also apply for the enzyme

ever, in a few instances anionic groups were present; but at most pH values they were effectively balanced or overpowered by the cationic groups present in the molecule. A limited number of ionographic experiments at high pH values (pH 11·5–12·5) indicated that N(ring)-substituted histamine derivatives might be included among these substances. Only results from experiments at pH 3·5 have been included as an example in Table 2. Further identifications based on migratory properties and certain colour reactions (diazo reaction, ninhydrin, etc.) would only be tentative at this stage and are deferred until isolation of each of these products, now in progress in this laboratory.

In conclusion, the experimental approach outlined above, namely incubation of isotopically labelled histamine in isolated stomachs and intestines of mice and frogs, led to the preliminary separation of a few derivatives of histamine. Isolation and identification of these derivatives are now in progress. It is hoped that this might lead to recognition of the moiety (R_1 or R_2 of Fig 1) of the postulated substrate implicated in the hydrogen ion secretion. However, it should be emphasized that even after positive identification of this imidazolytic product, the exact nature of the parent compound bearing the 'onium' structure (Fig. 1) would still remain uncertain. Different approaches now considered in this laboratory would be required to clarify this problem.

I wish to thank my associate, Mrs. F. Ungar, as well as Messrs. D. Cohen and L. Lukacs, for their invaluable assistance in the performance of these experiments. This investigation was partly supported by Grant No. *E*-2436 from the U.S. National Institutes of Health, Grant No. *G*-7644 from the National Science Foundation, Washington, D.C., and Grant No. *P*-241 of the American Cancer Society, Inc.

[1] Heinz, E., and Öbrink, K. J., *Physiol. Rev.*, **34**, 643 (1954).
[2] Durbin, R. P., and Heinz, E., *J. Gen. Physiol.*, **41**, 1035 (1958).
[3] Heinz, E., and Durbin, R., *Biochim. et Biophys. Acta*, **31**, 246 (1959).
[4] Popielski, L., *Pflug. Arch. ges. Physiol.*, **178**, 214 (1920).
[5] Code, C. F., in "Histamine". Ciba Foundation Symposium ed. by Wolstenholme, G. E. W., and O'Connor, C. M., 191 (Little, Brown and Co, Boston, 1956).
[6] Alivisatos, S. G. A., and Woolley, D. W., *J. Biol. Chem.*, **219**, 823 (1956).
[7] Alivisatos, S. G. A., *Nature*, **183**, 1034 (1959)
[8] Alivisatos, S. G. A., *Nature*, **181**, 271 (1958).
[9] Alivisatos, S. G. A., La Mantia, L., Ungar, F., and Savich, B. *Biochim. et Biophys. Acta*, **33**, 660 (1958).
[10] Schayer, R. W., *Physiol. Rev.*, **39**, 116 (1959).
[11] Brown, D. D., Axelrod, J., and Tomchick, R., *Nature*, **183**, 680 (1959).
[12] Alivisatos, S. G. A., Ungar, F., Lukacs, L., and La Mantia, L, *J. Biol. Chem.* (in the press).
[13] Alivisatos, S. G. A., and Denstedt, O. F., *Science*, **114**, 281 (1951).
[14] Davenport, H. W., and Jensen, V., *Gastroenterology*, 11, 227 (1948).
[15] Davenport, H. W., "In Methods in Medical Research", ed. by Visscher, M. B., 4, 185 (The Year Book Publishers, Inc., Chicago, 1951).
[16] Davies, R. E., *Biochem. J.*, **42**, 609 (1942).
[17] Schayer, R. W., Wu, Kwang Ying Tai, Smiley, R. L., and Kobayashi Yutaka, *J. Biol. Chem.*, **210**, 259 (1954).
[18] Karjala, S. A., and Turnquest, III, B. W., *J. Amer. Chem. Soc*, **77**, 6358 (1955).
[19] Karjala, S. A., *J. Amer. Chem. Soc.*, **77**, 504 (1955).

SIGNIFICANCE OF THE 'EQUIVALENT REDOX POTENTIAL' IN AQUEOUS SOLUTIONS UNDER IONIZING RADIATION

By Dr. G. H. CARTLEDGE
Chemistry Division, Oak Ridge National Laboratory, Tennessee

IN a recent paper[1], Henderson, Lovering, Haines and Casey presented results which support the view of Dainton and Collinson[2] that an aqueous system exposed to ionizing radiation has a unique 'equivalent redox potential' which is characteristic of the solvent. This concept arose from Allen's prior discussion of the fate of an added oxidation-reduction couple under irradiation[3]. The concept was criticized by Veselovsky[4], who pointed out briefly that it neglects consideration of the kinetic factors involved. Reference made to work done by Clark in Oak Ridge National Laboratory[5,6] indicates that the kinetic factors still have not been adequately appreciated, though the experimental results of Henderson *et al.* appear to be entirely valid and constitute an excellent confirmation of the general idea.

To discuss the equivalent redox potential requires careful discrimination as to the nature of the potential under consideration. The radiolytic radicals, for example, H and OH, are not in equilibrium with water, but are present at concentrations dependent upon the intensity of irradiation and the rates of their disappearance by various processes. If one knew the standard free energies of H and OH and their concentrations in the irradiated solution, one could calculate the e.m.f. of a cell corresponding to the overall reaction $H + OH \rightarrow H_2O$. Such an e.m.f. could be measured only if it were physically possible to have two electrodes, each acting reversibly with respect to one of the half-reactions alone. This e.m.f. would bear no relation to a single potential such as the equivalent redox potential is considered to be, however. To refer to a real and presumably measurable half-cell potential characteristic of the aqueous medium under irradiation presupposes the insertion of an inert conducting material for the measurement of the potential. When this is done, however, the potential measured between the electrode and a reference electrode is a steady-state mixed potential, the value of which depends upon the kinetics of all processes, anodic and cathodic, occurring at the interphase between metal and solution[7]. The observed potential will depend upon electrode reactions by which the system is attempting to approach a state of chemical equilibrium while radicals are being continuously produced, and the rates of these processes are determined by kinetic parameters. Posey[8] has given a mathematical treatment of similar situations, which would be applicable here if the electrode processes were under activation control and the requisite data were available.

The measurable, although irreversible, value of an electrode potential in an irradiated solution thus includes anything that affects the polarization of the electrode, such as the activation energies of the individual processes, which, in turn, depend in different ways upon the composition of the electrode and its surface state. Such effects were shown clearly by the experiments in this Laboratory and also in those cited by Veselovsky. The potential is affected also by the passage of different gases through the solution, or by addition of materials which react rapidly with one or the other of the active radicals produced by radiolysis. Initial reaction-rates are chiefly interesting to radiation chemists in connexion with the determination of G values. These are necessarily complicated, however, by the fact that the radiolytic products may act both as oxidizing agents and as reducing agents in individual cases, and that the oxidation-reduction reactions may proceed through unstable intermediates. There are numerous competing processes, therefore, and an electrochemical treatment is scarcely possible, though transient potentials are conceivable which would still be determined by the particular mechanisms in operation and by the condition that the sum of all anodic currents at the electrode must equal the sum of all cathodic currents on open circuit. The kinetics of such processes has been determined in certain cases[9]. The discussion which follows applies only to steady states.

We may consider, first, the case in which the solution contains no redox system other than radiolytic radicals themselves and their reaction products, at concentrations which may depend upon the type as well as the intensity of radiation. At an electrode, these reactants enter into electrode reactions in the futile attempt to approach equilibrium, the direction of change in each reaction being in accordance with the appropriate free energies. The electrode then takes a potential that is fixed uniquely by the kinetics of all cathodic and anodic processes occurring on it. Clark's measurements were made in a solution containing no redox couple foreign to the water and acid, other than trace impurities. With a platinized electrode in 0·10 N sulphuric acid at 85° under gamma radiation and exposed to air, the stable potential was found to be approximately 0·90 V. noble to a reversible hydrogen electrode in the same solution. The potential was shown to be quite different, however, when the solution was swept by hydrogen or nitrogen, or when smooth platinum or stainless steel replaced the platinized electrode. In these measurements, the potential was determined by electrode reactions of radiolytic products alone, and the value shifted rapidly upon application or removal of the gamma source.

If, now, a redox system is added to the solution after the steady-state potential appropriate to radiolytic products alone has been established, additional electrode processes become possible. Assume first that reactions of the added substances with radiolytic products occur only heterogeneously as electrode processes at the surface of the electrode. Depending upon the value of the normal potential of the redox couple, the activity of its components in the solution and various kinetic parameters, these reactions will polarize the electrode either cathodically or anodically, the relative activities of the oxidized and reduced species changing correspondingly. Since radiolytic products are being formed continuously, however, no steady-state potential can be attained until net oxidation or reduction of the added components proceeds to the point that their potential at the same electrode equals the potential of the radiolytic products alone under the prevailing experimental conditions. (This assumes that the processes at the electrode are kinetically independent.) Hence the observed potential should be independent of the system added, so long as a true steady state is reached. Unless the E^0 value of the oxidation-reduction couple is within a few tenths of a volt of the potential indicated by the platinized (reversible) electrode, however, one or the other of its components must necessarily be converted essentially completely into the other, as observed. If the reactions occurred only at the electrode, however, the fate of the redox couple would depend upon the polarization characteristics of the electrode used.

The situation is not greatly different if it is assumed, more realistically, that the reactions between added components and radiolytic products proceed chiefly and rapidly in the homogeneous aqueous phase. Again, the steady state to be reached involves production and consumption of radiolytic products at equal rates. The oxidation-reduction reactants then adjust themselves to such activities that this condition is satisfied. In other words, the relative activities of the added oxidation-reduction components in the steady state have become such that their reactions no longer disturb the steady-state concentrations of radiolytic products attained in the absence of these components. A suitable indicator electrode inserted in the solution will now give the corresponding redox potential, which the results of Henderson *et al.* show to be essentially independent of the identity of the system used. That a platinized electrode in Clark's experiments without added oxidation-reduction components indicated nearly the same potential as observed by Henderson *et al.* at a lower temperature shows merely that this type of electrode indicates reliably the kinetics of the radical reactions in the homogeneous phase, which is not true for stainless steel or silver, for example.

The behaviour of the potential upon cessation of irradiation is also understandable. In Clark's experiments, no added oxidation-reduction system was present other than trace impurities; hence the potentials shifted rapidly when irradiation ceased. The shift was in the direction determined by the transient condition then prevailing at the active interphase. In the experiments of Henderson *et al.* cessation of irradiation left an oxidation-reduction system in solution in electrochemical equilibrium, with concentrations much larger than those of the radiolytic products by which the steady-state potential was determined in their absence. The potential therefore shifted only slowly from the reversible potential of the couple at the existing activities, doubtless owing to reactions of residual radiolytic products of long life, such as hydrogen peroxide.

Dainton and Collinson discussed the numerical value of the equivalent redox potential in terms of reversible couple potentials for H and OH, respectively. Since the equivalent redox potential is a kinetic, rather than a thermodynamic quantity, however, the free energies determined the direction of the several reactions, but not their rates, or the value of the resulting mixed potential. Clark observed that a platinum electrode in a solution swept by hydrogen showed no detectable change in potential when the gamma source was applied. This demonstrates that, at 85°, the electrode processes were unaffected by the hydrogen atoms and hydroxyl radicals produced, or, in other words, that the normal exchange current of the process $(\mathrm{Pt})\mathrm{H}_2 \rightleftharpoons 2\mathrm{H}^+ + 2e^-$ was sufficient to prevent a change of potential by any added electrode reactions due to hydrogen atoms or other active species formed under irradiation. According to Veselovsky, the normal potential of the hydrogen electrode is almost realized when an acidic solution is irradiated after being freed of dissolved gases. These results agree in indicating that hydrogen atoms disappear so rapidly in one way or another that they do not disturb the equilibrium among H_2, H, H^+, and electrons at the metal-solution interface.

Removal of hydrogen atoms as a chief reactant still does not explain the observed potential, however, since the reversible normal potential of such a couple as $\mathrm{OH} + \mathrm{H}^+ + e^- \rightarrow \mathrm{H}_2\mathrm{O}$ would be approximately 3 V. noble to a hydrogen electrode in the same solution. It is therefore evident on electrochemical grounds that OH radicals also disappear rapidly. It is to be observed, further, that both the value of the equivalent redox potential in the presence of air or radiolytic oxygen and its dependence on pH are approximately the same as those indicated by a platinum electrode in a dilute solution of hydrogen peroxide[10]. From these observations it appears that, although short-lived atoms and radicals may participate in both homogeneous and electrode reactions, the principal electrochemical effects may be ascribed to molecular hydrogen and oxygen and hydrogen peroxide. The mixed potential indicated by any given electrode therefore depends upon both the polarization characteristics of the electrode, including its surface state, and also any conditions that alter the surface concentrations of these radiolytic products. The value 0·85–0·90 V. noble to the hydrogen electrode is to be considered a unique property of the system only when a reversible electrode is used and when air is present or radiolytic products are allowed to accumulate in a steady state. The potential is independent of the identity of the redox system, so long as a steady state is reached; but its measurement is facilitated by having such a system present to give stability to the potential.

I acknowledge helpful discussions with E. H. Taylor, C. J. Hochanadel, F. A. Posey, and K. E. Heusler of this Laboratory, with Prof. Milton Burton, of the University of Notre Dame, and with Prof. F. S. Dainton and Dr. E. Collinson, of the University of Leeds.

[1] Henderson, H. S., Lovering, E. G., Haines, R. L., and Casey, E. J., *Canad. J. Chem.*, 37, 164 (1959).

[2] Dainton, F. S., and Collinson, E., "Ann. Rev. Phys. Chem.", 2, 99 (1951). Cf. also *Faraday Soc. Disc.*, 12, 251 (1952).

[3] Allen, A. O., *J. Phys. Chem.*, 52, 479 (1948).

[4] Veselovsky, V. I., Int. Conf. Peaceful Uses of Atomic Energy, 7, 599 (1956).

[5] Clark, W. E., and Cartledge, G. H., Oak Ridge Nat. Lab., Semi-Annual Prog. Rep., Chemistry Div., June 20, 1956, *ORNL*-2159, p. 71.

[6] Clark, W. E., *J. Electrochem. Soc.*, 105, 483 (1958).

[7] Cartledge, G. H., *Werkstoffe und Korrosion*, 9, 493 (1958).

[8] Posey, Franz A., *J. Electrochem. Soc.*, 106, 571 (1959).

[9] See, for examples, Boyle, J. W., Weiner, S., and Hochanadel, C. J., *J. Phys. Chem.*, 63, 892 (1959).

[10] Bockris, J. O'M., and Oldfield, L. F., *Trans. Farad. Soc.*, 51, 249 (1955). Cf. also Gerischer, R., and Gerischer, H., *Z. phys. Chem.*, 6, 178 (1956).

STEROL ANALYSIS BY GAS CHROMATOGRAPHY

By R. K. BEERTHUIS and J. H. RECOURT

Unilever Research Laboratory, Vlaardingen, Holland

USE of gas chromatography in the analysis of sterol mixtures by itself or as a supplement to other methods of separation may yield more detailed results than have been possible up to now. The relative simplicity with which in general very effective separations can be rapidly obtained—in which case direct quantitative determination is frequently possible—is a great advantage of this technique.

We have investigated the possibilities of the analysis of sterols using model substances and natural mixtures. In view of the very low volatility of sterols, high column temperatures had to be used; but in the high-temperature range the choice of the stationary phase is considerably limited.

'Apiezon *L*' and alkathene appeared to be completely unsuitable for this purpose. The sterols eluted as broad, asymmetric peaks. With silicon oil, on the other hand, completely symmetrical peaks were obtained.

We used the residue of a molecular distillation at 200° C. and 2µ pressure of Midland silicones No. 550. The carrier, 'Celite 545', was treated with acid to remove traces of metal, screened to a suitable particle size and treated with dichloro-dimethyl silane as described for 'Hyflo'[1] to make it as inert as possible.

At present we have only investigated separations on a relatively short column (length: 90 cm.; internal diameter: 4 mm.) packed with 20 per cent by weight of silicone oil on 'Celite'. The best results were obtained with 'Celite' having a particle size of 150–178µ. The column was conditioned at a working temperature (287° C.) for 2 days. During this period the column was repeatedly vibrated and filled up with packing until a constant level had been obtained. The substances were brought on to the column as such in a small perforated stainless steel basket, or dissolved in methyl myristate using a capillary pipette. As detector the gas density balance[2] was used, which, together with the column, was placed in an electrically heated air-bath. With the help of the internal standard technique, it was found that the elution of the investigated substances proceeded quantitatively.

Infra-red recordings of cholesterol, before and after passing the column, displayed no differences. It is evident, therefore, that no structural changes occur at this high temperature.

Fig. 1 shows the separation of cholesterol, 7-dehydrocholesterol, ergosterol and stigmasterol. Because of the conjugation in the *B*-ring of 7-dehydrocholesterol there is such a difference in volatility with cholesterol that these two substances can be separated almost completely. The influence of the length of the side-chain upon the retention time appears from the separation of ergosterol, stigmasterol and cholesterol. Cholesterol was also completely separated from technical sitosterol (supplied by Messrs. S. A. F. Hoffmann-La Roche and Co., Ltd., C.O. Basel). The sitosterol, however, was found to consist of at least three components. Separations can also be effected of sterol esters (Fig. 2).

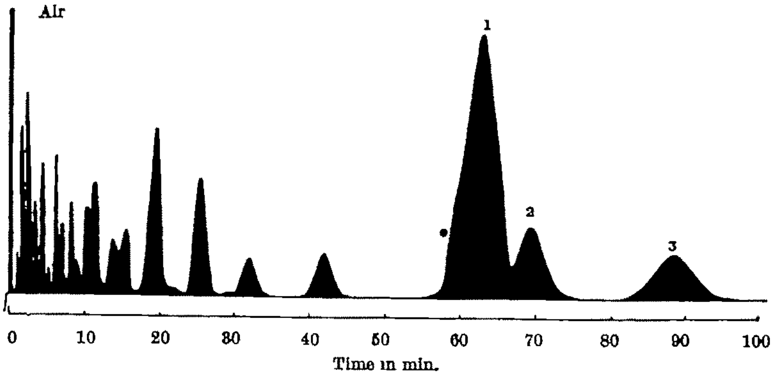


Fig. 3. Conditions (see Fig. 1). Zone *D* from rat fæces: (1) coprostanol; (2) probably cholestanol; (3) methostenol

The following example shows that with gas-chromatography it is possible to obtain separations which can only be indirectly achieved when other methods are applied.

When feeding rats a fat-free diet the fæces contain cholesterol, cholestanol, Δ^7-cholestenol, 7-dehydrocholesterol, coprostanol, and methostenol. The analyses of these sterols have been worked out by Coleman, Wells and Baumann[3,4]. Application of their chromatographic methods results in the separation of two main sterol bands, the so-called zones *C* and *D*. Zone *D* contains at least two sterols: coprostanol and methostenol. These two substances can be determined individually by means of the Liebermann–Burchard reaction. Coprostanol is the slow- and methostenol the fast-acting component. The structure of methostenol appeared to be: 4 α-methyl-Δ^7-cholesten-3 β-ol[5].

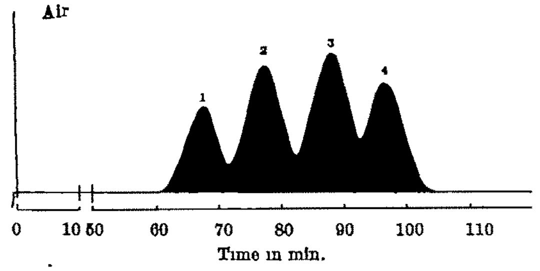


Fig. 1. Conditions: column, 90 cm. × 4 mm.; packing, 'Celite' 150–178μ; silicon oil, 4.1; temperature, 287° C.; overpressure on top of the column, 53 cm. mercury; flow-rate, 24 ml. N_2/min. Separation of: (1) cholesterol; (2) 7-dehydrocholesterol; (3) ergosterol; (4) stigmasterol

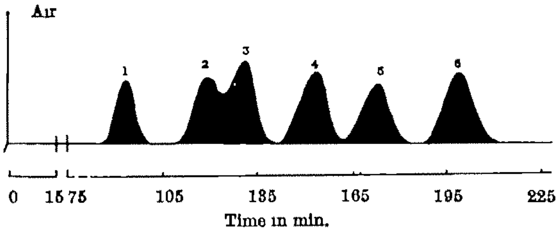


Fig. 2. Conditions (see Fig. 1). Separations of esters of cholesterol: (1) acetate; (2) propionate, (3) isobutyrate; (4) butyrate, (5) isovalerate; (6) valerate

Coprostanol and methostenol can only be separated chromatographically via the *p*-phenyl azobenzoates, which is a time-consuming process. By means of gas-chromatography, however, these sterols can be rapidly and quantitatively separated and determined.

Fig. 3 shows the chromatogram of the above-mentioned band *D* from the unsaponifiable fraction of rat fæces. The peaks in the sterol range are indicated as 1, 2 and 3. These three substances were collected individually and their behaviour with respect to the Liebermann–Burchard reagent investigated. Coprostanol, the slow-acting sterol, is represented by peak 1, methostenol as fast-acting sterol by peak 3.

The substance in peak 2, with a retention time equal to that of cholestanol and cholesterol, gave a negative Liebermann–Burchard reaction. On application of a modified chromatographic procedure based on the method of Coleman *et al.*[4] zones *C* and *D* can be eluted. This proceeds in such a way that on elution of the bands zone *C* leaves the column immediately after zone *D*. Cholestanol is already present at the beginning of band *C* and slight overlapping of the two zones is possible. Cholestanol also gives a negative Liebermann–Burchard reaction and therefore it is highly probable that the substance in peak 2 is cholestanol originating from zone *C*.

The gas-chromatographic separation obtained illustrates the great influence of methyl addition in the *A*-ring of the cholestenol molecule upon the retention time. At the same time it appears that the stereoisomers cholestanol and coprostanol are completely separated.

Table 1 contains the relative retentions of the sterols mentioned as well as of some higher hydrocarbons.

From our results it appears that sterols which differ in the total number of carbon atoms can not only be readily separated but can also be determined

Table 1. RETENTION VOLUME RELATIVE TO CHOLESTEROL ON SILICON OIL

Coprostanol	0·9	Cholesterylacetate	1·42
Cholesterol	1	Tetratriacontane	1·45
Cholestanol	1	Cholesterylpropionate	1·83
Δ^7-Cholestenol	1·14	Cholesterylisobutyrate	2·0
7-Dehydrocholesterol	1·14	Cholesterylbutyrate	2·32
Methostenol	1·28	Cholesterylisovalerate	2·64
Ergosterol	1·30	Cholesterylvalerate	3·02
Stigmasterol	1·36	Octatriacontane	3·96

quantitatively, and if necessary the various fractions be used for further identification.

The plate number computed for cholesterol was 2300.

The resolution obtained can be improved by applying longer packed or coated capillary columns in combination with more sensitive detectors.

Our thanks are due to Mr. P. Smits and Mr. H. Dronkers, who carried out the group separation of the sterols. Further, we are greatly indebted to the management of Unilever N.V. for permission to publish these results.

[1] Martin, A. J. P., and James, A. T., *Biochem. J.*, 63, 138 (1956).
[2] Howard, G. A., and Martin, A. J. P., *Biochem. J.*, 46, 532 (1950).
[3] Wells, W. W., Coleman, D. L., and Baumann, C. A., *Arch. Biochem. Biophys.*, 57, 437 (1955).
[4] Coleman, D. L., Wells, W. W., and Baumann, C. A , *Arch. Biochem. Biophys.*, 60, 412 (1956).
[5] Neiderhiser, D. N., and Wells, W. W., *Arch. Biochem. Biophys.*, 81, 300 (1959).

DETOXICATION DURING SECONDARY GROWTH IN PLANTS

By C. M. STEWART

Division of Forest Products, Commonwealth Scientific and Industrial Research Organization,
69-77 Yarra Bank Road, South Melbourne

PLANTS, in contrast with animals, do not possess well-defined organs for the excretion of potentially injurious metabolic products. However, it is obvious that means must exist whereby toxic substances are rendered non-toxic or, if toxic, are 'excreted' to locations within the plant where the toxicity of the substances is of little consequence. For example, it is well known that succinic and oxalic acids are immobilized, in special parenchyma cells of secondary xylary tissues, as crystals of aluminium succinate and calcium oxalate.

In general, substances with reactive groups (whether they be toxic or non-toxic) are transported usually in an inactivated state to the regions of active secondary growth. For example, sugars are transported chiefly as sucrose, coniferyl and sinapyl alcohols as glycosides, and so on. These products of photosynthesis are soluble and, for purposes of permanent or temporary storage, they are converted, enzymatically, to the polymolecular ergastic substances of the cell wall (cellulosic and non-cellulosic polysaccharides and lignin) and the materials extraneous to the cell wall (tannins, kinos, lipids, starch, etc.).

High concentrations of acids and especially of phenolic substances exhibit an inhibitory effect or are toxic to cambial tissues. For example, Jacquiot[1] has shown that tannins inhibit the proliferation of isolated fragments of cambial tissues from *Quercus* and *Castanea*. In agreement with this observation, it has been found, for *Eucalyptus regnans*, that tannins are present in minimal amounts in the cambial zone and that the amounts increase on each side of the cambium ; this evidence was taken as an indication that tannins are waste materials which are excreted to each side of the cambium and eventually accumulated in the tanniniferous parenchyma cells of the phloem (eventually transformed to the rytidome and thus periodically shed), and, via the parenchyma cells of the sapwood, in the dead cells of the heartwood[2]. Thus the formation of tannins and their excretion as outlined above may be, primarily, a means of 'detoxication' of excess phenolic substances. This does not mean that the tannin precursors (possibly by-products formed during the biosynthesis of lignin[3] or flavonoid compounds[3]) or the tannins themselves may not have important physiological functions in plant life ; for example, it has been suggested that they may act as antioxidants or as inhibitors of fungal growth[4].

Again, lignin is a polymer formed from phenolic base units. Hence lignification, whether it proceeds by the utilization of phenolic substances from the nutrient phloem 'sap' stream ('detoxicated' coniferyl or sinapyl alcohols[5], flavonoid compounds[6], etc.) or by the utilization of lignin precursors produced within the developing cell either during its normal active life[7] or during its senescence[8], may be essentially a process of 'detoxication'. A secondary 'evolutionary' function of lignin may be to give rigidity and compressive strength to the cell walls of xylary and other plant tissues ; however, plant tissues tend to be brittle when the lignin content is high[4,9].

There is much indirect evidence which indicates that, during lignification, the lignin becomes chemically bonded to the non-cellulosic polysaccharides of the primary, and outer portions of the secondary, cell walls. Much of the evidence suggests that the lignin is attached, by ester bonds, to the uronic acid units. For example, it is known that ruthenium red, a stain specific to carboxyl groups[10] in mature fibre cell walls, stains the intercellular layer and primary cell wall more intensely than any other portion of the cell wall ; in the case of *Eucalyptus regnans* wood, the intensity of staining diminishes as lignification proceeds (Wardrop, A. B., unpublished work) and becomes almost zero in the mature fibre cell wall ; analogous staining behaviour has been observed during the lignification of *Pinus sylvestris*[11]. When sections of mature wood of *E. regnans* are hydrolysed with dilute acids or alkalis, the red-staining potentialities increase with time of hydrolysis, the alkali being about 10^3 times as effective as acid in this respect (Stewart, C. M., Watson, A. J., Dadswell, H. E., and Kottek, J. F., unpublished work). Also, when holocellulose, prepared from *E. regnans* wood, is treated with dilute alkali (0·08 per cent sodium hydroxide for 1 hr. at 98°) the residual lignin is removed[12].

Many workers have shown that the 4-O-methyl-D-glucuronic acid units of the non-cellulosic polysaccharides of woods are attached glycosidically to the xylose units of the polymer chains. Thus, during lignification, lignin units may become attached to the uronic acid residues by the formation of 'lignyl' 4-O-methyl-D-glucuronate side-chains linked through the 2-O- or 3-O-positions on to the xylose units of the main chains of the glycosan uronides ; this linkage process, and the possible further addition of lignin units to those already incorporated in the side-chains, may represent the 'detoxication' mechanism which is applicable to the plant cell wall. During animal metabolism, many aromatic substances appear in the urine as derivatives of D-glucuronic acid; for example, alcohols and phenols appear as β-glycosides (for example, phenyl β-D-glucosiduronic acid) and carboxylic acids appear as β-hemiacylals (for example, benzoyl β-D-glucosiduronic acid)[13]. Hence uronic acids may serve as 'detoxication' agents during the metabolism of both plants and animals.

Perhaps other examples of 'detoxication' during the secondary growth of plants could be cited. For example, excess aliphatic acids such as formic and acetic acids, which do not form insoluble salts, may be immobilized by their attachment, as formyl or acetyl groups, to certain of the cell-wall polysaccharides; glycosan uronides, especially in hardwoods, have relatively high contents of acetyl groups, equivalent in some cases to about 25 per cent acetylation[12]. Again, alcohols may be immobilized as O-alkyl or alkoxy groups attached either to cell-wall components or to extraneous substances.

From the above discussion it will be noted that there are several possible general means of 'detoxication' and/or excretion which may operate within a plant. Normally, while in solution, the toxic substance is 'detoxicated' by the formation of a non-toxic derivative, usually a glycoside. If the production of such substances were to continue, without some means of lowering their concentration, the cell fluids would become extremely viscous because of the high concentration of substances in solution. A mechanism of preventing the formation of high concentrations must exist; this mechanism, in general, seems to depend upon polymerization of the soluble substances to ensure temporary or permanent 'detoxication' of reactive toxic groups (during the polymerization reactions), with parallel increased insolubility and deposition in the walls or cellular contents of cells, which will eventually be isolated from the regions of active growth.

In the case of substances such as aliphatic acids which neither form glycosides nor readily polymerize, two means of 'detoxication' seem possible: first, the formation of insoluble salts which are stored in special crystalliferous parenchyma cells; and, secondly, attachment as acyl groups to the glycosan uronides, excess acids perhaps being excreted to the bark or heartwood. It should be noted, especially in old xylary tissues, that the acids may be re-liberated from acyl groups by autocatalysis, with consequent damage to the tissues resulting from prolonged hydrolytic reactions (Stewart, C. M., Watson, A. J., Dadswell, H. E., and Kottek, J. F., unpublished work).

[1] Jacquiot, C., *C.R. Acad. Sci., Paris*, 225, 484 (1947).

[2] Stewart, C. M., Amos, G. L., and Harvey, L. J., *Austral. J. Biol. Sci.*, 6, 21 (1953).

[3] Hillis, W. E., *Austral. J. Biol. Sci.*, 9, 263 (1956).

[4] Wise, L. E., "Wood Chemistry" (Reinhold Pub. Corp., New York, 1944).

[5] Freudenberg, K., *Mitt. Österr. Ges. Holzforsch.*, 1952 (3), 72.

[6] Hillis, W. E., and Carle, A., *Holzforschung*, 12, 136 (1958).

[7] Bonner, J., "Plant Biochemistry", 129 (Academic Press, Inc., New York, 1950). Wardrop, A. B., *Tappi*, 40, 225 (1956).

[8] Byerrum, R. U., Flokstra, J. H., Dewey, L. J., and Ball, C. H., *J. Biol. Chem.*, 210, 633 (1954). Siegel, S. M., *Quart. Rev. Biol.*, 31, 1 (1956). Stewart, C. M., *Tappi*, 40, 244 (1956).

[9] Dadswell, H. E., and Hawley, L. F., *Indust. Eng. Chem.*, 21, 973 (1929). Phillips, M., Davidson, J., and Weihe, H. D., *J. Agric. Res.*, 43, 619 (1931).

[10] Joslyn, M. A., and Phaff, H. J., *Wallerstein Lab. Commun.*, 10, 39 (1947).

[11] Allen, C. E., *Bot. Gaz.*, 32, 1 (1901).

[12] Stewart, C. M., McPherson, A. J., and Frydman, L., *Aust. Pulp Paper Indust. Tech. Assoc. Proc.*, 10, 298 (1956).

[13] Fruton, J. S., and Simmonds, S., "General Biochemistry" (John Wiley and Sons, Inc., New York, 1958).

COBALT IN NITROGEN FIXATION BY A LEGUME

By Prof. H. M. REISENAUER

Department of Agronomy, Washington State University, Pullman, Washington

OUR understanding of cobalt as a micro-nutrient element required by animals and various micro-organisms centres around the role of vitamin B_{12}. This vitamin is required by most animal species[1] in the formation of hæmoglobin and may be concerned with protein metabolism[2]. Most workers agree that vitamin B_{12} is synthesized only by micro-organisms[1]. Many micro-organisms require preformed B_{12} (refs. 3–5); others, including *Rhizobia*[6], produce the vitamin.

Cobalt has not been demonstrated as being a requirement for the growth of higher plants, although it has been shown to be essential for blue-green algae[7]. With higher plants, cobalt supplements have been reported to increase growth of the rubber plant and tomatoes[8] and to increase elongation of pea stem sections[9,10]. Recently, Ahmend and Evans[11] have suggested that soy-bean plants grown with symbiotically fixed nitrogen as their only source of this nutrient were "distinctly benefited" from small quantities of cobalt. The experiment reported here makes it quite clear that enormous reductions in the amount of nitrogen fixed by inoculated lucerne plants result when culture solutions are sufficiently purified and controlled with respect to cobalt contaminants. Other experiments in progress at the present time at the University of California, where higher degrees of control have been obtained more recently, are giving further evidence of correspondingly greater yield differentials between inoculated lucerne plants grown on cobalt-deficient and cobalt-sufficient culture solutions.

An essential role of cobalt in symbiotic nitrogen fixation and possibly in all biological nitrogen-fixation processes is suggested by the following information. The nodules of legume plants contain hæmoglobin very similar to that of animal blood[12,13]. Nitrogen fixation is directly related to the hæmoglobin content of the nodule[14–17]. Vitamin B_{12} has been found to be concentrated in the root nodules of legume plants and particularly those that contain hæmoglobin[18]. The synthesis of hæmoglobin in the nodule is a result of the symbiotic relationship since it cannot be synthesized by either the plant or the micro-organism alone[12]. A possible relationship of cobalt to a biological nitrogen-fixing process is suggested from the results of Holm-Hansen and co-workers[7]. In their demonstration of a cobalt requirement for the growth

Table 1. NITROGEN FIXED BY *Medicago sativa* (LUCERNE) WITH AND WITHOUT COBALT SUPPLEMENTS

Purification of salts	Cobalt supplement	Inoculation	Sodium chloride supplement	Dry wt. of plants gm./pot	Dry wt. of nodules gm./pot	Nitrogen (fixed) mgm./pot	Nitrogen (in plants) per cent
None	0	0	0	2·3	0	0	0·83
Yes	0	+	0	6·1	0·19	34	1·07
Yes	0	+	0·5 m*M*	6·6	0·20	27	0·79
Yes	0·1 μ*M*	+	0	11·9	0·53	237	2·33
Yes	0·1 μ*M*	+	0·5 m*M*	9·2	0·39	154	2·06
None	0	+	0	8·0	0·26	160	2·39

of blue-green algae, these workers noted that upon their cultures with low cobalt content, growth reduction of the nitrogen-fixing species was more pronounced than for the species requiring combined nitrogen.

The experiment reported here was undertaken to observe whether or not cobalt supplies could effect nodulation and symbiotic nitrogen fixation in lucerne (*Medicago sativa*). The culture solutions were restricted as to nitrogen salts and contained 1·3 m*M* nitrogen, 2·0 m*M* phosphorus, 3·1 m*M* potassium, 4·0 m*M* calcium, 1·0 m*M* magnesium, 5·0 μ*M* manganese, 2·0 μ*M* zinc, 0·5 μ*M* copper, 17·5 μ*M* iron (from Fe-ethylenediaminetetraacetic acid), 5·0 m*M* sulphur, 25 μ*M* boron, 0·5 μ*M* molybdenum, 22·5 μ*M* chlorine and 1·0 gm. calcium carbonate per litre. Treatment variables are described in Table 1. All chemicals used in formulating the 'purified' cultures were treated to remove contaminant cobalt in so far as possible with the purification processes mentioned here. All water, volatile acids, bases and organic reagents used were redistilled in 'Pyrex' glass apparatus. Solutions of 2·0 *M* calcium nitrate, 1·0 *M* $K_{1\cdot1}H_{1\cdot9}PO_4$ and 0·5 *M* potassium sulphate were purified by iron-oxinate coprecipitation at *p*H 5·1–5·2 as described by Hewitt[19]. Dithizonate extraction at *p*H 8·5 was used in preparing low cobalt solution of magnesium sulphate. Iron was purified by extracting as ferric chloride with ether from hydrochloric acid solution[20]. Reagents supplying the micro-nutrients, except iron, and sodium chloride were twice recrystallized before use. The calcium carbonate added to maintain the reaction of the cultures above *p*H 6 was precipitated from purified calcium nitrate solution.

Lucerne plants were grown in a glasshouse at Berkeley during May and June. The treatments were arranged in a randomized block design and repeated four times. Three 10-day-old lucerne plants were transplanted to 2-litre, continuously aerated cultures. The following day the pots were inoculated with 1 ml. of a suspension containing a mixture of two effective *Rhizobia* strains—approximately 10^4 bacteria per pot. The plants were harvested six weeks after transplanting, separated into tops, roots and nodules, dried and weighed. Total nitrogen was determined in all plant parts.

The fixed nitrogen supplied by the culture solutions was adequate for normal growth of the plants of all treatments for four weeks. In the fifth week nitrogen deficiency symptoms developed on the plants of the 'not inoculated' treatments as well as those of the 'inoculated-minus cobalt' treatments. Nodules were visible on the roots of the inoculated plants within three weeks. No nodules were found on the plants which were not inoculated. Nodule counts made four weeks after transplanting showed the 'plus cobalt' and 'unpurified' cultures as having plants with larger nodules than the plants deprived of cobalt. The 'not inoculated' and 'minus cobalt' plants displayed characteristic symptoms of nitrogen starvation, whereas inoculated plants having cobalt supplements were green and obviously not short of nitrogen.

Whole plant weights, nodule weights and the nitrogen content of the plants are given in Table 1. Addition of cobalt to the 'purified' cultures increased plant growth by 66 per cent during an evident stress period of only two weeks. This effect of cobalt is significant at odds of 2,000 : 1. Similarly, nodule weight was doubled—significant at odds of 200 : 1.

In the presence of *Rhizobia* but without added cobalt the plants fixed 34 mgm. of nitrogen without sodium chloride and 27 mgm. of nitrogen with sodium chloride. However, with cobalt added the corresponding cultures fixed 237 and 154 mgm. of nitrogen, respectively. The variable of 0·5 m*M* sodium chloride in the culture solution which resulted in a lesser amount of nitrogen being fixed in each case was introduced into the experiment in order to give other levels of plant growth not associated with cobalt. Within this experiment, however, cobalt was by far the overriding factor in determining the amount of nitrogen fixed by inoculated *Medicago sativa*.

The magnitude of the results obtained here distinctly implies an essential role of cobalt in symbiotic nitrogen fixation. Additional results from this and an expanded confirming experiment are to be published elsewhere.

This work was conducted during the tenure of a lectureship with the Kearney Foundation of Soil Science, University of California, Berkeley, which is gratefully acknowledged. I am indebted to C. M. Johnson, C. C. Delwiche and P. R. Stout for their assistance and valuable suggestions.

[1] Davis, G. K., in Trace Elements Proc. Conf., Wooster, Ohio, 1957 (Academic Press, Inc., New York, 1958).

[2] Arnstein, H. R. V., and Simkin, J. L., *Nature*, **183**, 523 (1959).

[3] Starkey, R. L., *Soil Sci.*, **79**, 1 (1955).

[4] Young, R. S., *Sci. Prog.*, **44**, 16 (1956).

[5] Lockhead, A. G., and Thexton, R. H., *J. Bact.*, **63**, 219 (1952).

[6] Vyas, S. R., and Prasad, N., *J. Sci. India Res.*, **15C**, 52 (1956).

[7] Holm-Hansen, O., Gerloff, G. C., and Skoog, F., *Physiol. Plantarum*, **7**, 665 (1954).

[8] Bolle-Jones, E. W., and Mallikarjuneswara, V. R., *Nature*, **179**, 738 (1957).

[9] Thimann, K. V., *Amer. J. Bot.*, **43**, 241 (1956).

[10] Brian, P. W., and Hemming, H. G., *Naturwiss.*, **44**, 593 (1957).

[11] Ahmend S., and Evans, H. J., *Biochem. Biophys. Res. Com.*, **1**, 271 (1959).

[12] Keilin D., and Wang, Y. L., *Nature*, **155**, 227 (1945).

[13] Virtanen, A. J., and Laine, T., *Nature*, **157**, 25 (1946).

[14] Keilin, D., and Smith, J. D., *Nature*, **159**, 692 (1947).

[15] Magee, W. E., and Burris, R. H., *Plant Physiol.*, **29**, 199 (1954).

[16] Cheniae G. M., and Evans, H. J., *Biochim. Biophys. Acta*, **26**, 654 (1957).

[17] Nicholas, J. D. J., in "Nutrition of the Legumes", 239 (Academic Press, Inc., New York, 1958).

[18] Levin, A. P., Funk, H. B., and Tendler, M. D., *Science*, **120**, 784 (1954).

[19] Hewitt, E. J., Commonwealth Bur. Hort. and Plant. Crops, Tech. Com. 22 (1952).

[20] Sandell, E. B., "Colorimetric Determination of Traces of Metals", 2nd ed. (Interscience Publishers, Inc., New York, 1950).

LETTERS TO THE EDITORS

PHYSICS

The Possibility of a Self-sustaining Corbino Disk

An impressed radial current and an axial magnetic field combine in the Corbino disk[1] to induce a circulating component of current due to the Hall effect. Whichever sense the axial field may have, it is aided by the field of the circulating currents themselves, provided that the radial current is always inwards. This applies to a material with the normal sign of Hall coefficient for *n*-type conduction.

Without the impressed axial field, the disk would be a two-state element, which could form the basis of a digital computer. The two states would be self-sustaining current vortices of opposite spin. The existence of such vortices is suggested by a solution of the field-equations for an indefinitely thin disk of infinite radius, immersed in a medium of permeability μ :

$$J_r = \frac{I}{2\pi r.\delta z} \qquad J_\theta = \sigma.E_\theta$$

$$E_\theta = R.J_r.B_z \qquad J = \frac{\text{curl } B}{\mu.\eta_0}$$

where r,θ,z are cylindrical co-ordinates; I, total current (amp.); J, current density (amp./sq. metre); E, electric field intensity (volts/metre); R, Hall coefficient (metre^3/coulomb); σ, conductivity (mho/metre); $\eta_0 = 4\pi \times 10^{-7}$ henry/metre.

B_z, E_θ and J_θ all satisfy an equation of the form :

$$\frac{dB_z}{dr} + \mu.\eta_0.\frac{\sigma.R.I.B_z}{2\pi r.\delta_z} = 0$$

which has the solution : $B_z = A.r^{-k}$

where A is a constant of integration, and k is $\sigma\mu\eta_0 R.I/2\pi\delta z$.

More significant than the increase towards the centre in the flux density B_z is the increase in total flux within a ring of width δr when $k \geqslant 1$. This establishes a critical value for the radial current, above which amplification and regeneration are possible. A transformer exploiting the creation of a secondary flux in excess of the primary flux would behave as a magnetic power amplifier. The introduction of a magnetic feedback path in such a transformer would lead to a bi-stable trigger circuit.

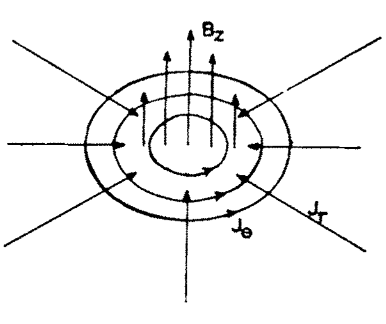


Fig 1. Axial magnetic field in relation to the radial and circulating components of the current density

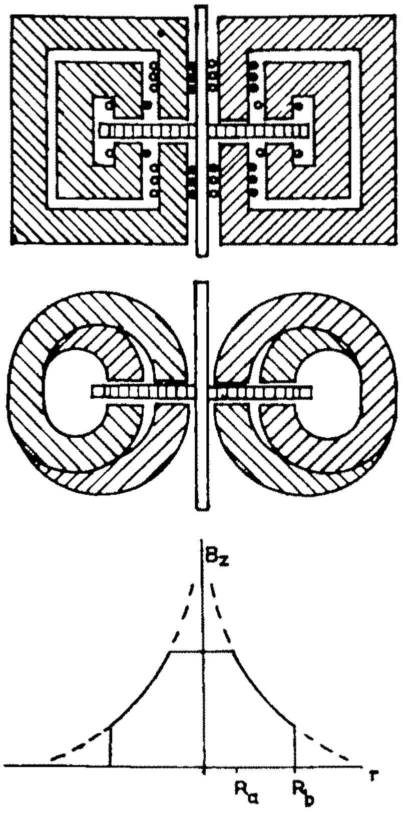


Fig. 2. Top : A magnetic amplifier having an input coil to provide B_z at R_b and an output coil at R_a. (Permeable material is diagonally shaded and Hall-sensitive material vertically shaded. The radial current is introduced by a conducting rim on the disk and is removed along the two halves of the axis)
Centre : A magnetic feedback circuit for a two-state element. (If a fraction f of B_z at R_a is returned to R_b, the fields become self-sustaining when $k = \frac{\ln(f)}{\ln(R_a/R_b)}$
Bottom : Axial flux density, circulating current density and circulating electric field-strength for an infinite disk : - - -. The same for a finite disk : ———

A vital question is whether the critical current is necessarily destructively large, as it would be for the conductivities and small Hall coefficients of ordinary metals at room temperature. However, products of conductivity and Hall coefficient of the order unity have been observed in germanium alloys at low temperatures[2]. Assuming that, by restricting the thickness of the disk to 0·01 per cent of the magnetic path, an effective permeability of 10^4 could be maintained, a current of 5 amp. per cm. of magnetic path would be required for criticality.

D. Midgley

University of St. Andrews,
Queen's College,
Dundee.

---

[1] Von Corbino, O. M., *Phys. Z.*, **12**, 561 (1911).

[2] Debye, P. P., and Conwell, E. M., *Phys. Rev.*, **93**, 693 (1954).

Rheological Properties of Barytes Suspensions

THE rheological properties of suspensions, which are used in coal preparation by dense-medium washing, are being studied. Initially, suspensions of barytes prepared by ball milling and containing particles of all sizes less than 250μ, and in most cases less than 100μ, were investigated. The effects of the concentration of solids and of the particle size of the solids on the consistency curve have been studied. It is hoped to extend the work to more complex systems containing three solid components (barytes, coal and shale) each or all of which may be deficient in smaller-sized particles. The present communication is intended to direct attention to some interesting features of the results obtained.

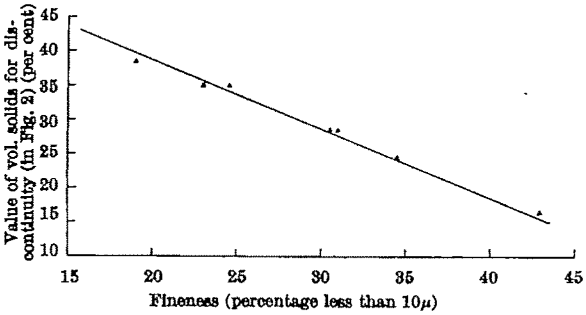


Fig. 3

The work was carried out using a Ferranti portable (rotating cylinder) viscometer[1]. This enabled the consistency to be studied over a fairly wide range of shear-rates (68–950 sec.$^{-1}$). Readings were taken immediately after thorough stirring, which could lead to the presence of a third phase (air bubbles) in the system. However, it is likely that suspensions used in practice will also contain air bubbles. All the consistency curves reveal that the suspensions are Bingham fluids over the range of shear rates used.

From the consistency curves, the yield point and plastic viscosity were estimated for suspensions containing different solids concentrations and containing solids over a range of fineness. For the suspensions studied, the results are illustrated in Figs. 1 and 2. The concentrations, at which the discontinuity in the plastic viscosity vs. concentration relationship occurs, have been found to bear a linear relation to the fineness of the barytes as expressed by the weight less than 10 microns (Fig. 3). This suggests that the phenomenon is due to the irregularities in the particles carrying immobile layers of liquid as proposed by Ward and Whitmore[2], and should enable the mean thickness of the layer to be estimated.

In earlier investigations a Gallenkamp universal torsion viscometer had been used in viscosity measurements on suspensions. A study of mode of operation and the results obtained on this instrument and the rotating cylinder viscometer lead us to conclude that, to a first approximation, the readings on the torsion viscometer (using 11/16-in. and 1⅝-in. cylinders) were a measure of the yield point of the suspensions (see Fig. 4).

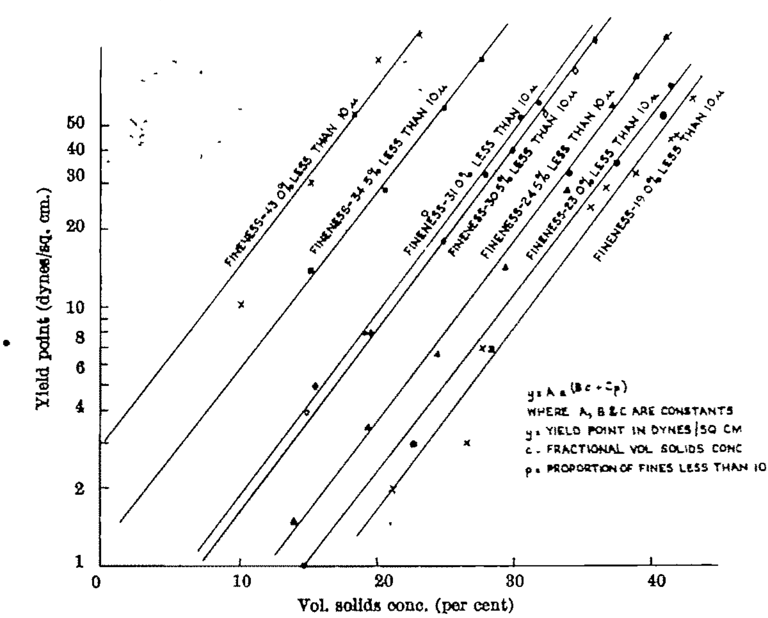


Fig. 1

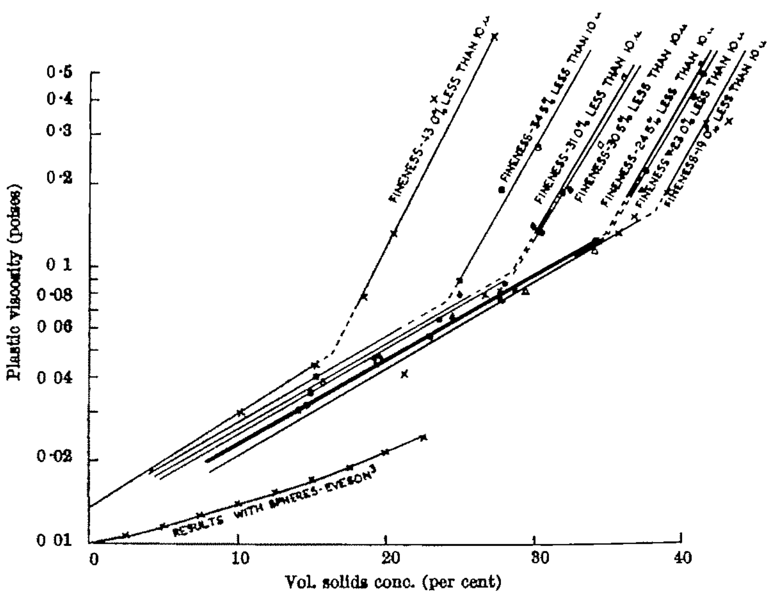


Fig. 2

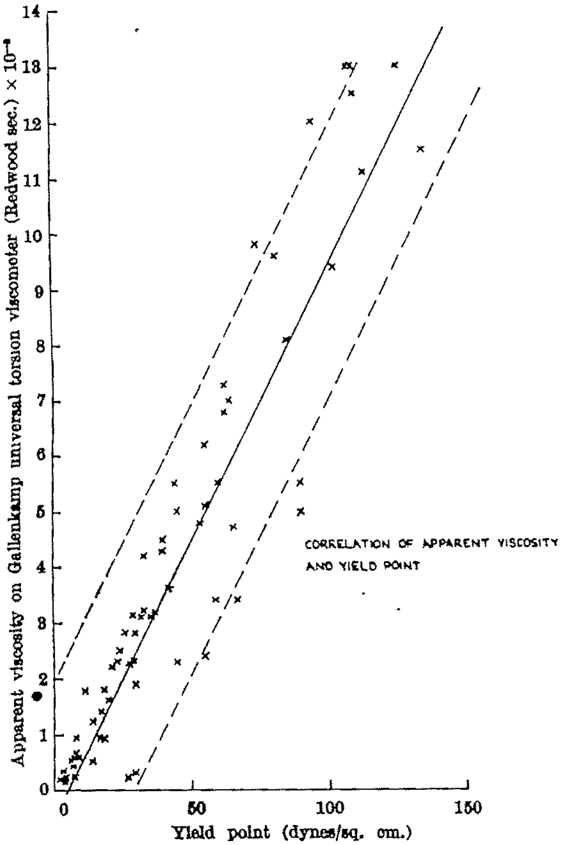


Fig. 4

This communication is published with the permission of the National Coal Board, which is not committed to the views expressed by us.

A. W. Earnshaw
J. C. Sproson

N.C.B. Northern (N and C) Division,
Scientific Department,
'The Grange',
Longbenton,
Newcastle upon Tyne, 12.

[1] Reiner, M., "Deformation Steam and Flow", 34 (Lewis, London).
[2] Ward, S. G., and Whitmore, R. L., *Brit. J. App. Phys.*, 1, 325 (1950).
[3] Eveson, G. F., *J.O.C.C.A.* (Feb. 1959).

An Energy Band Interpolation Scheme, with Application to Body-centred Cubic Lithium

An interpolation scheme has been developed for the calculation of the energy bands in solids, using plane wave expansions of the wave functions and accurately known values of the energy-levels at high-symmetry points of the Brillouin zone. For valence electron states having the same symmetry as those of the ion cores, these expansions must be modified by the use of an additional repulsive pseudo-potential V_r. Of various suggested forms[1] of V_r, that found most useful was that of Gáspár[2] and Antončík[3], an extension to metals of that derived for atoms by Gombás[4]. By using only a small number of terms in the expansions it was then found possible to reproduce the energy-levels at high-symmetry points with at least the accuracy to which they had been originally determined. The levels at a large number of general points of the zone were then calculated, and, in order to obtain the density of states $N(E)$, these energy values were fitted by a symmetrized triple Fourier expansion of $E(k_x,k_y,k_z)$.

The method has been applied to body-centred cubic lithium, for which energy-levels at high-symmetry points have been obtained by Glasser and Callaway[5,6], using the orthogonalized plane wave method and the corrected Seitz potential[7], and with a stated accuracy $\pm 0{\cdot}05$ Ry. The number of terms used in the plane wave expansions to reproduce these levels was taken to be equal to the degeneracy of the corresponding level in the free-electron approximation (for example, 6 for the lowest state H_1, in the notation of Bouckaert *et al.*[8]). For the *s*-like levels V_r involves the 1*s* wave function of the ion core, which was chosen to be hydrogenic with a screening constant which was taken to be a disposable parameter, fixed by giving agreement with the lowest state Γ_1. To reproduce the *p*-like levels, the truncation of the plane wave expansions was brought about by using as a correction a very small further pseudo-potential, while the *d*-like levels could be reproduced by using the Seitz potential alone. The lower levels thus calculated agreed with those of Glasser and Callaway to within their stated accuracy. Levels were then calculated at general points within the first zone on a lattice $(a/2\pi)(k_x,k_y,k_z) = (1/10)n$ $(n = 1,2\ldots)$ by using an appropriate number of terms of the plane wave expansion, and the first 22 Fourier coefficients of $E(k_x,k_y,k_z)$ obtained by least squares. Finally, $N(E)$ was obtained by numerical integration. The calculations were carried out on the Mercury Computer of the University of London.

Fig. 1 shows the calculated $N(E)$ curve, with E_F, the Fermi energy, $-0{\cdot}425$ Ry., and E_N, the lower energy at N, $-0{\cdot}400$ Ry., N being the point on the surface of the first zone nearest to its centre Γ. Since $E_F < E_N$, the calculation thus shows that the Fermi surface does not touch the zone boundary; however, $(E_N - E_F)$ is only equal to $0{\cdot}025$ Ry., which is within the accuracy of Glasser and Callaway. The broken curve on Fig. 1 gives the $N(E)$ curve

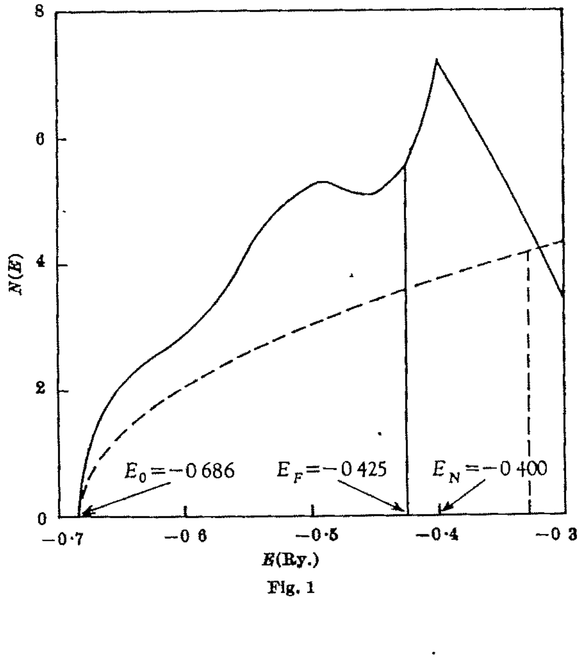


Fig. 1

for free electrons. The energy surfaces near Γ can be expressed as[7]:

$$E(\mathbf{k}) = E_0 + E_2k^2 + E_4^{(1)}k^4 + 5E_4^{(2)}(k_x^2k_y^2 + k_y^2k_z^2 + k_z^2k_x^2 - 1/5k^4)$$

where $E_0 = -0{\cdot}686$, $E_2 = 0{\cdot}754$, $E_4^{(1)} = -0{\cdot}064$, $E_4^{(2)} = -0{\cdot}146$, and where E_2 corresponds to an effective mass at Γ, $m^* = 1{\cdot}32\ m_e$, and $E_4^{(2)}$ gives a measure of the anisotropy. Previous values of these constants are given in refs. 6 and 9. The value $E_F - E_0 = 0{\cdot}261$ Ry. compares with a value 0 235 Ry. based on the soft X-ray emission spectrum[10]. The calculated low-temperature electronic heat coefficient is $2{\cdot}38 \times 10^{-4}$ cal. mol.$^{-1}$ deg.$^{-2}$, compared with the observed value[11] $4{\cdot}18 \times 10^{-4}$, which was, however, not obtained for body-centred cubic lithium.

The method is now being applied to other metals including sodium, potassium, titanium and beryllium, and fuller details will be published elsewhere.

We are indebted to Prof. H. Jones for helpful discussions, and one of us (J. F. C.) acknowledges the award of a University Postgraduate Studentship of the University of London.

J. F. CORNWELL
E. P. WOHLFARTH

Department of Mathematics,
Imperial College,
London, S.W.7.
March 21.

[1] Phillips, J. C., and Kleinman, L., *Phys. Rev.*, **116**, 287 (1959)
[2] Gáspár, R., *Acta Phys. Hung.*, **9**, 79 (1958).
[3] Antončík, E., *J. Phys. Chem. Solids*, **10**, 314 (1959).
[4] Gombás. P., "Handbuch der Physik", **36**, 109 (1956).
[5] Glasser, M. L., and Callaway, J., *Phys. Rev*, **109**, 1541 (1958).
[6] Callaway, J., *Solid State Physics*, **7**, 99 (1958).
[7] Kohn, W., and Rostoker, N., *Phys. Rev.*, **94**, 1111 (1954).
[8] Bouckaert, L. P., Smoluchowski, R., and Wigner, E. P., *Phys Rev.*, **50**, 58 (1936).
[9] Cohen, M. H., and Heine, V., "Adv. in Physics", **7**, 395 (1958).
[10] Bedo, D. E., and Tomboulian, D. H., *Phys. Rev.*, **109**, 85 (1958).
[11] Roberts, L. M., *Proc. Phys. Soc*, B, **70**, 744 (1957).

Trace Analysis by X-Ray Fluorescence using Ion Exchange Resins

THE analysis of trace elements in concentrations of a few parts per million, or less, by X-ray fluorescence spectrography has hitherto not been practicable, mainly as a result of the relative weakness of the emitted spectra. Grubb and Zemany[1] have obviated this difficulty by showing that traces of cobalt at levels of 1 μgm./l. may be analysed by first adsorbing the element on to a small piece of cation membrane and irradiating this in an X-ray spectrograph. The long equilibration times involved (16–48 hr.) have, however, precluded the general application of their method in a wider field, particularly in process control, where the time-factor is important.

The method which we have developed is based on a similar concentration step, but the element to be determined is collected on an ion-exchange resin (granular or liquid), after which the resin is irradiated directly in the X-ray spectrograph. A number of elements may thus be collected and determined simultaneously without the necessity of time-consuming separations. We have found that rapid equilibrium with solid resins is attainable, provided that the resin is soaked beforehand. Equilibrium with liquid resins is even faster. The relative amounts of resin and solution are so chosen that the enrichment ratio brings the concentration of the element on the resin within the range where it can be determined directly by X-ray spectrography. Provided that the variation in particle size of the solid resin is small, no extra variance is introduced in the results by distributional variations in the resin bed. Where relatively large amounts of co-adsorbed elements give rise to interferences, such as absorption or enhancement of the measured radiation, the effects can be overcome by the use of suitable internal standards. The voids between the solid resin particles are filled with the reference element in non-adsorbing form. The reproducibility of the results obtained justify the introduction of standards in this way.

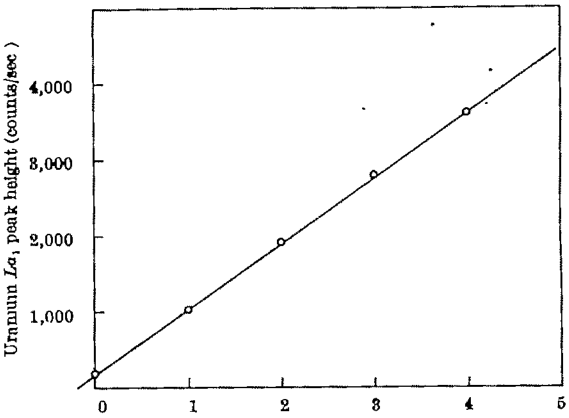


Fig. 1. Extraction of uranium from 'barren' solution with solid resin, '*AG–1X*'

The determination of uranium in barren sulphate effluent, from the ion-exchange columns in the Witwatersrand uranium industry, serves as a good illustration of this technique. (Detailed results will be published elsewhere.) The major ionic constituents of these solutions are:

Fe^{2+} (2–3 gm./l.) Fe^{3+} (2–3 gm./l.)
Mn^{2+} (4–6 gm./l.) Al^{3+} (4–6 gm./l.) and
SO_4^{2-} (~20 gm./l.) at a *p*H of about 3

The uranium content varies between 0 and 3 p.p.m. 500 ml. of this solution is shaken for 5 min. with 2 gm. (dry weight) of '*AG–1X*' anionic resin in sulphate form which has been soaked beforehand in 0·25 *M* ammonium sulphate solution. The resin is filtered by

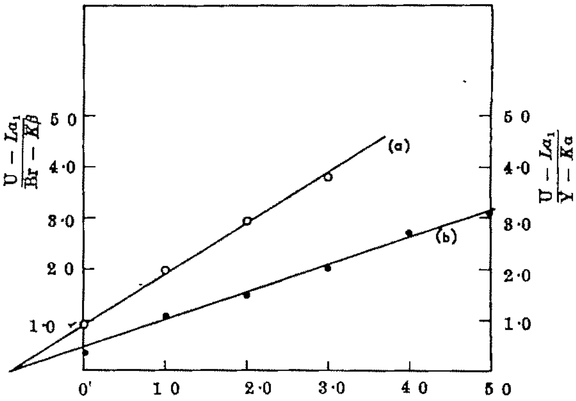


Fig 2. Calibration curves using: *a*, bromine; *b*, yttrium, as internal standards with the '*AG–1X*' extractions

Table 1. Sample Uranium Determinations in Barren Solutions

'*AG*–1*X*' resin		20 per cent '*LA*–2' in kerosene	
Uranium added (p.p.m.)	Uranium found (p.p.m.)	Uranium added (p.p.m.)	Uranium found (p.p.m.)
1·70	1·68	2·30	2·44
3·76	3·60	3·40	3·50
4·35	4·30		

suction, washed over into a suitable liquid sample holder[2] and irradiated (Philips high-intensity molybdenum tube). The linearity obtained when making standard additions of uranium to barren solutions is illustrated in Fig. 1. Iron, probably co-adsorbed as negative ferric sulphate complexes, absorbs the uranium-$L\alpha_1$ radiation, so that the use of internal standards is advisable where the iron content of the solutions tends to fluctuate. (In practice, we have found this unnecessary as the iron concentration in these barren solutions remains constant within narrow limits.) Fig. 2 illustrates the feasibility of using alcoholic bromobenzene and aqueous yttrium sulphate as internal standards. Under the above conditions about 90 per cent of the uranium in a solution containing 2 p.p.m. is extracted with good reproducibility (standard deviation 1–2 per cent).

Good extraction is also possible with anionic liquid resins (for example, 'Amberlite *LA*–2'). The sensitivity is somewhat lower (see Figs. 1, 3), as the highest practicable concentration ratio is only about 50. The linearity obtainable when extracting 500 ml. of 'barren' solution with 10 ml. 20 per cent '*LA*–2' in kerosene is shown in Fig. 3. Although much less iron is co-extracted in this case, so that absorption effects are not serious, we have established that internal standard procedures can also be applied here by using bromobenzene in kerosene. Typical results are given in Table 1. The accuracy of both variants of the method is estimated at 5 per cent on 1 p.p.m. uranium, the main source of error residing in the statistical counting error due to the unfavourable peak to background ratio. The limits of detection, under the above conditions, are estimated to be 0·1 p.p.m. uranium using solid resin, and 0·2 p.p.m. using liquid resin.

As the method is also applicable to cationic resins, we believe that this technique extends the scope of X-ray fluorescent analysis far beyond its present limits, and its rapidity should render it useful for the routine trace analysis of a wide range of elements.

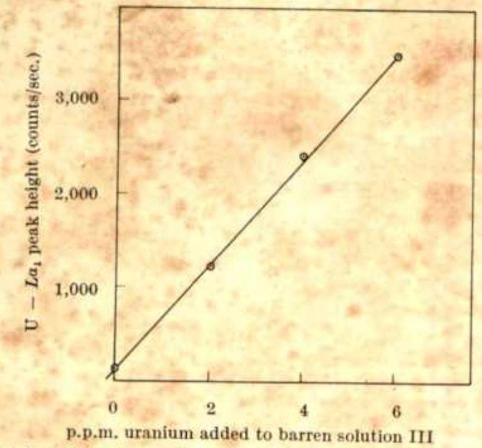


Fig. 3. Extraction of uranium from 'barren' solution using liquid resin, 'Amberlite *LA*–2'

J. N. van Niekerk
J. F. de Wet*

National Physical Research Laboratory,
South African Council for Scientific
and Industrial Research,
Pretoria.

---

* Present address: Department of Physical Chemistry, University of Pretoria, Pretoria.

[1] Grubb, W. T., and Zemany, P. D., *Nature*, **176**, 221 (1955).

[2] Van Niekerk, J. N., and Wybenga, F. T., *J. App. Spectr.* (in the press).

Micromosaic Patterns in Single Crystals of Potassium Chloride containing Barium Chloride

Dislocation networks generated in alkali halide crystals when subjected to mechanical strain have been rendered visible by 'decoration' with colloidal aggregations of colour centres[1] and with silver[2]. Amelinckx *et al.*[3] obtained micromosaic patterns in sodium chloride crystals containing sodium or barium chloride and Hedges and Mitchell[4] in silver bromide containing excess silver.

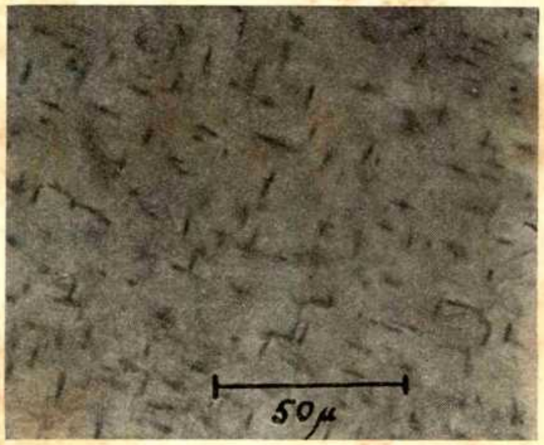


Fig. 1

In the present work barium chloride in concentrations varying from 5×10^{-5} to 10^{-2} barium/potassium atoms was added to melts of potassium chloride and single crystals grown from the melt by the Kyropoulos method[5]. The crystals were cleaved to produce specimens of about 0·5 mm. thick and microphotographs made of interior planes at a magnification of 500. It was found that crystals containing about 5×10^{-4} barium/potassium showed throughout the interior a pattern consisting of a network of lines some 5–10μ long (Fig. 1). Pure crystals showed no such patterns. Occasionally, deep within the crystal, was seen a pattern such as that shown in Fig. 2, which gave the impression of voids within the crystal some 5μ or less in depth and some hundreds of microns in length. It might be supposed that such voids might be generated as a means of reducing the strains set up by the relatively high impurity content or by the unavoidable thermal strains in the formation of the crystals. It has not been possible so far to anneal out such voids even after many hours heating and of subsequent cooling to room temperature at a rate of about 5 deg. C. per

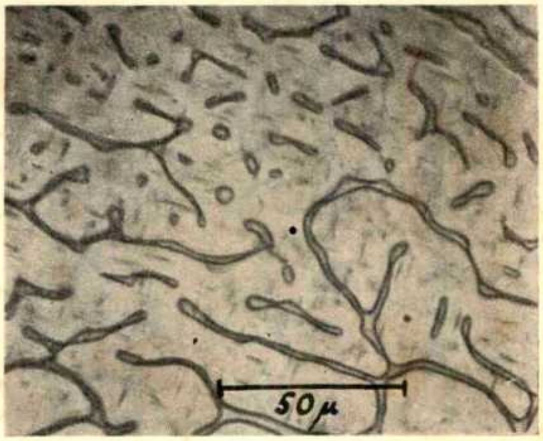


Fig. 2

hr. The pattern of fine lines seen in Fig. 1 might be interpreted in two ways. It might be the result of dislocations produced by the added barium chloride, a minimum concentration being necessary and a too high concentration resulting in such extensive disorganization of the lattice that no simple pattern is formed or can be discerned. Or, the pattern may be already present in the 'pure' crystal in the form of invisible internal surfaces or lines and is revealed by precipitation on these surfaces or lines of an added substance such as barium chloride when this is present within certain limits of concentration. High concentration of barium chloride produces a cloudiness which can be cleared again by heating. It is not possible from the present observations to decide between the two possibilities, but it seems that the incorporation of a suitable impurity in single crystals of alkali halides reveals a defect structure which might be used in the study of the formation and behaviour of such structures and the part they play in the behaviour of crystals under various conditions.

J. EWLES

Department of Physics,

J. B. DAWSON

Department of Medical Physics,
University of Leeds.
March 19.

[1] Hosoya, S., *J. Phys. Soc. Japan*, **11**, No. 12, 1231 (1956).

[2] van der Vorst, W., and Dekeyser, W., *Phil. Mag.*, **1**, No. 9, 882 (1956).

[3] Amelinckx, S., van der Vorst, W., Gevers, R., and Dekeyser, W., *Phil. Mag.*, **46**, 450 (1955).

[4] Hedges, J. M., and Mitchell, J. W., *Phil. Mag.*, **44**, 223 (1953).

[5] Kyropoulos, S., *Z. anorg. allgem. Chemie*, **154**, 308 (1926).

RADIATION CHEMISTRY

Polymer Formation in Irradiated *p*-Xylene

INVESTIGATIONS of the radiochemical behaviour of alkylbenzenes have predominantly been focused on the gaseous decomposition products, and data about the liquid reaction products are rather scarce.

As part of a study of the kinetics of radiolysis of alkylbenzene mixtures, *p*-xylene was submitted to mixed atomic pile radiation.

In view of the complex nature of mixed atomic pile radiation, a direct determination of the amount of energy absorbed by the sample is not always possible. For the work reported here it was chosen to use biphenyl as a reference component.

Biphenyl has been extensively studied in relation to its use as a moderator, and by choosing it as an irradiation standard it is expected to make possible a direct comparison of the data obtained on the lighter alkylbenzenes with the data which have already been accumulated for heavier products such as the terphenyls.

In addition to samples of pure *p*-xylene and biphenyl a certain number of mixtures of *p*-xylene and biphenyl were irradiated and analysed. The *p*-xylene and biphenyl both had a purity of 99 + per cent.

4-gm. samples of *p*-xylene, biphenyl or a mixture of both were sealed under vacuum in silica capsules (diam. 2 cm., height 6 cm.). Each capsule was placed in a tightly fitting aluminium container and irradiated in the *Y*7 channel of the *BR* I reactor at Mol, Belgium. The equilibrium temperature of the samples during irradiation was approximately 95° C.

After irradiation the liquid phase was analysed by gas-liquid partition chromatography using a 5-m. stainless steel column (1/4 in.) packed with 30/50 mesh 'Sil-O-Cel', impregnated with 30 per cent 'D–C' high-vacuum silicone grease. Helium at a rate of 100 ml./min. was used as a carrier gas and column temperature was stabilized at 150° C. The retention time of biphenyl was about 1 hr.

For quantitative analysis of the liquid-phase naphthalene was used as a tracer, and benzene as a solvent. The area correction factors were determined with solutions of known composition at the different concentration-levels encountered.

From the measured ratio of *p*-xylene or biphenyl to naphthalene and the known ratio of naphthalene to total sample, one derives the concentration of *p*-xylene or biphenyl in the sample. In order to investigate further the nature of the polymer formed, a fraction of the irradiated sample was distilled for 1 hr. at 150° C. under a pressure of 0·05 mm. mercury, yielding a colourless distillate and a gummy brownish residue of heavy polymer tar.

The concentration of *p*-xylene or biphenyl in the distillate was determined by the same analytical technique.

From the concentration of *p*-xylene in the sample before irradiation, after irradiation, and in the distillate one calculates the amount of *p*-xylene which has disappeared by radiolysis, as well as the amount of polymer formed, which can be differentiated in compounds of the boiling range of terphenyl and heavy polymer tar.

No correction was made to account for the gaseous decomposition products, as it was found that their weight was well below 1 per cent of the total sample weight.

Furthermore, a preliminary analysis showed that the amount of liquid products of lower molecular weight formed upon irradiation was so small that it has also been neglected in the material balance calculations.

The results have therefore been treated as if the disappearance of the initial compound measures the formation of products of higher molecular weight.

Typical experimental results on *p*-xylene and biphenyl are summarized in Table 1.

Table 1. TOTAL INCIDENT DOSAGE: 1·21 × 10^{19} nVT (THERMAL)

Weight (per cent)	*p*-Xylene	Biphenyl
Unchanged after irradiation	92	91
Total polymer	8	9
Heavy tar	2	7

From the results obtained at an incident dosage of $1 \cdot 21 \times 10^{18}$ nVt (thermal) (Table 1) and those obtained at $0 \cdot 76 \times 10^{18}$ nVt (thermal) it follows that *p*-xylene polymerizes according to the same rate law as biphenyl, which means that the reaction is a first-order process[1].

Mixtures of *p*-xylene and biphenyl varying in composition from 4·75 to 28·5 per cent weight of *p*-xylene were irradiated under the same conditions. The experimental results show that within the limit of accuracy of the analytical method the first-order rate law also applies. The results for heavy tar formation are not so conclusive as those concerning the *p*-xylene/biphenyl ratio. The rather large scatter of the results about heavy tar content versus *p*-xylene/biphenyl ratio may be attributed to the limitations of the analytical method used. The general trend of the results is, however, in agreement with a first-order rate law.

From the similarity of behaviour of *p*-xylene and biphenyl under the influence of mixed pile radiation one may also expect a similar behaviour with respect to gamma irradiation. As regards the radiochemical polymerization yield $G_p = \frac{\text{molecules polymerized}}{100 \text{ eV.}}$ of *p*-xylene, its magnitude may be taken as approximately 1·45 times the corresponding value for biphenyl.

A more detailed account will be published elsewhere.

I am indebted to Dr. F. Dupire for his advice about the chromatographic technique and to M. A. de Wilde for his interest in this subject.

FRANOIS VAN HECKE

Conseil en Génie Chimique,
183 Avenue de Tervueren,
Bruxelles, 4.
March 14.

---

[1] de Halas, D. R., Hanford Atomic Products Operation *HW*-56769.

Use of Ionizing Radiation in Spot Tests for Nitrogenous Compounds

SEVERAL spot tests are available for determining substances containing nitrogen, and are widely used in qualitative and semi-quantitative analysis[1]. All these involve the development of colour or fluorescence by spraying with suitable reagents. We have discovered that many nitrogenous compounds give a brown colour when spotted on to filter paper and exposed to doses of ionizing radiation in the range 5×10^{6}–2×10^{8} rads.

The results described below stem from an observation by one of us that ammonium dihydrogen phosphate spotted on filter paper and exposed to a flux of 10^{11} neutrons/cm.^{2}/sec. in the reactor *Bepo* for six days developed a brown colour. In subsequent work we used a 4-MeV. linear accelerator as a radiation source, since this could be used to deliver 10^8 rads in a much shorter time than the reactor and without inducing any radioactivity. Several different types of filter paper were tested and Whatman No. 4 selected as the most suitable: all papers became brittle and pale yellow after 10^8 rads, and cellulose acetate papers crumbled completely away after this treatment[2]. Colours developed slowly at room temperature and faster on warming. The best conditions for colour development were obtained using aliquots containing about 20 μgm. nitrogen exposed to 10^8 rads, when the limit of detection was approximately 2 μgm. nitrogen. Under these conditions well-defined brown spots were obtained from the following materials: ammonium chloride, methylamine hydrochloride, diethylamine hydrochloride, glycine, alanine, asparagine, proline, potassium nitrate, sodium nitrite and nitrobenzene. Fainter spots were obtained with acetamide, diphenylamine, pyridine and azobenzene, but no spots could be found when tetramethyl ammonium bromide and cetyl trimethyl ammonium bromide were tested. β-indolyl acetic acid gave a pink spot, while aspartic acid and trimethylamine hydrochloride were anomalous in giving deep brown spots on heating (with or without ionizing radiation).

The colour formation is probably due to a Maillaird reaction between amino-groups and aldehydic substances resulting from radiation-induced breakdown of cellulose. Presumably nitro groups are reduced to amino groups under these conditions of irradiation, and tertiary amines like pyridine undergo ring cleavage. However, no improvement in colour development could be obtained by soaking the filter paper in glucose solution before spotting and irradiating. As an analytical technique, the reaction is not so sensitive as the ninhydrin reaction for amino-acids, which can detect about 0·1 μgm. nitrogen, but it might be useful for detecting other substances which do not give the ninhydrin test. It has been used to develop paper chromatograms of amino-acids.

Finally, the reaction may be of interest to those concerned with radiation dosimetry. The fact that a colour will develop at 5×10^{6} rads, which is near the sterilizing dose for food and pharmaceutical materials, is important in this connexion.

H. J. M. BOWEN
E. ARTER
P. A. CAWSE

Wantage Radiation Laboratory,
Grove,
Berks.

---

[1] Feigl, F., "Spot Tests in Organic Analysis" (Elsevier, 1956).

[2] Saeman, J. F., Millett, M. A., and Lawton, E. J., *Indust. Eng. Chem.*, 44, 2848 (1954).

Radiation Synthesis of Urea

LOISELEUR and PETIT[1] have reported that urea is formed in the X-irradiation of an ammoniacal and methanolic solution of *m*-phenylenediamine and dichloromethane in the presence of air. A further report has been given recently by Loiseleur, Petit and Clémentin[2] on the effect of oxygen-acceptors on the yield of urea. We set out to synthesize substituted ureas and to study the proposed mechanisms, but we found that no urea was formed in experiments with similar solutions.

γ-radiation from a cæsium-137 source (dose-rate: 10^{16} eV./ml./min.), taking $G_{Fe^{3+}} = 15 \cdot 5$, and X-rays from a copper target at 40 kV. and 20 m.amp. (dose rate: $1 \cdot 5 \times 10^{15}$ eV./ml./min.) were used in the experiments. Closed glass irradiation cells of 25 ml. capacity were fitted with polythene capillary tubing through which air was bubbled, after it had first passed through a vessel containing the solution to be irradiated. The solution (32 ml. methanol, 4 ml. dichloromethane, 250 mgm. *m*-phenylenediamine, 0·25 ml. 30 per cent aq. ammonia) was freshly prepared for each experiment. Reagents were carefully purified: methanol and dichloromethane were fractionated; ammonia (sp. grav. = 0·880) was diluted with distilled water; *m*-phenylenediamine was twice distilled under nitrogen and used immediately after the second distillation as well-defined light-yellow crystals (m.p. 61° C.) and xanthydrol was synthesized and used as a 10 per cent solution in ethanol[3]. After receiving total absorbed doses of γ-radiation ranging from 6×10^{17} eV./ml. to 7×10^{18} eV./ml. and of X-rays at $4{\cdot}5 \times 10^{16}$ eV./ml., the solutions were analysed for urea using Fosse's method with the xanthydrol reagent. This is the method used by Loiseleur and it might be noted that it is not specific for urea although a well-defined dixanthyl urea compound is formed[4]. (The reaction was erratic and even failed to proceed with quite large amounts of added urea when the reagent was used in the normal way.)

In all experiments where the xanthydrol reaction was used, whether the solutions were irradiated or not, well-defined white crystals were obtained in reasonable yield. Infra-red absorption spectra and elemental analysis showed quite clearly that the compound was not dixanthylurea. The empirical formula was $C_{6\cdot7}H_{4\cdot9}N_{0\cdot26}O_{0\cdot61}$.

A paper chromatographic method was therefore developed to detect urea. Various methods are available for the detection of as little as 10γ of urea[5]. However, the uni-dimensional technique with numerous solvents failed to distinguish urea satisfactorily from the more reactive *m*-phenylenediamine. The two-dimensional technique with butanol/ethanol/water (4 : 1 : 1) was adequate for more than 50γ urea. Aqueous pyridine (4 : 1) was found to allow good separations using the uni-dimensional ascending technique. The chromogenic reagent was 1 per cent dimethylaminobenzaldehyde in ethanol containing 1 ml. concentrated hydrochloric acid. After spraying, the chromatogram was heated at 100° C. for 5 min. to increase the intensity of the yellow urea spot. The limiting sensitivity of the method was 10–20 μgm. of urea in 1,400 μgm. of *m*-phenylenediamine.

Analyses by paper chromatography of aerated solutions, which were irradiated as described above, showed no trace of urea. For comparison, the lowest urea yield reported by Loiseleur and Petit (350 mgm. urea derivative per 100 ml. after an estimated $0{\cdot}75 \times 10^{6}$ r. of X-rays) is well within the limits of detection by chromatography. Our conclusion from these preliminary experiments, which were arranged to reproduce the conditions reported as closely as possible, is that no urea is synthesized by γ- and X-radiation of the 'Loiseleur' solution, or that the synthesis is extremely sensitive to dose-rate.

S. Dilli
J. H. Green

Department of Nuclear and Radiation Chemistry,
University of New South Wales,
Sydney.

---

[1] Loiseleur, J., and Petit, M., *C.R. Acad. Sci., Paris*, **240**, 1026 (1955). Loiseleur, J., *J. Chim. Phys.*, **52**, 626 (1955).

[2] Loiseleur, J., Petit, M., and Clémentin, A., *C.R. Acad. Sci., Paris*, **248**, 1720 (1959).

[3] Kny-Jones, F. G., and Ward, A. M., *Analyst*, **54**, 574 (1929). Gilman, H., and Blatt, A. H., "Organic Syntheses", Collective Vol. 1 (Wiley, New York, 1941).

[4] Elderfield, R. C., edit. by, "Heterocyclic Compounds", 2 (Wiley, New York, 1951).

[5] Milks, J. E., and Janes, R. N., *Anal. Chem.*, **28**, 846 (1956).

CHEMISTRY

Overturning of Stearic Acid Molecules in Monolayers

I have recently reported some experiments on the exchange of stearic acid molecules and potassium ions between mica surfaces brought into contact, and emphasized the importance of these phenomena in lubrication[1]. I wish now to describe some further results of these experiments, and discuss their significance in terms of the motions which long-chain polar molecules in mono-molecular layers on solid surfaces may undergo.

Rideal and Tadayon[2] first reported radiometric observations on the transfer of stearic acid–carbon-14 from monolayers deposited on solid surfaces to other solids brought into contact with them. Their experiments were carried out with metal-coated mica sheets as substrates, and no measurements of the area of contact were made, although it was suggested that it was only a small fraction of the total area of the sheets. After long periods (20–100 hr.) of contact, an apparent equilibrium in the amount transferred was reached. In Table 1, their results are summarized in terms of the surface from which the stearic acid was removed.

Table 1. 'Equilibrium' Transfer of Stearic Acid; 36° C. (Rideal and Tadayon)

From	To	Amount (per cent)
Mica	Mica	50–60
	Tin	85
	Platinum	90
Tin	Tin	50
	Nickel	65
	Copper	85
	Silver	80
Silver	Silver	45
	Copper	80
	Tin	65
	Platinum	90
Copper	Copper	4
	Silver	4
	Tin	6
	Platinum	8
Nickel	Nickel	6
	Tin	8
	Copper	10
Platinum	Silver	15
	Copper	8

As shown in Table 1, the substrates used fall into two groups: those which can give up a major fraction of the stearic acid (mica, tin, silver) are relatively inert to reaction with the fatty acid, while those which lose only a few per cent of the acid initially present (copper, nickel) are reactive metals. (Platinum seems to be somewhat anomalous; as Young[3] has suggested, this may reflect a strong physical interaction due to the thinness or absence of an oxide film on platinum.)

In the previous report[1], it was shown that the extent of transfer of a stearic acid monolayer between two mica sheets brought into contact for even a few minutes was about half that present in the area of contact. It was also found that potassium ions from the exchangeable-ion sites on the mica surfaces were exchanged, even in the presence of the stearic acid monolayer. Two other cases have now been examined qualitatively. Transfer between two monolayers of stearic acid has been observed, using one radioactive and another non-radioactive stearic acid film, both deposited on mica. Some observations of transfer from barium stearate monolayers (stearic acid spread on solution 10^{-4} *M* barium chloride and 10^{-3} *M* in potassium bicarbonate, adjusted to *p*H 9 with potassium hydroxide) on mica have also been made. In the present measurements, the technique of Rideal and Tadayon was used. The possibility of vapour-phase transport in these systems was also examined. Young[3] had observed such transport at elevated

Table 2. OBSERVED COUNT RATES (PER CM.^{2}) ON MICA SHEETS IN CONTACT AND TRANSFER EXPERIMENTS (EACH 5–10 MIN.)
(Corrected for background count)

	Radioactive sheet		Inactive sheet
	Initial	Final	
Stearic acid monolayers :			
Separated 1 mm., air	650 c./m.	650 c./m.	0 c./m.
Separated 1 mm., p = 50μ	650	450	75–150
Contact	650	—	uncoated 18–40 stearic acid monolayer 5–15
Barium stearate monolayers :			
Separated 1 mm., p = 50μ	650 c./m.	620 c./m.	—
Contact	650	—	42 c./m. (uncoated)

temperatures, and suggested that it might account for the apparent diffusion described by Rideal and Tadayon. The present experiments were carried out at room temperature (25 ± 2° C.).

The experimental results are shown in Table 2, where count-rates observed with an end-window Geiger–Müller counter placed over the sample after the indicated exposure are listed. For the measurement of initial rates, and for the samples exposed without contact, a mask was used and an area of 1 cm.^{2} near the centre of the sheet was examined. The samples in contact, as might be expected, showed wide variations in activity over their surfaces. The values given for them represent the count-rate of the whole sheet (observed without a mask) divided by the sheet area to give the average count-rate for 1 cm.^{2}.

As indicated in Table 2, exposure of two sheets of mica 1 mm. apart in room air shows no significant transfer after 5–10 min. After 1 hr. of such exposure, the result is the same. However, when the samples are placed in a vacuum chamber and the pressure is reduced to 50μ for 5 min., almost one-third of the activity of the radio-stearic acid monolayer is lost, and a comparable amount is found on the initially inactive sheet. With barium stearate, however, the loss of activity is much less. In contact experiments, however, no such difference appears ; transfer of barium stearate and stearic acid to fresh mica surfaces is of the same order of magnitude. When a stearic acid monolayer is confronted not with a clean mica surface, but with one which is coated with another stearic acid monolayer, transfer (exchange ?) also occurs. It seems that the amount transferred is less in the latter case, although the possible variation in true contact area in these experiments prevents any definite statement on this point.

The results are in good agreement with the observations of Young on stearic acid and stearate monolayers, and support his suggestion of vapour-phase transport in the work of Rideal and Tadayon. If we consider all these results in the framework of Langmuir's mechanism for the overturning of stearate molecules in monolayers[4], correlations are obvious. The molecules in the monolayer are held in their 'normal' (polar head toward the substrate) position if there is a strong interaction between the polar head and the underlying material. This can be a chemical bond or perhaps a strong physical interaction such as that between stearates and platinum. This accounts for the strong attachment, lack of reduction of contact angle in the presence of water and lack of vapour-phase transfer with monolayers on reactive solids.

If a stearic acid monolayer is deposited on an unreactive substrate, some of the molecules may at any time be overturned. Whenever there is a possibility of anchoring these molecules in the overturned position (another surface brought into contact or a liquid water drop placed on the surface), such a process will proceed to an equilibrium determined by the minimization of the energy of the system. Analogous behaviour will be found with soap monolayers. It now appears probable that the transfer of potassium ions observed in my previous work[1] is to be associated with soap formation.

Differences should, however, be expected in the vaporization behaviour of divalent soap and free-acid monolayers on unreactive solids. The energy required to separate a barium stearate molecule from its neighbours will obviously be greater than that required to remove a single stearic acid molecule, on the basis of chain–chain interactions. This is in agreement with the experimental results.

From the point of view of lubrication phenomena, of course, it is necessary to consider liquid systems and adsorbed polar films. Studies of how the presence of bulk liquid will affect the processes described above are now in progress.

GEORGE L. GAINES, JUN.

General Electric Research Laboratory,
Schenectady, New York.

---

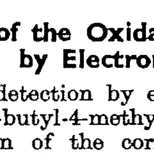
[1] Gaines, jun., G. L., *Nature*, 183, 1110 (1959).
[2] Rideal, E., and Tadayon, J., *Proc. Roy. Soc.*, A, 225, 346 (1954).
[3] Young, J. E., *Aust. J. Chem.*, 8, 173 (1955).
[4] Langmuir, I., *Science*, 87, 493 (1938).

Study of the Oxidation of Hindered Phenols by Electron Spin Resonance

THE detection by electron spin resonance of the 2,6,-di-t-butyl-4-methylphenoxy radical during the oxidation of the corresponding phenol with lead dioxide has been reported recently[1]. The purpose of this communication is to report a similar investigation of the free radicals formed during the oxidation of solutions of the hindered phenols 2,6,-di-t-butyl-4-R-phenol [where $R \equiv$ methyl (I) ; ethyl (II) ; and t-butyl (III)] with an alkaline solution of potassium ferricyanide.

This method of oxidation has the advantage that only the phenoxy radicals are formed, whereas in the former case secondary radicals were soon observed. Furthermore, the hydrocarbon solution of the radical can be rapidly separated from the oxidizing medium, which permits the kinetics of radical decay to be determined.

Both the methyl and ethyl phenols, (I) and (II), give transient electron spin resonance spectra which are attributed to the corresponding phenoxy radicals, (IV) and (V). The t-butyl phenol (III) gives the spectrum due to the stable phenoxy radical (VI)[2].



R ≡ methyl (IV)
ethyl (V)
t-butyl (VI)

The spectrum from the methyl phenoxy (IV) consists of four triplets. This is identical with the spectrum already reported[1]. The spectrum of the ethylphenoxy (V) consists of three triplets, and is attributed to the interaction of the unpaired electron with the two —CH_2— protons of the ethyl group (major splitting) together with a much smaller interaction with the two ring protons. The interaction

Table 1. HYPERFINE SPLITTING CONSTANTS OF 2,6-DI-*t*-BUTYL-4-*R*-PHENOXY RADICALS

Para-substituent *R*	Hyperfine splitting (oersted)	
	Para-alkyl protons	Ring protons
Methyl	11·0 ± 0 1	1·65 ± 0 05
Ethyl —CH_2—	8·65 ± 0·1	1 70 ± 0·05
Ethyl —CH_3	not resolved	
t-Butyl	not resolved	1·84 ± 0·05

with the —CH_3 protons of the ethyl group is too small to give a resolvable splitting of the spectrum. This is in line with the fact that the protons of the para *t*-butyl group of the butyl-phenoxy (VI) do not give a resolvable splitting. The hyperfine splitting constants of the electron spin resonance spectra are summarized in Table 1.

The assignment of the electron spin resonance spectra to the phenoxy radicals is confirmed by the fact that all three spectra can be interpreted logically on the same basis.

The oxidation of the methyl phenol (I) yields appreciable amounts of the following dimers: 1,2-*bis*(3,5-di-*t*-butyl-4-hydroxyphenyl) ethane and 3,5,3',5'-tetra-*t*-butylstilbene-4,4'-quinone, which suggests that the initial oxidation occurs on the methyl group to give the 4-hydroxy-3,5,-di-*t*-butylbenzyl radical. However, Cook *et al.*[3] have suggested that the following sequence of reactions occurs during the oxidation:

$$\text{phenol} \xrightarrow[\text{[O]}]{} \text{phenoxy} \xrightarrow[\text{[rearrangement]}]{} \text{benzyl} \xrightarrow[\text{[dimerization]}]{} \text{end products} \quad (1)$$

Becconsall *et al.*[1] have confirmed that the phenoxy radical (IV) is formed during the oxidation, but suggest that the next step is the formation of a complex between two phenoxy radicals, rather than a re-arrangement to the benzyl radical. There is also the possibility that the phenoxy radical decays by the reaction:

$$\text{phenoxy} + \text{phenol} \longrightarrow \text{phenol} + \text{benzyl} \quad (2)$$

The present results show that the methyl phenoxy (IV) decays with first-order kinetics, and that the rate of decay is independent of the concentration (0·1–5 per cent) of the parent phenol (I) initially present. However, the rate of decay is influenced by the solvent, and is slower in a highly polar solvent; for example, the rate constants in benzene, methyl*cyclo*hexane and acetone at 25° C. are $1 \cdot 33 \times 10^{-2}$ sec.$^{-1}$, $1 \cdot 23 \times 10^{-2}$ sec.$^{-1}$ and $0 \cdot 35 \times 10^{-2}$ sec.$^{-1}$ respectively. In methyl*cyclo*hexane the decay process has an activation energy of 11·4 kcal./mole and a frequency factor of $3 \cdot 1 \times 10^{6}$ sec.$^{-1}$.

These kinetic results show that the phenoxy radical does not decay according to equation (2), since such a reaction would follow second-order kinetics. Furthermore, the first-order kinetics are consistent with the decay being due to an intramolecular rearrangement rather than dimerization or complex formation, which would follow second-order kinetics.

The suggestion that two phenoxy radicals form a complex before rearranging is based on the fact that the cross-products, from the reaction between phenoxy and benzyl radicals, are not formed in appreciable quantities. However, recent results suggest that the *t*-butyl-phenoxy (VI) reacts surprisingly slowly with various other free radicals[4]. Thus it is quite possible that the cross-reactions in the case of the methyl phenoxy (IV) only occur slowly.

The frequency factor is very low for a unimolecular reaction. Dewar[5] has suggested that during an intramolecular rearrangement the migrating group forms a π-complex with the ring, and that bulky substituents on the ring will reduce the rate of rearrangement. In addition, since a free radical possesses an excess electron, it will only form a π-complex with difficulty and thus be rearranged only slowly. Both these effects may be the cause of the low rate of rearrangement found for the methyl phenoxy (IV).

The ethyl phenoxy (V) also decays with first-order kinetics, but at a slower rate than the methyl phenoxy (IV); for example, the rate constant in benzene at 25° C. is $0 \cdot 75 \times 10^{-2}$ sec.$^{-1}$. The first-order kinetics for the ethyl phenoxy (V) show that this also decays by a rearrangement reaction. This is in contrast to the *iso*propylphenoxy ($R \equiv$ *iso*propyl), which decays by a radical–radical reaction, giving second-order kinetics[6].

I wish to thank the directors of "Shell" Research, Ltd., for permission to publish this communication, Mr. J. H. T. Brook and Dr. R. L. Allen for helpful discussion, and Mr. E. J. H. Morgan for assistance in the experimental work.

J. E. BENNETT

"Shell" Research, Ltd.,
Thornton Research Centre,
P.O. Box 1,
Chester.

[1] Becconsall, J. K., Clough, S., and Scott, G., *Proc. Chem. Soc.*, 308 (1959).

[2] Müller, E., Ley, K., Scheffler, K., and Manat, R., *Chem. Ber.*, 91, 2682 (1958).

[3] Cook, C. D., Nash, N. G., and Flanagan, H. R., *J. Amer. Chem. Soc.*, 77, 1783 (1955).

[4] Cook, C. D., and Depatie, C. B., *J. Org. Chem.*, **24**, 1144 (1959). Also unpublished work in this laboratory.

[5] Dewar, M. J. S., "Electronic Theory of Organic Chemistry", 229, 263 (Oxford, 1949).

[6] Cook, C. D., and Norcross, B. E., *J. Amer. Chem. Soc*, 81, 1176 (1959).

Decomposition of Methyl Acetylene

METHYL ACETYLENE (propyne) is akin to acetylene in being an endothermic compound the induced decomposition of which will support a flame in the absence of air. The work now reported and a parallel investigation[1] have shown that as in the case of acetylene there is a critical pressure below which a flame is not propagated in pure propyne vapour. This low-pressure limit of propagation has been determined in a cylindrical vessel of internal dimensions 2 in. diameter by 7 in. long mounted vertically; the pressure of the vapour in the vessel was measured by means of a Bourdon gauge with a steel tube. A fuse-wire igniter supported on the vertical axis near the bottom of the chamber was used to ignite the vapour; the wire, a 1-in. length of 0·0135 in. diameter tinned copper, was energized by a 12 volt a.c. supply. Determinations were made at approximately 20° C. and at 120° C. by increasing the pressure of propyne vapour in the vessel until propagation occurred (indicated by a pressure rise) when the igniter was fired.

Dilution tests have been made in the same apparatus, which was then contained in a heated cabinet maintained at 120° C. to prevent condensation of the propyne vapour at the pressures used. Propyne vapour was mixed with nitrogen, methane and ethane respectively; the composition of the mixtures was

Table 1

Temp. (° C.)	Values of low-pressure limit (p.s.i.g.)	Initial total pressure (p.s.i g.)	Percentage by volume of diluent required to render mixture non-explosible		
			Nitrogen	Methane	Ethane
Approx. 20	50				
120	31				
		100	30	26	15
		200	45	37	23
		300	55	41	26

determined from measurements of the partial pressures of the constituents in the apparatus and checks were made by analysis using a mass-spectrometer. The minimum amount of each diluent required to prevent flame propagation in the mixture at total pressures of 100, 200 and 300 pounds per square inch (gauge) was determined.

The results of the determinations are shown in Table 1.

At the low-pressure limit the dissipation of heat from the flame is so disproportionately large compared with the heat release by reaction that the flame temperature is reduced to a point where the reaction cannot continue and extinction occurs. The heat is dissipated as radiant losses, in heating the combustion products of the flame and any diluents in the flame, and possibly by thermal cracking of the diluents. Thus diluting the flame increases the quantity of heat dissipated within it and limits can occur above the low-pressure limit for pure propyne.

As might be expected from the presence of the methyl group attached to the acetylene molecule the value of the low-pressure limit of propyne is higher than that reported for acetylene in a vessel of the same diameter[2]. An increase of the temperature of the system causes a decrease in the lower limit of flame propagation for propyne, presumably by decreasing the radiation loss from the flame front to the container walls and also by increasing the available enthalpy in the system. When the values of the low-pressure limit from this and a parallel investigation[1] are plotted versus diameter of vessel in which the determinations were made, a graph of the same form as that reported for acetylene is obtained, though the minimum decomposition pressure range reported for acetylene and some substituted acetylenes[2] has not been investigated in this work.

As an inhibitor of the decomposition flame nitrogen is the least efficient of the diluents used, followed by methane and then ethane. This is the order expected on the basis of the combined effect of the molar heat capacities and readiness to decompose with absorption of heat. Thus the hydrocarbons are the more efficient as they have higher specific heats than nitrogen and they absorb heat on cracking; ethane is more efficient than methane as it is less thermally stable[3]. This result is in agreement with previous work[4] where dilution tests were made with acetylene mixtures at total pressures up to 100 pounds per square inch (gauge), which showed that the efficiency of hydrocarbons in inhibiting the reaction increased with increasing molecular weight, and to a much lesser extent with decreasing thermal conductivity. The result is also in agreement with other results for acetylene decomposition at pressures up to 300 pounds per square inch (gauge), where methane appears to be a more efficient inhibitor than nitrogen; no explanation of the results is offered by the authors[5].

The products of the decomposition of propyne are soot and gases. Mass-spectrographic analysis of the cooled gases from both pure and diluted propyne showed them to be hydrogen and methane (the latter up to 30 per cent of the total volume), though unreacted propyne and traces of ethylene and acetylene were found and the diluents from the mixtures. No 'fixing' of the nitrogen as hydrocyanic acid or ammonia previously reported for acetylene and nitrogen mixtures[6] was noted. It is believed that this is because of the low temperature of the reaction (approximately 1,550° C. theoretical temperature for the reaction $C_3H_4 = 3C_{(s)} + 2H_2$, and probably much less than this due to radiation loss from the flame); previous work[7] indicates that free carbon must be available at temperatures above 1,700° C. in the presence of nitrogen and hydrogen in order for hydrocyanic acid to be formed.

The propyne used was approximately 98 per cent pure, the main impurity being the isomer allene.

The work was carried out at the Rocket Propulsion Establishment, Westcott, Bucks. The help and guidance given by Dr. A. R. Hall during the course of the work are gratefully acknowledged; the gas analyses were made by Dr. G. A. Heath.

F. FITZGERALD

Department of Chemistry,
College of Advanced Technology,
Birmingham, 4.

[1] Hall, A. R., and Straker, R. A. M. (to be published).

[2] Nelson, H. H., Sixth Symp. (Internat.) on Combustion, 823 (1956).

[3] Egloff, G., and Parish, C. T., *Chem. Rev.*, 19, 145 (1936).

[4] Jones, G. W., Kennedy, R. E., and Spolan, I., U.S. Bureau of Mines, Report of Investigations, No. 4196 (Jan. 1948).

[5] Hanford, W. E., and Fuller, D. L., *Indust. Eng. Chem.*, 40, 1171 (1948).

[6] Garner, W. E., and Matsuno, K., *Trans. Chem. Soc.*, 119, 1903 (1921).

[7] Garner, W. E., and Saunders, S. W., *Trans. Chem. Soc.*, 128, 1634 (1924).

Alkylation of Coal by Benzyl Chloride-Aluminium Chloride

ALTHOUGH several reports have recently been made[1] on the carbonization of model substances synthesized to imitate the structure of coal, the study of coal pyrolysis has been hampered due to lack of knowledge of the pattern of behaviour of the functional groups. It was therefore decided to alkylate coals with alkylating agents of known structure and study their behaviour on carbonization. This seems to be the first time that alkylation of coal has been reported.

Coal (25 gm.) suspended in carbon disulphide (40 ml.) was heated with benzyl chloride (10 ml.) in the presence of anhydrous aluminium chloride (3 gm.) at 90–100° C. for 2 hr. Under similar conditions benzene is known to be alkylated to diphenyl methane[2]. The product was then hydrolysed by hydrochloric acid and filtered. The residue was repeatedly washed with distilled water until free of acid, and then dried in a vacuum oven.

Elementary analyses of the coals and products are given in Table 1. With the exception of lignite, the coals show an increase in the content of volatile matter. Similarly, except for the high-rank Albion, Jharia and Bhulan Bararee coals, all the coals show an increase in their carbon content. The ratio hydrogen/carbon changes erratically—in some cases increasing, in others decreasing, and in others not showing any change.

Table 1. ALKYLATION OF COAL BY BENZYL CHLORIDE–ALUMINIUM CHLORIDE

Coal	Elementary analysis of original coal (dry mineral-free basis per cent)							Elementary analysis of alkylated coal (dry mineral-free basis per cent)						
	V.M.	C	H	N	S	O	Atomic H/C	V.M.	C	H	N	S	O	Atomic H/C
1 South Arcot lignite	54·0	69·0	4·9	0·6	1·1	24·4	0·86	53·9	73·5	4·6	0·6	0·7	20·6	0·76
2 Jambad Bowlah	39·0	77·9	5·2	1·9	0·4	14·6	0·80	49·1	82·7	5·7	1·2	0·3	10·1	0·83
3 North Chora vitrain	35·5	78·7	5·0	2·3	0·8	13·2	0·75	—	79·1	5·0	2·0	0·7	13·6	0·75
4 Dishergarh	41·8	83·8	5·7	2·3	0·4	7·8	0·82	43·0	85·1	5·6	1·9	0·3	7·1	0·78
5 Seetalpur vitrain	33·5	82·9	5·1	2·1	0·5	9·4	0·73	—	82·8	5·2	1·7	0·9	9·4	0·75
6 Bhulan Bararee	31·5	86·5	5·0	1·9	0·5	6·1	0·70	38·0	86·9	5·1	1·4	0·4	6·2	0·72
7 Albion Jharia vitrain	—	87·6	4·8	2·2	0·5	4·9	0·66	36·2	87·9	4·9	2·2	0·5	4·6	0·68

Table 2. LOW-TEMPERATURE CARBONIZATION OF ALKYLATED COAL

Coal	Original coal (dry mineral-free basis per cent)				Alkylated coal (dry mineral-free basis per cent)			
	Coke	Tar	Liquor	Gas	Coke	Tar	Liquor	Gas
1	42·2	13·4	28·1	17,375	61·2	19·1	6·7	12,120
2	70·5	13·0	6·7	—	60·3	25·3	6·6	10,310
3	72·8	8·3	7·1	11,320	65·8	16·3	10·8	8,970
4	73·0	12·4	8·5	10,670	68·0	19·3	5·0	9,390
5	79·3	8·4	4·6	11,200	71·0	15·0	6·6	7,250
6	80·2	7·3	3·2	9,930	74·6	15·8	—	9,930

A careful study of the ratio hydrogen/carbon in alkylated models of polycondensed aromatic systems shows that it depends on the number of aromatic rings present in the system. For example, benzene, naphthalene, and pyrene exhibit a decrease in the ratios hydrogen/carbon on alkylation, whereas a 10-membered system indicates an increase in the hydrogen/carbon ratio on alkylation. But in the case of coal, it is not clear whether or not the variation in the hydrogen/carbon ratio is attributable to the number of rings in the aromatic system. X-ray results with treated coals have indicated marked variation in the size and distribution of the aromatic nucleus compared to original coals (Ali, S. Z., private communications).

The most significant changes are in the carbonization assays (Table 2). In all cases there is considerable increase in the yield of tar, which is nearly doubled. Except for lignite, the coals show a decrease in the coke yield. In the case of lignite there is a marked decrease in the liquor yield and also in the coke yield. But in the other cases there is no regularity about the variation in the liquor. There is also a deterioration in the quality of coke. For example, Bhulan Bararee coal gave originally a G_1 type coke, but after treatment only a C type coke. In all cases there is a decrease in yield of gas.

There is no doubt that coal reacts with benzyl chloride and that this reaction considerably influences the yield of tar, and the quality of coke. A detailed consideration of the structural changes on alkylation and the changes on carbonization will be published later.

M. S. IYENGAR
D. D. BANERJEE
D. K. BANERJEE

Central Fuel Research Institute,
Jealgora, Bihar, India.

[1] Kipling, J. J., and Wilson, R. B., Proc. Cong. Science in the Use of Coal, Inst. Fuel, *C*-8 (1958). Wolfs, P. M. J., Van Krevelen, D. W., and Waterman, H. I., Third Int. Conf. Coal Science, Netherlands (1959). Depp, E. A., Slevens, C. M., and Neuworth, M. B., *Fuel* (Lond.), **35**, 437 (1956). Depp, E. A., and Neuworth, M. B., Proc. Second Int. Conf. Coal Science, *Brennstoff-Chemie*, **39**, 590 (1958).

[2] Adams, R., Bachman, W. E., Fieser, L. F., Johnson, J. R., and Snyder, H. R., "Organic Reactions", **3**, 38 (John Wiley and Sons, New York, 1947).

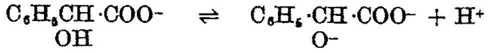
Acidic Dissociation Constant of Alcoholic Hydroxyls of Oxycarboxylic Acids: Mandelic Acid

THE oxycarboxylic acids are very strong complex-forming agents, and both the carboxylic and the alcoholic hydroxyl groups take part in such formation. For calculation of complex stability constants it is necessary to know the acidic dissociation constants of both groups. However, the alcoholic hydroxyls are so weakly acidic that it is not possible to determine the dissociation constant by the usual methods. So far as we know, until now none of the oxycarboxylic acids has been investigated successfully from the point of view of acidity of alcoholic hydroxyls. The only data which we found referred to citric acid; however, these were theoretical values[1].

In general, the oxycarboxylic acids show no absorption even in the extreme ultra-violet regions. An exception is the absorption of mandelic acid, which, due to the benzene ring, is fairly high in the ultra-violet region. However, absorptions of mandelic acid and the mandelate ion do not differ from each other. We determined the change of absorbancy at very high *p*H, that is to say, in strongly alkaline solution.

The mandelic acid shows a maximum absorption at 264 mμ and a minimum at 244 mμ. The effect of ionizing the carboxyl group is to increase the maximum to 260 mμ; however, the minimum does not change. The effect of greater alkali concentration (increasing ionization of alcoholic hydroxyl) causes both the maximum and the minimum to disappear; the absorption monotonously increases with decreasing wave-length.

To calculate the dissociation constant we assumed that the only reason for the change in absorption on treatment with sodium hydroxide is the gradual ionization of alcoholic hydroxyl. Table 1 shows the change of absorption at 244 mμ as a function of *p*H. We used the *p*H values determined by Schwarzenbach and Sulzberger[2] instead of sodium hydroxide concentration. The absorption does not reach a limiting value due to the equilibrium:



$$\mathrm{C_6H_5}\underset{\mathrm{OH}}{\mathrm{CH}}\mathrm{\cdot COO^-} \rightleftharpoons \mathrm{C_6H_5\cdot}\underset{\mathrm{O^-}}{\mathrm{CH}}\mathrm{\cdot COO^-} + \mathrm{H^+}$$

(I) (II)

being shifted so far to the right even at maximal sodium hydroxide concentration that practically all the mandelic acid is in the form of ion II. Thus the molar absorption of II cannot be calculated directly and hence we calculated it by Stearns and Wheland's method[3]. The molar absorption of I at 244 mμ is 120·5, while that of II is 719 at the same wave-length. Using these values the concentrations of I and II in the dissociation constant:

$$K = \frac{[\mathrm{II}]\ [\mathrm{H^+}]}{[\mathrm{I}]}$$

can be calculated. The values of K are given in the fourth column of Table 1, its average being 7·19 × 10^{-16}.

Table 1

[NaOH]	pH	A_{244}	$K \times 10^{16}$
—	4	0·250	—
—	10	0·236	—
0 279	13·3	0 250	6·75
1·395	14·1	0·344	8 24
2·79	14·5	0·477	8·29
5·58	15·2	0·747	4·45
10·16	16 2	1 815	7·96
		Average	7·19

Details of this research will be published in full elsewhere. Thanks are due to Dr. J. Császár for the measurements of absorption.

M. T. Beck

Institute of Inorganic and Analytical
Chemistry,

M. Halmos

Institute of Organic Chemistry,
University of Szeged,
Hungary.

---

[1] Warner, R. C., and Weber, I., *J. Amer. Chem. Soc.*, 75, 5086 (1953).

[2] Schwarzenbach, G., and Sulzberger, R., *Helv. Chim. Acta*, 37, 348 (1944).

[3] Stearns, R. S., and Wheland, G. W., *J. Amer. Chem. Soc.*, 69, 2025 (1947).

BIOCHEMISTRY

Structure of Bhilawanol

Bhilawanol is the golden yellow liquid found in the pericarp of the marking nut *Semecarpus anacardium*. It forms a di-naphthylurethane and a dimethyl ether and on catalytic reduction it absorbs one mole of hydrogen to give hydrourushiol (3-pentadecylcatechol)[1,2].

Ozonolysis of the diphenylmethylene ether gave heptaldehyde[2] (in low yield), suggesting that at least a portion of the bhilawanol is 3-(pentadecenyl-8′)-catechol (thus corresponding to the urushenol of poison ivy and Japanese lac[3]).

Although distillation of dimethyl bhilawanol[1] and chromatography of the diphenylmethylene ether[2] pointed to bhilawanol as being a single substance, chromatography of the dimethyl bhilawanol using the procedure described by Symes and Dawson[4] showed that it was not homogeneous (Symes, W. F., unpublished work). Furthermore, the glycol, m.p. 56–60°, prepared by performic acid hydroxylation of distilled dimethyl bhilawanol, on chromatographing, separated into two glycols, one melting at 66·8°, the other at 93–4° (Symes, W. F., unpublished work).

The low-melting isomer is identical to the glycol prepared by performic acid (*trans*) hydroxylation of the dimethyl ether of the stereochemically pure *cis* poison ivy urushenol[4]. The high-melting isomer is identical to the glycol prepared by osmium tetraoxide (*cis*) hydroxylation of this same material[3]. It therefore becomes clear that the bhilawanol is a mixture of the *cis* and *trans* isomers of urushenol.

These conclusions are evident from Table 1.

Table 1

Compound	n_D^{25}	m.p.	Dimethyl ether		Di-naphthyl-urethan, m.p.
			n_D^{25}	Glycol, m.p.	
Bhilawanol*	1 5032 (ref. 1)	15°	1 5000	67 and 93†	138–40° (ref. 1)
Urushenol (*cis*)‡	1 5081	33°	1 4945	95† 67§	139–41° (ref. 3)
Urushenol (*cis–trans*) (ref. 3)	1 4970	10–15°		92° and lower melting solid†	137–39° (ref. 3)

* Distilled but not chromatographed; † performic acid hydroxylation; ‡ synthetic (ref. 3); § osmium tetraoxide hydroxylation.

The melting ranges of the solid derivative, the dinaphthyl urethane, is evidently a poor criterion of homogeneity in this series.

Bhilawanol and the *cis–trans* urushenol prepared by acid catalysed isomerization of *cis* urushenol[3] are very similar, and there can be little doubt that bhilawanol contains a component identical to the monolefinic component of poison ivy urushenol.

Bernard Loev*

Department of Chemistry,
Columbia University,
New York.

---

* Present address: Smith Kline and French Laboratories, Philadelphia, Pennsylvania.

[1] Pillay, P., and Siddiqui, S., *J. Indian Chem. Soc.*, 8, 1517 (1931).

[2] Mason, H. S., *J. Amer. Chem. Soc.*, 67, 418 (1945).

[3] Loev, B., and Dawson, C. R., *J. Org. Chem.*, 24, 980 (1959).

[4] Symes, W. F., and Dawson, C. R., *J. Amer. Chem. Soc.*, 76, 2959 (1954).

Age Difference in Nicotinamide Mononucleotide Synthesis by Human Erythrocytes

It is well known that human erythrocytes contain an active enzyme system capable of synthesizing considerable amounts of nicotinamide mononucleotide from nicotinamide added *in vitro*[1]. The nicotinamide mononucleotide synthetase is very specific for human erythrocytes as the only other mammal in the blood cells of which it could be detected is the guinea pig[2]. It was found here, however, that the activity of the given synthetase in human erythrocytes can be shown at the beginning of the fifth month of life when its activity rapidly reaches almost a maximum level, remaining then practically without change. Whereas mammalian erythrocytes not synthesizing nicotinamide mononucleotide are characterized by a high content of pyridine nucleotides, their amount being several times higher than in human and guinea pig erythrocytes[2], the non-synthesizing child erythrocytes contain even somewhat less pyridine nucleotides than those of adult humans.

The amount of pyridine nucleotides and the nicotinamide mononucleotide synthetase activity were determined fluorometrically by a slightly modified method of Leder and Handler[1]. The nicotinamide mononucleotide synthetase activity was expressed as:

$$I_{20h} = \frac{b - a}{a}$$

where a is the concentration of pyridine coenzymes in µmoles/ml. erythrocyte mass before incubation and b the same after 20 hr. stationary incubation at 37° C. in Krebs–Ringer phosphate solution containing 250 mgm. per cent glucose and 2 per cent nicotinamide besides the mineral constituents. A total of 80 samples of heparinized blood from quite normal children and adults was examined. The results are shown in Fig. 1.

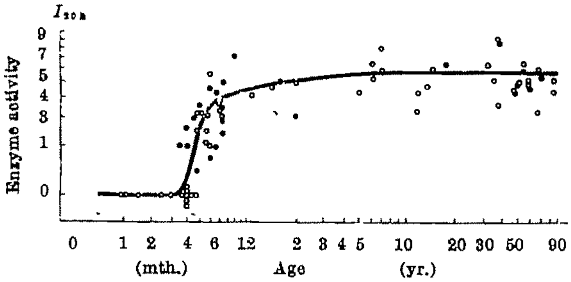


Fig. 1. Age difference in nicotinamide mononucleotide synthetase activity in human erythrocytes

The erythrocyte synthetase activity of adult humans under the given conditions amounts to 4·8 ± 1·3. Marked changes are observed in some diseases; for example, the activity is considerably decreased or completely lost in uræmia (a communication on this point will be presented later). The content of pyridine nucleotides in adult human erythrocytes is 0·11 ± 0·01 µmole/ml. erythrocyte mass, erythrocytes of infants before 4 months of age 0·09 ± 0·01 µmole/ml. The pyridine coenzyme-level of erythrocytes is very constant and is not affected by those factors which change markedly the nicotinamide mononucleotide synthetase activity *in vivo*.

The basis of inability of sucklings' erythrocytes to synthesize nicotinamide mononucleotide has not yet been elucidated. It is possible that erythrocytes produced in the course of the first months of life, when the synthesis of fœtal hæmoglobin regresses, are not mature in this respect; it cannot be excluded, however, that a specific or a non-specific inhibitor of the given synthetase was present.

However, the results present a further proof that human biochemical ontogenesis is not limited to the embryonic and fœtal period. Some metabolic systems develop and improve only after birth; the first months of life appear to be of exceptional importance in this respect.

We are grateful to Dr. M. Lukešová, Clinic of Pediatry, and to Dr. V. Čepelák, Medical University Clinic, for supplying us with the blood samples. We also wish to thank Miss E. Maidlová for technical assistance.

VLASTIMIL HABERMANN
SONA HABERMANNOVÁ

Institute of Medical Chemistry and Institute of General Biology,
Charles University Medical Faculty,
Plzen, Karlovarská 48,
Czechoslovakia.

---

[1] Leder, I. G., and Handler, P., *J. Biol. Chem.*, 189, 889 (1951).

[2] Tulpule, P. G., *Nature*, 181, 1804 (1958).

Microbiological 11β-Hydroxy Dehydrogenation of Corticosterone

A LARGE number of bacteria are known to dehydrogenate the secondary alcohol group of the steroid molecule, at carbon 3 and 17 [1], and also in position 7 and 12 [2].

However, dehydrogenation of the 11β-hydroxy group by micro-organisms has been reported in a few cases. For example, *Cunninghamella blakesleeana*[3] produced a certain amount of cortisone as a by-product of hydrocortisone from Reichstein's compound *S*, and *Trichothecium roseum*[4] produced a small amount of cortisone besides hydrocortisone from corticosterone. From these examples, it appears that 11β-hydroxy dehydrogenase, which has been known to be present in mammalian tissues, is also present in micro-organisms.

During our work on microbiological oxidation of steroids, we found the effective dehydrogenation of the 11β-hydroxy group of corticosterone by *Absidia regnieri*. In this case, introduction of a hydroxy group in the 14α position of the steroid molecule was caused by this micro-organism.

The present communication reports the effective dehydrogenation of the 11β-hydroxy group of corticosterone. In our experiment, *Absidia regnieri* was grown on a reciprocating shaker for 48 hr. at 27° in 5 l. of a medium of the following composition: 5 per cent glucose, 2 per cent peptone and 0·5 per cent corn steep liquor. Then 2·5 gm. corticosterone dissolved in methanol was added in this culture and fermentation was allowed to proceed for an additional 48 hr. At the end of fermentation, the culture was separated into mycelium and liquid, and these were extracted with ethyl acetate ester, respectively. The combined ethyl acetate ester extract was evaporated to dryness *in vacuo*. Paper partition chromatography of this residue showed only one oxygenated product and no unreacted steroid. The oxygenated product was isolated by direct crystallization or chromatography of 'Florisil'.

Crystallization of this residue with acetone afforded a 14α-hydroxy-11-dehydrocorticosterone (I); m.p. 205–215°; $[\alpha]_D + 69°$ (methanol); $\lambda_{\text{max.}}^{\text{MeOH}}$ 237·5 mµ (ε = 15,000); $\lambda_{\text{max.}}^{\text{KBr}}$ 3,480, 1,705, 1,660 and 1,620 cm.$^{-1}$; anal. found: C, 69·70; H, 7·78 per cent; calc.: C, 69·97; H, 7·83 per cent. 21-Monoacetate of I was prepared with pyridine and acetic anhydride; m.p. 204–5°; $\lambda_{\text{max.}}^{\text{MeOH}}$ 237 mµ (ε = 15,300); $\lambda_{\text{max.}}^{\text{KBr}}$ 3,560, 1,750, 1,735, 1,690 and 1,625 cm.$^{-1}$.

The structure of I was established in the following manner. When 11-dehydrocorticosterone was fermented with this fungus, the oxygenated product obtained was identical to I. This result and the observed ultra-violet maximum 237 mµ of I indicate that the 11β-hydroxy group of the steroid was converted to ketone. To decide the position of the new hydroxy group introduced, we have prepared new steroid 14α-hydroxy-corticosterone (II) by incubation of known 14α-hydroxy-deoxycorticosterone with *Stachylidium bicolar*, which is capable of 11β-hydroxylating of steroid. The compound II melted at 206–215°; $[\alpha]_D + 180°$ (methanol); $\lambda_{\text{max.}}^{\text{MeOH}}$ 241·5 mµ (ε = 16,500); $\lambda_{\text{max.}}^{\text{KBr}}$ 3,400, 1,710, 1,650 and 1,620 cm.$^{-1}$. The 21-acetate of II prepared with pyridine and acetic anhydride was oxidized with chromium trioxide-pyridine to 11-ketone. The material thus obtained agreed with the 21-monoacetate of I by physical constants and infra-red spectrum. This result indicates that the newly introduced hydroxy group must be 14α-hydroxyl.

From these results we conclude that the structure of I is 14α-hydroxy-11-dehydrocorticosterone. This fungus, however, had no effect on the conversion of epicorticosterone and hydrocortisone. This fact shows the marked stereospecificity of this dehydrogenase, that is, it acts only on 11β-hydroxyl of corticosterone and not on that of hydrocortisone or 11α-hydroxyl of epicorticosterone.

With the other steroid substrate, this fungus also showed remarkable substrate specificity as reported previously[5]. That is, it hydroxylated progesterone or deoxycorticosterone at the 14α-position and 17α-hydroxyprogesterone or Reichstein's compound *S* at the 11α-position.

We wish to acknowledge with thanks the helpful advice of Profs. K. Tsuda and T. Asai, of the University of Tokyo.

M. SHIRASAKA
R. TAKASAKI
M. TSURUTA

Takamine Laboratory,
Sankyo Co., Ltd.,
Tokyo.

---

[1] Talalay, P., and Dobson, M. M., *J. Biol. Chem.*, **205**, 823 (1953). Turfitt, G. E., *Biochem. J.*, **40**, 79 (1946), etc.

[2] Hoehn, W. M., Schmidt, L. H., and Hughes, H. B., *J. Biol. Chem.*, **152**, 59 (1944).

[3] Hanson, F. R., Mann, K. M., Nielson, E. D., Anderson, H. V. Brunner, J. N., Collingsworth, D. R., and Haines, W. J., *J. Amer. Chem. Soc.*, **75**, 5369 (1953).

[4] Meyster, Ch., Vischer, E., and Wettstein, A., *Helv. Chim. Acta*, **37**, 1548 (1954).

[5] Shirasaka, M., Hayashi, R., and Tsuruta, M., *Bull. Agric Chem. Soc. Japan*, **23**, 244 (1959).

Enhancement of Peroxidase Action by Polysaccharides

A NUMBER of polysaccharides act as polymerization-directing matrices in peroxidase-catalysed eugenol oxidations[1]. Although deoxyribonucleic acid and cellulose increase markedly the rate of Fe(III)-catalysed pyrogallol oxidation by hydrogen peroxide[2,3], a similar test of polysaccharides has not been reported previously in peroxidase-catalysed reactions.

The present results show that the catalytic activity of peroxidase is increased appreciably by moderately low concentrations of starch and is somewhat influenced by methylcellulose as well.

Oxidations were followed at 25° C. with the Bausch and Lomb 'Spectronic 20' spectrophotometer in 10-ml. reaction mixtures containing 5 μgm. Worthington horseradish peroxidase, 10^{-3} *M* hydrogen peroxide, substrate and *M*/20 phosphate buffer, *p*H 4·5. Oxidation of 5×10^{-3} *M* pyrogallol was measured at 425 mμ; oxidation of 5×10^{-4} *M* eugenol was measured at 360 mμ.

The chemical substances used were of reagent grade when possible. Methylcellulose solutions were prepared from 'Dow Methocel *HG* 400'. Neither starch nor methylcellulose exhibited catalytic activity when tested directly with hydrogen peroxide and pyrogallol.

In ten experiments, 5×10^{-5} *M* starch increased oxidation of pyrogallol by peroxidase appreciably (Table 1). The initial rate (0·5 min.) was most affected, but considerable enhancement is still in evidence after 2–3 min., when the control reaction-rate has slowed markedly.

Table 1. EFFECT OF STARCH ON PEROXIDASE-CATALYSED PYROGALLOL OXIDATION*

Reaction time (min.)	(*a*) Control Average optical density	σ	(*b*) Starch* Average optical density	σ	*b*/*a* (percentage control)
0	0	—	0	—	—
0·5	0·098†	± 0·018	0·153	± 0·016	156
1·0	0·254	± 0·030	0·373	± 0·019	147
1·5	0·437	± 0·036	0·597	± 0·023	137
2 0	0·635	± 0·036	0·847	± 0·023	133
3·0	0·775	± 0·062	1·033	± 0·047	133

* Reaction mixture: 10 ml. *M*/20 phosphate, *p*H 4·5, containing 5×10^{-3} *M* pyrogallol, 10^{-3} *M* hydrogen peroxide, 5 μgm. peroxidase, with or without 5×10^{-5} *M* starch. Oxidation was carried out at 25° C. and measured at 425 mμ.

† Each figure is the mean of 10 determinations.

Stimulation is not limited to the oxidation of pyrogallol, but is also obtained with eugenol as substrate (Table 2*b*).

Table 2. EFFECT OF SEVERAL CARBOHYDRATES ON THE PEROXIDATION OF PYROGALLOL AND EUGENOL*

Carbohydrate	Concentration (*M*)	Effect (percentage control after 1 min.)
	(*a*) Substrate: pyrogallol	
Glucose	5×10^{-5}	100
	10^{-3}	99
	0·5	84
Maltose	5×10^{-5}	103
	10^{-3}	100
	0·5	86
Methylcellulose	5×10^{-5}	117
Starch	5×10^{-5}	147
	(*b*) Substrate: eugenol	
Glucose	0·5	83
Methylcellulose	5×10^{-4}	125
Starch	5×10^{-5}	143

* Reaction conditions as given in Table 1 except that eugenol was used at 5×10^{-4} *M* and its oxidation followed at 360 mμ.

Methylcellulose is not as stimulating as starch when tested with either substrate, but the activity of these two macromolecules may be contrasted with the effects of glucose and maltose (Table 2*a*, *b*). The simple sugars have no effect in low concentrations, and they are slightly inhibitory at high concentrations. A proper comparison between simple sugars and polysaccharides cannot be made on a mole-for-mole basis, nor can they be equated in a simple way by comparing the number of monosaccharide residues present.

A macromolecular basis for the stimulatory effects of polysaccharides is suggested by the absence of enhancement of sugars over a wide range of concentrations. Possibly the polysaccharides provide a concentrating surface, hence increasing the probability of reaction, and render adsorbed peroxidase more efficient as a catalyst. These suggestions receive support from the greater effect of starch on pyrogallol oxidation at lower peroxidase concentrations. Thus, with 0·5 μgm. of enzyme, an initial simulation (0·5 min.) of 100 per cent was observed, declining to 50 per cent after 3 min.

This work was carried out at the University of Rochester with the support of Public Health Service Grant *C*–2730, National Institutes of Health.

B. Z. SIEGEL

4 Orchard Parkway,
White Plains, New York

S. M. SIEGEL

Union Carbide Research Institute,
White Plains, New York.

---

[1] Siegel, S., in "Sub-cellular Particles", edit. by Hayashi, T., (Amer. Physiol. Soc., Washington, 1959).

[2] Siegel, S., and Siegel, B. Z., *Nature*, **179**, 421 (1957).

[3] Goodman, N. S., and Siegel, S., *Nature*, **184**, 53 (1959).

Starch–Agar-Gel Electrophoresis of Tuberculoproteins from Heated Culture Filtrates

IN order to improve the specificity of a bovine tuberculin purified protein derivative, precipitated with trichloracetic acid from heated culture filtrates[1], we decided to investigate its protein composition[2], and in this connexion we experimented with zone electrophoresis on paper-strips. Now this procedure has hitherto not been very successful[3-5], and in spite of our own numerous experiments with various procedures and methods we did not obtain anything other than unusable pictures of 'comets' or streaks. (This is in contrast with the more satisfying results obtained by others with non-heated tuberculins[4,5].) Smithies introduced starch gel electrophoresis which seems to be of great value in determining the ultrastructure of serum-protein patterns[6,7], the composition of toxins[8] and of cerebrospinal fluid[9]. Sorkin *et al.*[10] made preparative separations of some tuberculoprotein preparations from unheated culture filtrates by electrophoresis in starch gels, followed by transfer into glass. Our own investigations on this starch-gel electrophoresis led to the following method.

In order to prevent premature desiccating of the gels and to avoid the necessity of protecting them by placing covers and/or mineral oils on the surface and still to maintain a satisfactory consistency, we used 10 per cent w/v 'Merck Amylum Solubile' (*A.R.*) plus 0·27 per cent w/v 'Difco Bacto' agar. The agar was at first weakened for about 30 min. or longer in the buffer solution consisting of 15 gm./l. boric acid, 0·75 gm./l. bi-sodium salt of ethylenediamine tetraacetic acid and 2·5 mgm./l. 'Tween 80', brought up to *p*H 7·5 by adding about 6 gm./l. *tris* hydroxymethyl aminomethane. The mixture was then boiled until the agar was dissolved. After some time of cooling the solution, the starch was added, suspended, heated with continuous stirring and finally boiled for a few seconds. The liquid gel was poured out in plastic ('Perspex') trays to form layers of 240 mm. × 60 mm. × 3 mm., the trays having been placed in an electrophoresis apparatus with platinum electrodes. The electrode vessels and bridge vessels were filled with the above-mentioned buffer, only without 'Tween 80', and with sodium hydroxide instead of *tris* buffer. Thick filter-paper strips formed the connexion between bridge vessels and tray. After about 20 min. we made an incision, 8 cm. from the anodic side of the tray, with a thin blade and allowed 0·05–0·07 ml. of a protein solution of about 60 mgm./ml. to drip down slowly into the incision, even when it was scarcely visible on the surface. Immediately afterwards the gels were subjected to electrophoresis at room temperature for 17 hr. at 6 V./cm., then left to stain with Bayers 'Amidoschwarz 10 *B*' (2 gm./l. solution of methanol/water/acetic acid, 45 : 45 : 10) for 15 min., and washed with the same solution over a period of 1 hr., and repeated about 5 times with fresh solution. Fig. 1 shows the patterns of our bovine purified protein derivative tuberculin, solved from the lyophilized state by dialysing against a 0·25 per cent phenolic diluted buffer of *p*H 7 until the required protein concentration was reached; the '*C*'-like protein-fraction, prepared from the same purified protein derivative, fundamentally following Seibert's method[11] and the '*A* + *B*'-like proteins, prepared from the (purified protein derivative minus '*C*') remainder. Full details of these preparations will be described in a publication elsewhere.

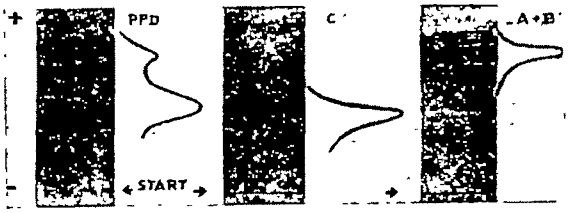


Fig. 1. The curves were obtained from colour diapositives of the patterns by photoelectric scanning

It appears from the purified protein derivative diagram that the proportion '*A* + *B*'/'*C*', calculated from planimetric measurement, is about a third, which is in accordance with the quantities of the chemically separated fractions. The '*C*'-like protein, its molecular weight probably being twice as great as that of the unheated '*C*' [11], is the slower one, in this respect quite the reverse of the unheated '*C*' in the Tiselius picture[2]. Furthermore, our '*C*'-like protein shows a greater tendency towards tailing than the '*A* + *B*'-like fraction.

These last two proteins appear to move closely together. *p*H's higher than 7·5 tend progressively to suppress separation while the lower ones tend to sharpen the zones but increase adsorption to the gel substance. Our results point to the combined effects of electric charge and particle size in starch-gel electrophoresis[13].

T. P. DEKKER

Central Veterinary Institute,
Rotterdam.
Dec. 29.

[1] Dekker, T., and Hultema, H., *Nature*, 182, 1387 (1958).
[2] Seibert, F. B., *Amer. Rev. Tuberc.*, 59, 86 (1949).
[3] Ribeiro, J. M., and Fernandes, A. A. S., *Bull. Int. Off. de l'Epiz.*, 42, 321 (1954).
[4] Rhodes, J. M., and Sorkin, E., *Experientia*, 10, 427 (1954).
[5] Sorkin, E., and Rhodes, J. M., *Helv. Chim. Acta*, 39, 1539 (1956).
[6] Smithies, O., *Biochem. J.*, 61, 629 (1955).
[7] Ashton, G. C., *Nature*, 179, 824 (1957).
[8] Poulik, M. D., *Nature*, 180, 1479 (1957).
[9] Pert, J. H., and Kutt, H., *Proc. Soc. Exp. Biol. and Med.*, 99, 181 (1958).
[10] Sorkin, E., Rhodes, J. M., and Boyden, S. V., *Helv. Chim. Acta*, 39, 1547 (1956).
[11] Seibert, F. B., Figueroa, E. S., and Dufour, E. H., *Amer. Rev. Tuberc.*, 71, 704 (1955).
[12] Takeya, K., and Toda, T., *Enzymologia*, 19, 65 (1958).
[13] Martin, N. H., *Analyst*, 84, 93 (1959).

Effect of Pituitary Growth Hormone *In vivo* on the Phosphorus/Oxygen Ratios of Isolated Rat Liver Mitochondria

RECENT reports tending to localize the site of action of thyroxine in uncoupling oxidative phosphorylation at the level of the mitochondrial membrane[1,2] have served to emphasize the need for similar studies on possible sites of action of anterior pituitary growth hormone, a substance which produces generalized metabolic changes even more striking than those found with thyroxine. The present communication reports some results concerning the effect of the hormone on oxidative phosphorylation, using mitochondria isolated from the livers of normal rats or rats treated with growth hormone.

Rats were injected 4 hr. before killing either with 1 mgm. purified beef growth hormone or with 1–5

Table 1. PHOSPHORUS/OXYGEN RATIOS OF MITOCHONDRIA ISOLATED FROM THE LIVERS OF NORMAL AND GROWTH HORMONE-TREATED RATS

Treatment	No. of animals	μmoles acetoacetate found	μmoles glucose-6-phosphate formed	Phosphorus/oxygen ratio
Control	5	0·240 ± 0·030	0·652 ± 0·072	2·71 ± 0·058
Growth hormone	5	0·337 ± 0·032	0·651 ± 0·049	1·93 ± 0·050
Albumin	3	0·260 ± 0·037	0·675 ± 0·095	2·64 ± 0·073
Fisher's '*p*' growth hormone *v.* controls		0·03	not significant	< 0·001

1 mgm. of growth hormone or 5 mgm. of bovine plasma albumin (Armour) injected 4 hr. before killing.

System. 0·3 ml. 0·3 *M* glucose; 0·1 ml. 0·04 *M* adenosine diphosphate; 0·1 ml. 3 × 10^{-4} *M* cytochrome *c*; 0·5 ml. 0·1 *M* phosphate buffer *p*H 7·4; 0·1 ml. 0·2 *M* magnesium sulphate; 0·05 ml. 1·5 *M* potassium chloride; 0·1 ml. 0·1 *M* versene *p*H 7·4; 0·3 ml. 0·1 *M* *dl*-β-hydroxybutyrate acid; 0·05 ml. hexokinase solution containing 50 units of enzyme activity; 0·2 ml. bovine plasma albumin (7·5 mgm./ml.); 0·2 ml. 0·02 *M* sodium fluoride and 1 ml. liver mitochondria (8 per cent suspension).

Temperature 27°. Time 5 min.

mgm. bovine plasma albumin. After killing, the livers were rapidly removed, the mitochondria isolated in 0·25 *M* sucrose and the phosphorus/oxygen ratios measured using a system adapted from that of Maley[3] with either *d*-, *l*-, or *dl*-β-hydroxybutyrate, *dl*-glutamate or reduced diphosphopyridine nucleotide as substrate.

Under the conditions employed here *d*-β-hydroxybutyrate was not oxidized at all, since *l*-β-hydroxybutyrate gave results exactly comparable with those obtained using the *dl*-salt. It will be seen that the mitochondria from growth hormone-treated rats have a lower phosphorus/oxygen ratio than those from normal rats, and that this difference can be largely ascribed to an increase in the rate of oxygen utilization rather than to any decrease in the rate of phosphorylation. The one-step oxidation of β-hydroxybutyrate involves the production of reduced diphosphopyridine nucleotide, and it is this latter compound which acts as substrate for the oxidative phosphorylation[4]. For this reason, the efficiency of the phosphorylation accompanying the oxidation of glutamate, an alternative source of reduced diphosphopyridine nucleotide, and diphosphopyridine nucleotide itself were studied. The phosphorus/oxygen values using these two substrates were lower than the values recorded for β-hydroxybutyrate (2·31 for glutamate and 1·77 for reduced diphosphopyridine nucleotide) and were entirely unaffected by prior treatment of the animal with growth hormone. Thus the ability of growth hormone to affect the efficiency of oxidative phosphorylation could only be demonstrated in one of the three enzyme systems tested, that is, β-hydroxybutyrate dehydrogenase and its associated electron transporting chain. It is interesting to notice that thyroxine also uncouples oxidative phosphorylation when β-hydroxybutyrate is used as substrate[1] although it should be observed that in this latter case the mechanism appears to be somewhat different from that shown by growth hormone (Table 1) in that thyroxine does not affect the oxygen uptake but causes a decrease in the associated phosphorylation.

In view of the widespread metabolic effects of growth hormone *in vivo* it would seem unlikely that the hormone has a specific effect on β-hydroxybutyrate dehydrogenase alone. Of the three substrates tested, only β-hydroxybutyrate seems to be oxidized exclusively by an 'internal pathway' (that is, one inside the mitochondrion) and since this enzyme is also the only one affected by prior treatment of the animal with growth hormone it would appear probable that the site of action of the growth hormone in lowering the efficiency of oxidative phosphorylation is at the level of the mitochondrial membrane, as has been suggested for thyroxine[1,2].

It is difficult to visualize a means by which a lowering of the efficiency of oxidative phosphorylation can be of advantage to an animal; but perhaps the lowered phosphorus/oxygen ratio is of secondary importance to the change in mitochondrial permeability. Ernster[5] has suggested that a reversible swelling of the mitochondria could provide a transfer system by which there could be an interchange of materials between the mitochondrial interior and cytoplasm. If the action of growth hormone is to alter the mitochondrial permeability then it is possible to consider that this effect of the hormone could, by permitting a transfer of metabolites or co-factors across the membrane, lead to increased metabolic activity which, even if there were some loss of efficiency in the coupling of some of the reactions, would be to the overall advantage of the animal. The increased rate of oxidation of β-hydroxybutyrate by the hormone-treated animal appears to point to such a possibility.

C. N. GRAYMORE

Institute of Ophthalmology,
Judd Street, London, W.C.1.

A. H. MELHUISH
A. L. GREENBAUM

Department of Biochemistry,
University College, London.

---

[1] Tapley, D. F., and Cooper, C., *J. Biol. Chem.*, **222**, 325 (1956).

[2] Lehninger, A. L., Ray, B. L., and Schneider, M., *J. Biophys. Biochem. Cytol.*, **5**, 97 (1959).

[3] Maley, G. F., *J. Biol. Chem.*, **224**, 1029 (1957).

[4] Lehninger, A. L., *J. Biol. Chem.*, **164**, 291 (1946).

[5] Ernster, L., *Exp. Cell Res.*, **10**, 721 (1956).

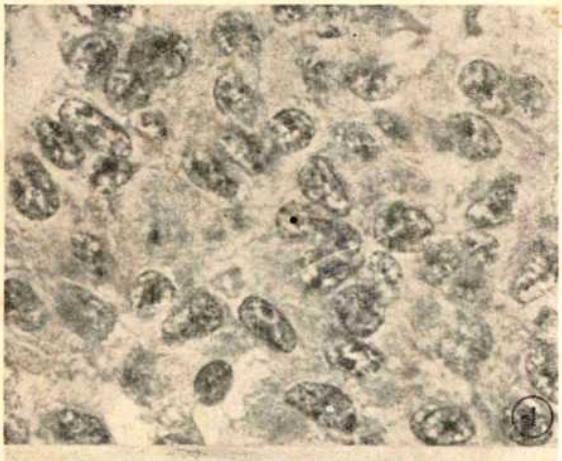
PHYSIOLOGY

Effects of Injection of Bovine Pineal Extract on the Nuclei of Rat Pineal Parenchymal Cells

THE pineal parenchymal cells are known to be rich in nucleoprotein[1,2]. Oksche[3] showed that pineal-cell nuclei contain a 'nucleolus apparatus' which extrudes some nuclear substance into the cellular cytoplasm. In general, the number of nucleoli and intranuclear granules in any cell is probably a useful index of the rate of protein synthesis[4]. This idea has led several authors to use pineal intranuclear changes as evidence of changed pineal functional status: both Oksche[3] and Quay[5] reported variations in pineal intranuclear activity owing to changes in illumination of their animals' cages. Quay[5] also correlated changes in pineal cell nuclei with periodic variations in pituitary gonadotropic activity.

The present communication describes changes in pineal nuclear status resulting from injections of a pineal extract. The occurrence of such changes suggests that exogenous pineal extract depresses pineal function in intact animals.

Studies were made on pineal glands from 15 Charles River rats which had been given intraperitoneal injections of a bovine pineal extract daily from the ages of 21–49 days; these were compared with the glands of control animals given saline injections.



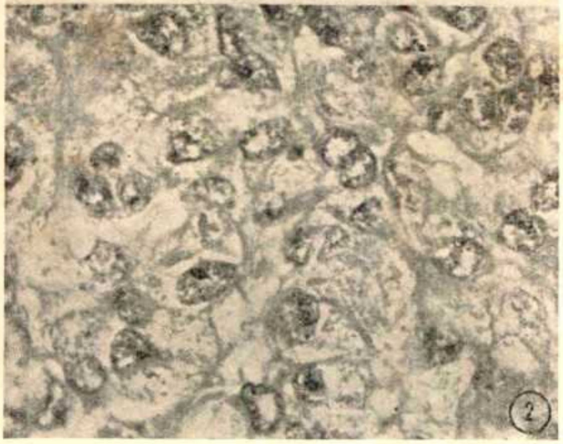


Fig. 1. The pineal parenchymal cells of the rat. Gomori's chrome hæmatoxylin–phloxin counter-stained in tartrazine (× *c.* 950). Fig. 2. The pineal parenchymal cells of a pineal-treated rat. Notice the decrease in number of nucleoli and in the amount of intranuclear material; the central portions of the nuclei are completely clear in many cases. The cytoplasm is also paler and less granular than in the control animals. Gomori's chrome hæmatoxylin–phloxin counter-stained in tartrazine (× *c.* 950)

The bovine pineal extract was prepared essentially according to the method described elsewhere[6].

The pineal glands were fixed in Bouin's solution to which 1 per cent calcium chloride had been added; they were stained with Gomori's chrome hæmatoxylin–phloxin and in phloxin and then counterstained with tartrazine according to Lendrum[7]. (The treatment with hæmalum was omitted.) The sections were cut at 3–4μ. The number of phloxinophilic nucleoli above approximately $0 \cdot 5\mu$ in diameter were counted.

The pineal parenchymal cells of the rats which had been given pineal extract showed a marked decrease in the number and size of the nucleoli and the amount of granular material in the nuclei (Figs. 1 and 2). The decrease in number of nucleoli in the pineal-treated animals was statistically significant ($P < 0 \cdot 001$). A slight decrease in the size of the pineal cells themselves was noted in the glands of the treated animals; the cytoplasm appeared less dense than in the control animals.

Caspersson[4] showed that a decrease in the number of nucleoli and intranuclear granules in cells indicated a reduced rate of nuclear synthesis. The decrease in the intranuclear granular and nucleolar material observed here in rats given a bovine pineal extract must therefore indicate that such extracts depress nuclear activity in the pineal cells of injected animals. Secretory activity in the pineal cell is known to be correlated with nuclear activity[3]. The reduced pineal nuclear activity found here therefore suggests that pineal cellular secretory activity might also be reduced. If the latter phenomenon does occur in these circumstances, it might be taken as an indication of suppression of endogenous pineal secretion caused by increased circulating pineal hormone owing to the injection of bovine pineal extract.

The pineal glands of rats given daily intraperitoneal injections of a bovine pineal extract for 28 days starting at the age of 21 days showed decreased numbers of nucleoli and intranuclear phloxinophilic granules. This finding was taken to indicate depression of pineal cellular secretory activity owing to the increase in circulating pineal hormone caused by the injection.

This work was supported by a grant from the Commonwealth Fund.

UNO HOLMGREN
MARK D. ALTSCHULE
RICHARD J. WURTMAN

Biological Laboratories,
Harvard University,
and the
Laboratory of Clinical Physiology,
McLean Hospital,
Waverley, Massachusetts.

[1] Wislocki, G. B., and Dempsey, E., *Endocrinol.*, **42**, 56 (1948).

[2] Bargmann, W., "Handbuch der vergleich, Anat. Menschen", **6** (4), 309 (1943).

[3] Oksche, A., *Anat. Anz.*, **102**, 404 (1954).

[4] Caspersson, T. O., "Cell Growth and Cell Function" (W. W. Norton and Co., New York, 1950).

[5] Quay, W. B., *J. Morph.*, **98**, 71 (1956).

[6] Altschule, M. D., *New England J. Med.*, **257**, 919 (1957).

[7] Lendrum, A. C., *J. Path.*, **59**, 399 (1957).

Seromucoid Contents of Human Bile

VARIATIONS of seromucoid in pathological conditions and its clinical significance have been extensively investigated during the past few years. Greenspan[1], Winzler[2] and others have shown the seromucoid contents in the blood of normal human subjects to be $12 \cdot 4 \pm 0 \cdot 5$ mgm. per cent as expressed in hexose, and $3 \cdot 38 \pm 0 \cdot 27$ mgm. per cent as expressed in tyrosine. Seromucoid contents in the blood are significantly increased in obstructive jaundice and are decreased to very low figures in jaundice due to hepatitis. These pathological variations suggest the possibility of the liver playing an important part in seromucoid metabolism. Since for the time being the site of formation and metabolic fate of seromucoid are unknown, it has occurred to us that it might be synthesized by the liver or at least partly eliminated in the bile. We have therefore investigated the presence and contents of seromucoid in human hepatic bile.

Samples of hepatic bile draining through a Kerr tube were collected from patients who had undergone cholecystectomy. The bile was collected in the morning in post-absorptive conditions, during the last days preceding the removal of the Kerr drain, when the bile contained but a few cells and flakes of mucus were no longer present. Hepatic bile was also collected by duodenal catheterization in three patients who had undergone cholecystectomy 2, 3 and 5 years previously. The bile was immediately centrifuged at 12,000 r.p.m. for 15 min. and then filtered through Schleicher Schüll filter paper No. 589 (blue band).

Table 1. SEROMUCOID CONTENTS OF HUMAN HEPATIC BILE

Hepatic bile case	Hexoses (mgm. per cent)	Tyrosine (mgm. per cent)	Total solids (gm. per cent)	Hexoses in mgm. per 100 gm. of total solids	Tyrosine in mgm. per 100 gm. of total solids
P. E.	8·0	1·27	2·84	281	52·0
T. A.	6·0	0·95	2·50	240	37·8
G. O.	13·5	1·81	2·35	574	77·0
A. B.	9·2	0·38	3·08	298	12·0
T. P.	8·6	0·29	3·84	224	8·0
T. M.	2·4	1·14	4·12	58	27·0
C. V.	9·0	4·00	4·70	191	85·1
M. G.	12·0	6·80	3·37	356	101·0
Z. I.	7·0	2·64	5·56	126	47·0
W. K.	8·5	1·10	3·02	281	36·4
S. A.	6·7	0·90	2·75	244	32·6
V. H.	5·8	2·50	2·85	203	87·7
C. B.	6·5	0·85	3·20	203	27·7
±*S.E.*	7·93 ± 0·89	1·89 ± 0·49	3·39 ± 0·25	252·23 ± 18·52	48·5 ± 16·31

The clear bile obtained by these means was tested for the presence of seromucoid according to Winzler's method as modified by Weiner and Moshin[3]. Tyrosine as well as hexose contents were determined.

The total solid contents were determined in the same samples.

Seromucoid was present in all the samples of hepatic bile investigated. The seromucoid concentration in hepatic bile, as expressed in mgm. hexose and mgm. tyrosine per 100 gm. of total solids, the averages of these figures and the standard errors of the averages are listed in Table 1.

It can be seen that:

(1) The total solid contents of hepatic bile display a considerable degree of variation (3·39 ± 0·25 gm. per 100 ml.).

(2) There are great variations of seromucoid concentrations in fresh hepatic bile, both as expressed in terms of hexoses (7·93 ± 0·89 per 100 ml.) and in terms of tyrosine (1·89 ± 0·49 mgm. per 100 ml.).

(3) These fluctuations are not reduced by referring seromucoid concentrations to the total solid contents of the bile; it follows that variations of the latter cannot wholly account for these fluctuations.

No investigations were made on hepatic bile obtained by duodenal catheterization from normal subjects in order to avoid so far as possible the contamination of hepatic bile samples by mucus secreted by the extrahepatic bile ducts and by the duodenal wall. By collecting the bile draining through a Kerr tube, this bias is minimized. We consider the presence of seromucoid in hepatic bile to be unquestionable evidence of the elimination of this glycoprotein by the liver. This might be due either to excretion through the liver of the seromucoid present in the blood, or to synthesis in the liver of the seromucoid which is afterwards eliminated via the bile and possibly the blood. Further investigations are required in order to show seromucoid synthesis in the liver. However, the presence of seromucoid in hepatic bile is clear evidence of the part played by the liver in the elimination of this substance.

C. MIHAESCU
EDITH MIHAESCU

Institute of Therapeutics,
Academia Republicii Populare Romine,
Bucharest.

---

[1] Greenspan, E. M., and Dreiling, D., *Amer. Med. Assoc. Arch. Int. Med.*, **91**, 474 (1953).

[2] Winzler, R., "Methods of Biochemical Analysis", **2**, 279 (Interscience Pub., 1955).

[3] Weiner, H. E., and Moshin, J. R., *Amer. Rev. Tubercul.*, **68**, 594 (1952).

Distribution of Chromactivating Hormones in the Pituitary of the Minnow

IN a previous communication[1], I have described the distribution of melanophore-aggregating hormone in the pituitary of the minnow (*Phoxinus phoxinus*). By use of the method described there the distribution of minnow erythrophore-dispersing and frog melanophore-dispersing factors in the minnow pituitary has been investigated.

Erythrophore-dispersing activity was determined by scoring the degree of reddening around the pectoral and pelvic fins of black-adapted minnows (60–65 mm. long) from 0 (no reddening) to 6 (maximum reddening) 1 hr. after intraperitoneal injection of the aqueous gland extract; the minnows used were selected for uniformity of response to a standard dose of an extract of whole minnow pituitaries. Frog melanophore-dispersing activity was determined by measuring the melanophore-index of the web melanophores of the hind foot of white-adapted frogs (*Rana temporaria*) (20–25 gm. in weight) immediately prior to injection of the aqueous gland extract into the dorsal lymph sac and again 1 hr. after the injection. The results are summarized in Table 1.

Table 1

		Pituitary region	
		Anterior	Posterior
Response of erythrophores of black-adapted minnows. Change in erythrophore score 1 hr. after injection	No. of animals	15	15
	Mean response	1·33	4·93
	S.D.	2·225	1·982
		$P < 0{\cdot}01$	
Response of melanophores of white-adapted frogs. Change in melanophore-index 1 hr. after injection	No. of animals	6	6
	Mean response	1·27	3·47
	S.D.	1·212	0·392
		$P < 0{\cdot}01$	

The experiments reveal that the erythrophore-dispersing and melanophore-dispersing factors in the minnow pituitary are distributed in the same way as the melanophore-aggregating factor; that is, they are present in both the anterior and posterior portions but in significantly higher concentration in the posterior portion. Stahl[2] has described two distinct cell types in the meta-adenohypophysis of *Mugil* and suggests that they represent the source of the melanophore-aggregating and melanophore-dispersing hormones. If this is true it is necessary to explain the presence of substantial amounts of these hormones in the anterior part of the gland. Comparison of the values determined for hormone activity in the two regions of the gland with dose-response curves (unpublished work) suggests that the level of both melanophore-aggregating and melanophore-dispersing hormone in the posterior part is about five times greater than that in the anterior part. In view of the crude technique adopted in separating the two portions of the gland it would be reasonable to suppose that some 20 per cent of the meta-adenohypophysis was in fact included in the anterior portion in these experiments. The results described here and in the previous communication thus lend support to Stahl's suggestion. It must be admitted, however, that such an interpretation cannot easily be reconciled with the observations of Healey[3] on the minnow or Enami[4] on *Parasilurus asotus*.

The similarity in distribution of the melanophore-dispersing and erythrophore-dispersing factors adds support to the generally accepted view[5] that both effects are brought about by a single hormone. However, the results of these experiments do not preclude the possibility that either three distinct hormones, or a single hormone causing melanophore-aggregation and erythrophore-dispersion in the minnow, and melanophore-dispersion in the frog, are involved.

Thanks are due to the Department of Scientific and Industrial Research for a Research Fellowship and to Prof. N. Millott for the provision of facilities.

A. K. KENT

Department of Zoology,
Bedford College,
University of London.
Nov. 11.

[1] Kent, A. K., *Nature*, **183**, 544 (1959).
[2] Stahl, A., *C.R. Soc. Biol., Paris*, **152**, 1562 (1958).
[3] Healey, E. G., *Bull. Anim. Behav.*, **6**, 5 (1948).
[4] Enami, M., *Science*, **121**, 36 (1955).
[5] Pickford, G. E., and Atz, J. W., "The Physiology of the Pituitary Gland of Fishes" (New York Zoological Society, 1957).

Effect of Denervation on Potassium-42 Uptake by the Rat Muscle *in vitro*

WIDELY different reports exist concerning the changes in potassium-42 uptake by denervated muscle. Lyman[1] found an increased uptake after denervation. Fischer *et al.*[2] could show no differences in uptake between normal and denervated muscles in the rabbit. Finally, Harris and Nichols[3], who measured the uptake of potassium-42 into denervated frog muscle *in vitro*, reported, in agreement with their previous results[4], that the uptake is decreased.

Difference between the findings of Lyman[1] and Harris and Nichols[3] may be due to: (*a*) different uptake of potassium into frog and rat muscles; (*b*) different equilibration time of the isotope; or (*c*) different degrees of atrophy in the frog and rat muscles. Muscle atrophy in the frog, which was studied by Harris and Nichols[3], progresses very slowly, whereas muscles in the rat studied by Lyman[1] atrophy considerably more during the same period.

For this reason we investigated the question whether uptake of potassium-42 into frog and rat muscles is different when the equilibration time of the isotope and the degree of muscle atrophy are the same. The uptake of potassium-42 into normal and denervated diaphragm of the rat was therefore measured five days after denervation, that is, in a mammalian muscle, in which atrophy begins 20–40 days after denervation[5].

Experiments were performed on male rats of 90–100 gm. body-weight. The diaphragm was denervated by unilateral ligature of the phrenic nerve by the abdominal route. Five days after denervation, rats were killed and completeness of denervation was controlled by faradic stimulation of the phrenic nerve. The diaphragm was excised together with the rib, and after dividing it into halves the centrum tendineum was removed and the hemidiaphragms were incubated in 5 ml. of saline containing chloride labelled with potassium-42. Following incubation, the hemidiaphragms were carefully washed, isolated from the rib, and gamma-activity of the tissue was measured. The total content of potassium was determined by the flame photometer in the same way as previously described[6].

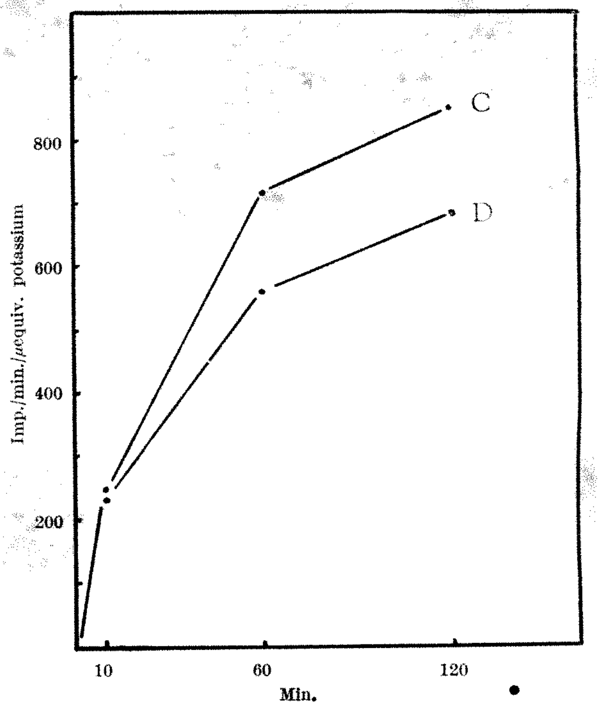


Fig. 1. Uptake of potassium-42 by normal and denervated hemidiaphragm. *D*, Denervated; *C*, control muscle

It was found that the uptake of potassium-42 by denervated hemidiaphragm is lower than in the control half (Table 1). The decrease in uptake becomes evident only after a longer period of incubation. After 10 min. incubation the uptake was the same on both the normal and denervated halves. Following 60 min. equilibration, the uptake was decreased by 118 ± 14·6 imp./min./μequiv. potassium, that is, by 16·6 per cent, while after 120 min. the uptake was decreased by 169 ± 41·5 imp./min./μequiv. potassium, that is, by 19·9 per cent (Fig. 1).

It was concluded from these results that under the same experimental conditions the uptake of potassium-42 by denervated muscle of the rat is decreased similarly to that of frog muscle[3]. Differences of uptake by denervated muscles are not caused by tissue specificity. The equilibration time of the isotope is an especially important factor when studying this uptake. The lower potassium-42 uptake

Table 1. UPTAKE OF POTASSIUM-42 BY NORMAL AND DENERVATED HALVES OF THE DIAPHRAGM

Time of incubation (min.)	Imp./min./μequiv. potassium		
	Denervated (*D*)	Control (*C*)	*D*—*C*
10	230	244	− 14 ± 23·8
60	596	714	− 118 ± 14·6
120	681	850	− 169 ± 41·5

Hemidiaphragms were incubated in 5 ml. Krebs–Ringer–bicarbonate saline with chloride labelled with potassium-42 (0·25 μc./ml.) in Erlenmeyer flasks at 37° C. The gaseous phase in the flask was 95 per cent oxygen + 5 per cent carbon dioxide. Each value is the average of five determinations.

occurred neither in our experiments nor in those of Harris and Nichols[3] until after a long period of equilibration. Lyman[1] showed an increased uptake after 2–9 min. of equilibration. However, in two experiments in which equilibration time lasted for 4 hr., he also found less potassium-42 in the denervated muscle (75 and 89 per cent). As has been shown in the literature as well as in the present report, the uptake of potassium-42 by denervated muscle following a longer period of equilibration is decreased. This conclusion further corroborates our previous findings concerning the restitution of potassium following various experimental conditions which were found to be retarded[7,8].

Z. Drahota
O. Hudlická

Institute of Physiology,
Czechoslovak Academy of Sciences,
Prague, 6.

[1] Lyman, Ch. P., *Amer. J. Physiol.*, **137**, 392 (1942).

[2] Fischer, E., Moore, J. W., Skowlund, H. V., Ryland, K. W., and Copenhaver, N. J., *Arch. Phys. Med.*, **31**, 429 (1950).

[3] Harris, E. J., and Nichols, J. G., *J. Physiol.*, **131**, 473 (1956).

[4] Nichols, J. G., *J. Physiol.*, **131**, 1 (1956).

[5] Sola, O. M., and Martin, A. W., *Amer. J. Physiol.*, **172**, 342 (1953).

[6] Drahota, Z., Klicpera, M., and Žák, R., *Biochim. Biophys. Acta*, **28**, 31 (1958).

[7] Drahota, Z., Gutmann, E., and Vrbová, G., *Physiol. Bohemoslov.*, **6**, 77 (1957).

[8] Drahota, Z., and Hudlická, O., *Physiol. Bohemoslov.*, **7**, 489 (1958).

Histochemical and Biochemical Studies of Rat Liver in Experimental Cirrhosis after Partial Hepatectomy

As an outcome of our earlier work on experimental cirrhosis[1,2] and regeneration of the liver[3] it seemed of interest to study the dynamics of the regenerative process in the normal and cirrhotic liver after partial hepatectomy.

The experiments were made on 90 male Wistar rats of 170 gm. average body-weight divided into two groups and kept on a standard diet. In the animals of group 1 cirrhosis was produced with carbon tetrachloride (0·1 ml. subcutaneously every fourth day, a total of 29 doses over a 120-day period), while group 2 was untreated. Partial hepatectomy (65–70 per cent) was made on both groups and rats were killed 24, 48, 72 and 96 hr. after surgery. The removed lobes and postsurgical remnants were examined by histomorphological, histochemical and biochemical methods.

Succinic dehydrogenase activity (neotetrazolium method) in the cirrhotic liver proved to be somewhat less than in the normal one. The activity of this enzyme decreased very much in both groups 24 hr. after partial hepatectomy. This decrease in normal livers persisted unaltered for 3 days and a partial return of the activity was seen only on the fourth day. In contrast to this, the activity of succinic dehydrogenase of the regenerating cirrhotic liver reached that of the intact (unoperated) cirrhotic liver within 48 hr., and after 96 hr. closely approached that of the normal controls. The succinic dehydrogenase activity was also measured by a quantitative biochemical procedure[4]; the results of these determinations confirmed entirely those obtained by the histochemical technique.

Acid and alkaline phosphatase activities were studied both by histochemical procedures (Gomori–Moffat) and by quantitative methods using liver suspensions[5,6]. The results of both types of analysis were in agreement; the quantitative results are shown in Table 1. There was a substantial increase in the alkaline phosphatase activity both in the cirrhotic and normal livers 24 and 48 hr. after partial hepatectomy, the activities returning to the pre-operative levels by 96 hr.; the alkaline phosphatase activities in cirrhotic livers were generally much higher than in the normal organ. The acid phosphatase-levels were somewhat variable in normal livers after hepatectomy, but showed substantial increases in the regenerating cirrhotic livers.

Table 1. ACID AND ALKALINE PHOSPHATASE ACTIVITIES IN NORMAL AND CIRRHOTIC LIVER AFTER PARTIAL HEPATECTOMY

Hours after hepatectomy	Normal liver			
	Acid phosphatase		Alkaline phosphatase	
	Per wet weight	Per dry weight	Per wet weight	Per dry weight
0	500	1,530	43	130
24	323	1,075	106	351
48	412	1,425	187	646
72	614	2,106	122	418
96	497	1,651	38	124
	Cirrhotic liver			
0	295	1,143	84	324
24	416	1,445	206	717
48	577	2,042	360	1,274
72	426	1,508	100	354
96	515	1,840	116	378

The activities are given as μgm. inorganic phosphorus liberated per hr. from β-glycerophosphate by 100 mgm. of wet or dry liver tissue. The inorganic phosphorus was determined by the method of Fiske and Subbarow (ref. 5).

In histochemical preparations the activity of lipase (Gomori's method) was seen to decrease early after partial hepatectomy in both groups of animals, but a return to normal followed quickly.

Cytochrome oxidase was also measured according to the method of Mitolo and Ruccia[7]. The activity of this enzyme showed a periodic change (decrease→return to normal→decrease) in the regenerating normal liver, whereas in the regenerating cirrhotic liver there was more than a threefold increase even on the fourth day after hepatectomy.

We could not observe any change in the architecture of the cirrhotic livers after partial hepatectomy. The mitotic activity seemed, however, greater in the cirrhotic post-operative remnants than in the non-cirrhotic ones during the early days of regeneration.

The results indicate that the enzymic responses of the cirrhotic liver after partial hepatectomy are more intense than those of the normal regenerating one. A more detailed study of this phenomenon and the evaluation of its significance in the regenerative process is in progress.

I. Bartók
Gy. Domján
E. Horváth
B. Korpássy

Department of Pathology and Biochemistry,
University Medical School,
Szeged, Hungary.

[1] Korpássy, B., *Cancer Res.*, **19**, 501 (1959).

[2] Korpássy, B., and Kovács, K., *Brit. J. Exp. Path.*, **30**, 266 (1949).

[3] Horváth, E., and Kovács, K., *Z. ges. exp. Med.*, **127**, 236 (1956).

[4] Domján, Gy., and Kovács, E., *Enzymologia* (in the press).

[5] Fiske, C. H., and Subbarow, Y., *J. Biol. Chem.*, **66**, 375 (1925).

[6] Flexner, L. B., and Flexner, J. B., *J. Cell. Comp. Physiol.*, **31**, 311 (1948).

[7] Mitolo, M. E., and Ruccia, D., *Arch. Sci. Biol.*, **39**, 132 (1955).

RADIOBIOLOGY

Whole-Body Turnover of Selenium in the Rat

Selenium has recently been shown to be an essential micronutrient for rats[1] and ruminants[2]. These discoveries have directed attention to the lack of information concerning the metabolism of selenium in subtoxic amounts. The present communication gives results for whole-body turnover, or total excretion, of selenium by the rat over a prolonged period of time.

Hooded rats of the Long–Evans strain were used. They were maintained on a complete stock colony ration (*ad libitum*) and weighed approximately 150 gm. at the time of administration of radioactive selenium; 0·0011 mc. of selenium-75 in physiological saline was administered interperitoneally. The total selenium content of the dose was 0·14 mgm. and the selenium was present as sodium selenite. The total selenium-75 content of the rats was determined three times daily for the first two days, twice daily for one week and daily for a second week. For measurement, individual rats were placed in a ventilated stainless steel tube and confined to a length approximately equal to that of the rat's body. The rat was then suspended approximately 20 cm. above a scintillation counter for measurement of radiation. The counter used was a standard well-counter operated without the top lead shield. The entire top surface of the crystal was unshielded. The 0·269-MeV. gamma-ray of selenium-75 was counted, using a single-channel pulse-height analyser and scaler. For calibration, a vial containing an aliquot of the dose was substituted for the rat. The standard error of measurement was 2·3 per cent as determined from duplicate counts[3]. There was no difference in the error of measurement between two operators.

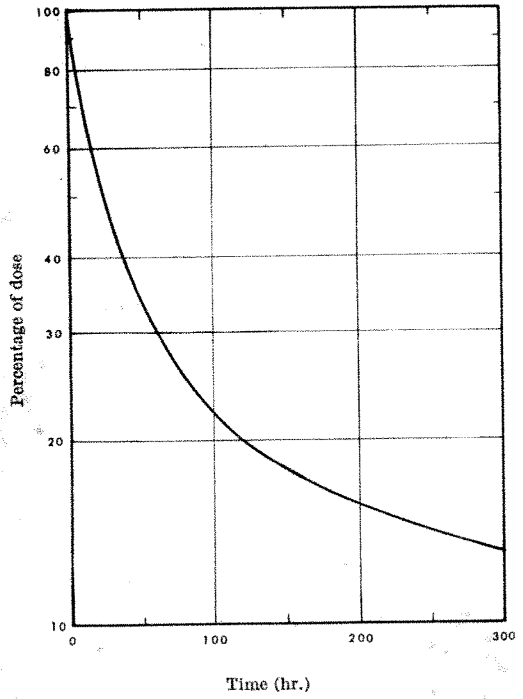


Fig. 1. Radioselenium turnover in the rat

Table 1. Whole-body Turnover of Selenium in the Rat

Rat No.	Rate constants (hr.$^{-1}$): K_1	K_2
0	0·037	0·0025
1	0·037	0·0018
2	0·036	0·0021
3	0·037	0·0025
6	0·040	0·0023
7	0·036	0·0021
9	0·038	0·0021
Mean	0·037	0·0022
Standard deviation	0·001	0·0002
$t_{1/2}$ (hr.)	19	318

The results were analysed by considering the whole-body turnover to be describable by a set of consecutive first-order chemical reactions. The rate constants for the various segments of the turnover curve were computed, fitting the data by the method of least squares.

For the first 300 hr. after injection of selenium-75, the whole-body turnover may be described by two first-order processes of widely differing rate constants (K_1 and K_2). A graph presenting the average results is shown in Fig. 1. The initial slope of the curve is determined by K_1 and the final slope by K_2. The individual rate constants are presented in Table 1.

Previously published work of selenium metabolism was for periods of less than 50 hr. and hence comparison is difficult. Also, other studies measured excretion, rather than retention, and often ignore one of the three routes of selenium excretion—urine, fæces and expired air. Harshfield[4] found the 'total recoverable selenium' in the rat to be about 75 per cent of dose at 6 hr. after injection and about 65 per cent of dose at 12 hr. These results agree with the present work. Harshfield found, however, no decrease in 'total recoverable selenium' between 12 and 48 hr. post-injection as was found here (see Fig. 1). McConnell[5] found the urine and fæcal excretion of selenium-75 from the mouse to be about 45 per cent of dose in the first 24 hr. The present work indicates a total excretion of about 48 per cent of dose in an equivalent time. Heinrich and Kelsey[6] reported the 'total recoverable selenium' in the mouse to be only 16·5 per cent of dose at 48 hr. after injection—considerably less than that found here for the rat.

The presence of two rate constants governing selenium turnover indicates that selenium is involved in the metabolism of the animal. Selenium is transferred from one (rapidly excreted) form to another (slowly excreted) form. Two choices are available: (1) the rate-limiting processes are the renal clearance of two chemically different forms of selenium; and (2) the rate-limiting process for the smaller rate constant is the rate of release of selenium from tissues in which it is fixed.

I acknowledge the assistance of Miss July Grafton with the laboratory procedures and Dr. W. B. Dye for his encouragement and counsel.

Clifton Blincoe

Department of Agricultural Chemistry,
Max C. Fleischmann College of Agriculture,
University of Nevada,
Reno.

[1] Schwarz, K., and Foltz, C. M., *J. Agric. Chem. Sci.*, **79**, 3292 (1957).

[2] Muth, O. H., Olfield, J. E., Remmert, L. F., and Schubert, J. R., *Science*, **128**, 1090 (1958).

[3] Youden, W. J., "Statistical Methods for Chemists", 16 (Wiley, New York, 1951).

[4] Harshfield, R. D., "A Study on the Metabolism of Selenium^{75} in the Mouse", M.A. thesis, University of South Dakota (1953).

[5] McConnell, K. P., *J. Biol. Chem.*, **141**, 427 (1941).

[6] Heinrich, M., and Kelsey, F. E., *J. Pharmacol. Exp. Therap.*, **114**, 28 (1953).

Selection of Iodinated Protein in the Young Mouse

The suckling mouse absorbs antibody readily when whole immune serum is administered by mouth[1] and transmission to the circulation is selective in the sense that antibodies prepared in a variety of species are characterized by different concentration quotients in the recipient plasma[2]. During the course of the work with serum protein preparations labelled with iodine-131 in other species a criterion of the physiological integrity of the labelled material was sought which would be sensitive and readily determined. Recourse was therefore made to gut transmission in the young mouse.

The mice employed throughout the work were L.A.B. Greys, obtained by courtesy of Dr. Lane-Petter in 1955 and bred randomly since then. Preliminary experiments suggested the standard conditions of testing. Protein, labelled by the jet-burette method[3], was made up finally in 1 per cent solution. This was fed to 8-day old mice which were killed 3 hr. later, the blood collected, and the activity of the serum protein determined after tungstic acid precipitation.

Values are expressed as the ratio:

$$\text{concentration quotient} = \frac{\text{c.min.}^{-1}\ \text{ml.}^{-1}\ \text{serum protein}}{\text{c.min.}^{-1}\ \text{ml.}^{-1}\ \text{preparation fed}}$$

Fig. 1*A* presents the regressions of the concentration-quotient with dosage for two levels of iodination of aliquots of a frozen-dried stock preparation of rabbit globulin which was prepared by final precipitation from 12 per cent sodium sulphate[4]. It is apparent that a very sharp selection occurs between these two preparations, although they differ only in the level of iodine-127 per molecule of globulin.

Fig. 1*B* illustrates the relation of concentration quotient to iodination-level at a chosen dose of 0·03 ml. fed, and is thus in effect a calibration curve for the testing of subsequent preparations of this protein at any future date. It is clear that there is no significant difference between the concentration quotient at the mean iodination-level of 0·5 atom per molecule and that for antibody from whole rabbit serum at the same dosage (Fig. 1*A*), so that it is possible to take the concentration quotient of isotope at this level as being maximal for the stock preparation of globulin in these experimental conditions. Since the reduction of concentration quotient at the mean level of 3 atoms per molecule is already highly significant, the proposed test is clearly a sensitive one. It is thus possible, by feeding small groups of mice, to check the integrity of labile preparations in the course of a few hours.

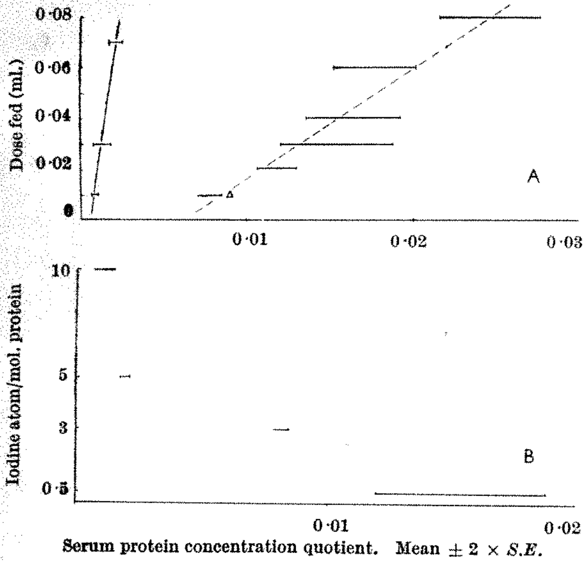


Fig. 1. Absorption of 1 per cent solutions of rabbit globulin from the gut of the 8-day old mouse. The means ± 2 standard error of groups of six mice are plotted; within each relationship each group was composed of one sibling of each of six litters. (*A*) Dosage relation: – – – –, regression where the mean iodination-level is 0·5 atom/mol. *b* = 4·4; ———, regression where the level is 10 atom/mol. *b* = 49·4; △ = mean concentration quotient of rabbit anti-sheep red cell serum from ref. 2. (*B*) The test calibration curve: dose fed 0·03 ml.

Selection between molecules differing only in the number, and presumably the distribution, of labelled tyrosine residues, since it is so sharp, may suggest that some at least of the tyrosine residues of the molecular surface normally play a part in selection of the protein by the entoderm cell.

W. A. HEMMINGS

Agricultural Research Council
Unit of Embryology,
Department of Zoology, Bangor.

[1] Morris, I. G., *Proc. Roy. Soc.*, B, **148**, 84 (1957).

[2] Hemmings, W. A., and Morris, I. G., *Proc. Roy. Soc.*, B, **150**, 403 (1959).

[3] McFarlane, A. S., *Biochem. J.*, **62**, 135 (1956).

[4] Kekwick, R. A., *Biochem. J.*, **34**, 1248 (1940).

Cæsium-137 in Toronto Milk during 1959

MEASUREMENTS of the changing cæsium-137 content of milk have been carried out in many parts of the world, particularly in the United States[1] and the United Kingdom[2]. The Los Alamos group measured the activity of Ontario milk during 1958[3]. Here we present results of measurements on milk taken from the Toronto milk-shed during the period April 1959–February 1960.

The measurements were carried out using as gamma-ray detector a 5-in. sodium iodide crystal placed in the University of Toronto 'steel room'[4]. 670 gm. of dried skimmed milk, received within a few days of production, were placed in a thin copper vessel immediately below the crystal. Counting was normally for 75 min.

The only photo-peaks observed were at energies of 0·66 MeV. and 1·46 MeV., corresponding to cæsium-137 and potassium-40 activities. By comparison of the areas of these photo-peaks, and making suitable corrections[4], the ratio cæsium-137/potassium of a sample is obtained. Calibration of the apparatus was carried out regularly using a weighed amount of potassium chloride in a standard copper vessel, and thus the potassium content of the milk could be determined, corrections once again being necessary for the differential absorption of the potassium gamma-rays in the potassium chloride and in the dried milk. It was in fact found that the potassium content of each sample of dried milk was approximately the same, the average value being 3·7 mgm. of potassium per gm. of dried milk.

The statistical error associated with the measurement of the potassium content of any one particular milk sample did not exceed 2 per cent.

The results for cæsium content during the period of observation, expressed in cæsium units (C.U.), that is, μμc. cæsium-137 per gm. of natural potassium, are given in the lower part of Fig. 1. For comparison,

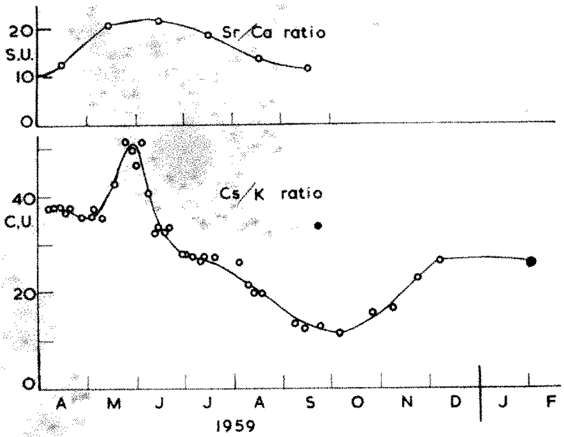


Fig. 1. Lower graph: change with time of the cæsium content of Toronto milk during April 1959–February 1960. (C.U. = μμc. cæsium-137 per gm. potassium.) Upper graph: Canadian average strontium-90/calcium ratio in milk (ref. 5). S.U. = μμc. strontium-90 per gm. calcium

the averaged ratio strontium-90/calcium for milk in Canada for the corresponding period[5] is given in the upper part of Fig. 1.

We interpret the cæsium curve in the following way:

(1) During April, cows are in barns, on winter feed, the cæsium-137 content of which will reflect the mean rate of fallout of the previous summer. Thus little change in the ratio cæsium/potassium in milk from these cows is expected in this period.

(2) The cows from which our milk came went out to pasture during the second week of May. This pasture would be contaminated with the fallout from the low-altitude Russian bomb tests of late 1958. As a result, the cæsium content of the milk rose rapidly after the change over to summer-feed. It will be noted that the time for the cæsium content to change by half the difference between the winter-level and the peak is approximately 12 days. The biological half-life of cæsium in the cow is stated to be about 20 days[6].

(3) The Russian fallout was apparently retained only a short time in the atmosphere, and after the rapid rise to the peak of 51 C.U. at the end of May, the cæsium activity in milk fell to the low value of 11·6 C.U. in October. This decrease seems to have two components, one rapid and one relatively slow. We attribute the former to the fact that cows grazing on new grass would pick up activity collected on the grass over about one month, while the second-growth grass would only have on it fallout collected over perhaps one or two weeks.

(4) In early November or late October the cows returned to the barns, to feed on hay, etc., cut during the early summer of 1959. As a result, the ratio cæsium/potassium rose, this time to a level equal to that of July 1959. Unfortunately, supplies of dried milk have been poor during the winter, and the presence of a plateau is only shown by the approximate equality of runs in late November and early December using dried milk, and one run in February 1960 using liquid milk.

It may be noted that during the summer decrease, during July 1–September 30, the cæsium content of milk fell by a factor of 2. On the assumption that cæsium-137 intake by cows is via direct fallout on foliage and not via the roots of plants, this suggests a half-life in the troposphere of the fallout of the order of 2 months.

The fact that there are two distinct rates of decrease of the cæsium/potassium ratio supports the assumption that most of the cæsium entering cattle comes directly from the foliage rather than via the grass root-system.

Comparison with the strontium-90 results show that the rise occurs in strontium content at the same time as the rise in cæsium content, and that correspondingly there is a fall throughout the summer in the strontium activity. However, the ratios of the spring peak values to the winter 1958–59 plateau values for cæsium-137 and strontium-90 are different (10 : 7 and 2 : 1 respectively) and the rate of decrease of the cæsium-137 content of milk was greater than that for strontium-90.

The October 1959 low value of 11·6 C.U. corresponds to an activity of approximately 19 μμc. of cæsium-137 per (Imperial) quart of milk. Assuming a 115-day biological half-life for cæsium in the body[7], and an intake of one quart of milk a day, this activity leads to a total maximum body burden due to this source of cæsium of $3\cdot1 \times 10^3$ μμc., which is 10,000 times less than the maximum permitted amount in the body[8].

K. G. McNeill
O. A. D. Trojan

Department of Physics,
University of Toronto,
Toronto, Canada.

[1] Langham, W. H., and Anderson, E. C., *Health Physics*, **2**, 30 (1959).

[2] Booker, D. V., *Nature*, **183**, 921 (1959). Anderson, W., Burton, L. K., and Crookall, J. O., *ibid.*, **184**, 89 (1959).

[3] Anderson, E. C., Clinton, B., and Shields, J. A., Los Alamos Report 2296 (1959).

[4] McNeill, K. G., and Green, R. M., *Can. J. Phys.*, **37**, 683 (1959).

[5] Department of National Health and Welfare Quarterly Reports on Levels of Sr 90 in Canadian Milk Powder Samples, June, September and December 1959.

[6] Hood, S. L., and Comar, C. L., *ORO*-91 (1953).

[7] McNeill, K. G., and Green, R. M., *Can. J. Phys.*, **37**, 528 (1959).

[8] National Committee on Radiation Protections and Measurement, NBS Handbook, 69 (1959).

HISTOLOGY

A Specific Stain for Mast Cell Granules

Examination of tissues stained for mast cells with a variety of accepted techniques has shown a need for a more specific staining method. The use of the conventional metachromatic dyes, though resulting in satisfactory preparations in many cases, presented problems of identification of mast cell granules in some tissues, for example, in lymph nodes where the intense nuclear orthochromatic staining of surrounding cells obscures metachromatic granules.

As recently as 1957, Barlow[1] was prompted by "a lack of a sufficiently reliable and selective method of identification" for mast cells to formulate a tribasic stain for their differential staining. The constituents for this tribasic stain were acridine red, neutral red, and basic fuchsin, but unfortunately the staining technique was lengthy and complicated.

When using metachromatic dyes, background or orthochromatic staining of tissue elements can be completely suppressed by acidifying the dye solution and adding metallic cations in suitable concentrations[2]. In dilute solutions, however, lengthy periods of immersion in the dye were necessary to produce even faint metachromatic staining of the mast cell granules. In order to increase the speed and intensity of the granule staining, dye concentrations were increased, and background staining was avoided by increasing the metallic cation concentrations.

The tissues employed were obtained from the lip and tongue of young adult Chester Beatty albino rats. These tissues were fixed in 10 per cent neutral formol saline, embedded in paraffin wax–'Celloidin' by Peterfi's method, and cut in serial section at 7μ thickness. These techniques have been shown to be satisfactory for the demonstration of mast cells in tissues obtained from the albino rat[3].

A 0·01 per cent toluidine blue solution buffered at *p*H 3·0 with a 1 in 10 dilution of McIlvaine's sodium hydrogen phosphate citric acid buffer was found to stain satisfactorily mast cell granules in 10 min. A concentration of 2 gm. per cent crystalline magnesium chloride, that is, 0·2 *N* concentration, was required to prevent background or orthochromatic staining. Except for faint staining of cartilage matrix, this solution was specific for the granules of mast cells (Fig. 1).

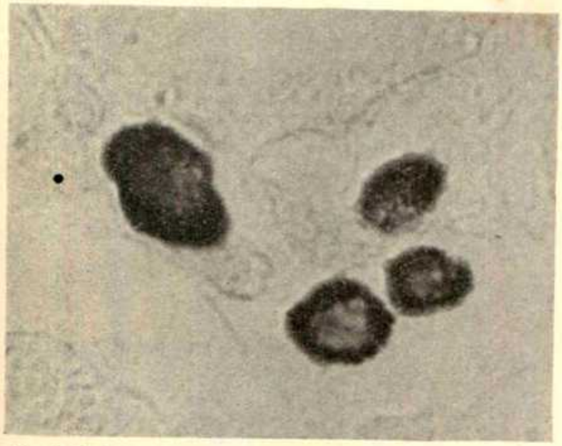


Fig. 1. Staining of mast cell granules with complete suppression of background staining. (× 1,000)

Nuclear fast red stained the nuclear material without interfering with the granule staining.

W. Montagna (personal communication, 1956) suggested that much 'washing out' of a metachromatic dye by the low-grade alcohols during dehydration procedures could be avoided by using tertiary butyl alcohol instead of the various grades of ethyl alcohol. As tertiary butyl alcohol was unobtainable, the closely related *iso*-propyl alcohol was used as a substitute and found to have no apparent deleterious effect on the toluidine blue staining.

Montagna's recommendation to employ toluene as a clearing agent has also given satisfactory results. In later work terpineol has been substituted for toluene, as it is less volatile and, therefore, easier to use. The results were similar to those obtained with toluene.

Diffusion of the dye into the mounting medium has been prevented by employing toluene-balsam, and avoiding heat in drying the mountant. Sections prepared in this manner have remained unchanged over a period of three years.

The technique for the 'specific' stain is as follows: (1) remove paraffin wax with xylene, and hydrate in descending grades of ethyl alcohol; (2) wash in distilled water; (3) immerse in a 'pretreatment' solution of a 1 in 10 dilution of McIlvaine's sodium hydrogen phosphate citric acid buffer at *p*H 3·0 for 1 hr.; (4) stain for 10 min. in a 0·01 per cent toluidine blue (Gurr 2706) solution in a 1 in 10 dilution of buffer at *p*H 3·0 to which 2 gm. per cent crystalline magnesium chloride have been added; (5) counterstain with 0·1 per cent nuclear fast red (Gurr 3569) for 5 min.; (6) rinse in distilled water; (7) dehydrate with three changes of *iso*propyl alcohol for 2 min. each; (8) clear in toluene or terpineol; (9) mount in toluene-balsam, and dry away from heat.

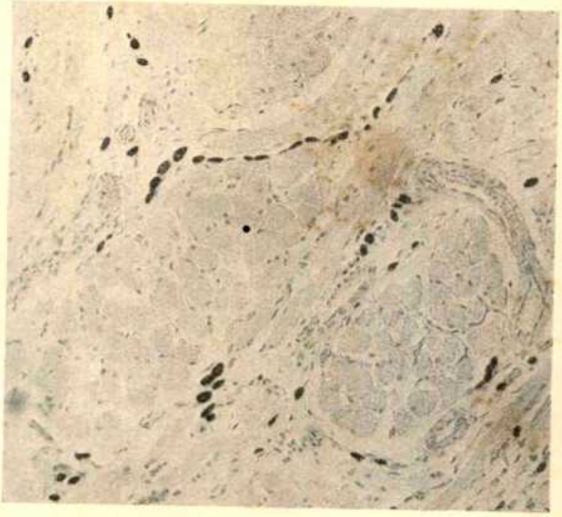


Fig. 2. 'Specific' stain preparation with mast cells clearly visible. (× 120)

With this technique the granules of mast cells are stained heavily with the toluidine blue, and the cartilage matrix faintly blue. Nuclei are stained red (Fig. 2).

In order to establish the precise relationship of the nuclei to the granules of the mast cells stained by the 'specific' stain, a composite Feulgen reaction 'specific' stain was carried out on sections of lip and tongue.

The Feulgen reaction (after Pearse[4]) was carried out first, without counterstain. The sections were then immersed in the 'pretreatment' buffer solution for 1 hr., and then stained with the 'specific' stain. Nuclear fast red counterstain was omitted from the 'specific' stain procedure.

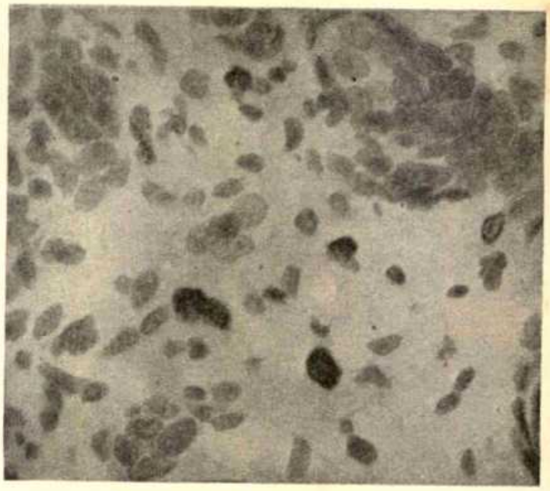


Fig. 3. Composite Feulgen reaction–'specific' stain. (× 540)

It was found that the subsequent staining of the mast cell granules by the toluidine blue was not affected by the preceding treatment of the Feulgen reaction. The granules remained metachromatic, and the nuclear chromatin was stained red from the Feulgen reaction.

The relationship of the granules to the nuclei was clearly apparent in those cells which contained only moderate numbers of granules (Fig. 3). In some cases, however, the granules were so numerous that the nuclear staining was obliterated. The distribution of the Feulgen-positive material corresponded to the nuclei demonstrated by the nuclear fast red in the 'specific' stain.

The 'specific' stain applied to frozen sections has given similar results to those of paraffin wax–'Celloidin' sections.

B. G. RADDEN

Department of Dental Histology and Pathology,
London Hospital Medical College,
London, E.1.

[1] Barlow, R. M., *J. Path. Bact.*, **73**, 272 (1957).
[2] Radden, B. G., submitted to *J. Histochem. Cytochem.*
[3] Radden, B. G., thesis accepted by the University of London for the degree of Ph.D. (1959).
[4] Pearse, A. G. E., "Histochemistry. Theoretical and Applied", 1st ed. (Little Brown and Co., Boston, 1953).

Ultrastructure of the Clear Cells in Renal Carcinomas and its Importance for the Demonstration of their Renal Origin

MOST pathologists will agree that the histogenesis of the so-called Grawitz tumours of the kidney was settled by the classical paper of Stoerk published in 1908 [1]; but the arguments of this author, convincing as they were in disproving the suprarenal nature of the 'hypernephroma', were much less so in demonstrating their renal origin. That is the reason why this latter opinion has been challenged time and again. New theories have been put forward, among which those of Apitz[2] and of Feyrter[3] have attracted some attention lately.

It seemed interesting then to inquire whether the ultrastructure of the clear cells might reveal some details which would provide conclusive evidence of their renal origin.

This is indeed the case, and the main cytological feature revealed by the study of 8 clear cell carcinomas of the human kidney will be briefly outlined here.

In the electron microscope the tumour cells appear clearly delimited, separated from the vascular stroma by a typical basal membrane, identical to the similar structure in the normal kidney tubule. But whereas in the optical microscope the cytoplasm of the clear cells appears empty, here it is filled with structural elements among which three are most conspicuous: mitochondria, heavy osmiophilic fat deposits and glycogen. The abundance of mitochondria is one of the main characters of these tumour cells. Many of them appear literally stuffed with these organelles and the presence of numerous microbodies indicates that an active multiplication of the chondrioma is taking place. In all probability the high amount of fatty material noticed long ago in the clear cells is related with this extraordinary aptitude of the clear cell to produce mitochondria. This fact has to be kept in mind because it is in itself a characteristic property of convoluted tubule cells.

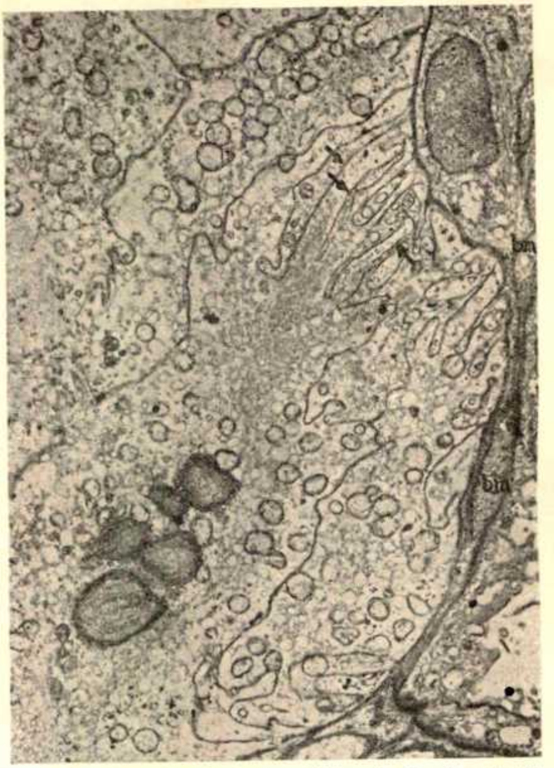


Fig. 1. Basal portion of a tumour cell showing the characteristic features of a convoluted tubule cell, especially smooth cytomembrane (arrows) inserted on the basal membrane (*bm*) (× 6,860)

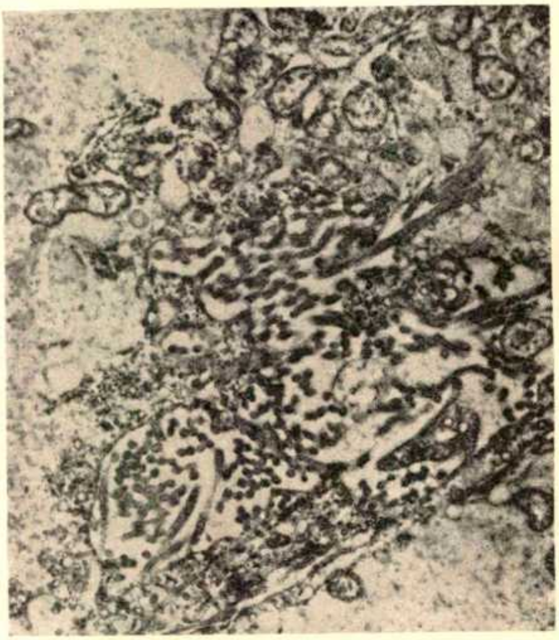


Fig. 2. Elements of brush border (central portion of the figure) belonging to a group of tumour cells (× 13,700)

But other and far more significant morphological details have come to light during these studies. In the first place the presence of smooth cytomembranes must be noticed. They form parallel sheets (Fig. 1) inserted perpendicularly upon the basal membrane. These formations exist in all cells where active exchange of liquid takes place such as in the choroid plexus, the ciliary epithelium and the submaxillary salivary gland[4]. They are also a very prominent constituent of the convoluted tubule cells. Furthermore, a number of the tumour cells exhibit a free apical surface provided with microvilli (Fig. 2) which are identical to the embryonic form of brush borders.

Here then are ultrastructural constituents of the clear cells in renal carcinomas which indicate clearly that these tumours arise from the epithelial cells of the convoluted tubule.

CH. OBERLING
M. RIVIÈRE
FR. HAGUENAU

Institut de Recherches sur le Cancer,
Villejuif, Seine.

[1] Stoerk, O., *Beitr. Anat. und Allg. Path.*, **43**, 393 (1908).
[2] Apitz, K., *Virch. Arch.*, **311**, 285 (1943).
[3] Feyrter, F., "Über diffuse endokrine epitheliale Organe" (J. A. Barth, Leipzig, 1938).
[4] Pease, D. C., *J. Biophys. Biochem. Cytol.*, **2** (Supp.), 203 (1956).

BIOLOGY

Collagenase Maceration of Kidney for Microdissection

THE traditional method of preparing kidney for microdissection is by maceration of formalin-fixed tissue with concentrated hydrochloric acid[1]. This method gives an excellent preparation of loosened nephrons and collecting tubules that can be disentangled and studied by microdissection. However, it suffers from the disadvantage that the acid treatment changes the nuclei so that they cannot be demonstrated in dissected preparations by the usual staining methods. A method of maceration that would allow nuclear staining after dissection would considerably widen the scope of the technique.

A variety of alternative macerating agents has been tried without success[2]. The present communication records the successful use of the collagenase of *Clostridium histolyticum* for maceration, permitting subsequent nuclear staining, of alcohol–acetic acid-fixed kidney.

In the course of the investigation, collagenase has been tested on fresh unfixed tissue and on tissue fixed with either alcohol, alcohol–acetic acid, acetone, acetone–acetic acid, saturated mercuric chloride, saturated picric acid, mercuric-dichromate (Zenker stock) or formol saline. Phosphate and borate buffers have been compared as diluents for collagenase; formol saline and 1 per cent acetic acid have each been tried as final fixatives for the macerated tissue; and the pretreatment of tissue slices with 6 *M* urea[3] has been tested. It has been confirmed that it is not possible to use collagenase for formalin-fixed tissue. Formalin alters the collagen substrate so that it is no longer susceptible to collagenase[4,5]. Alcohol-fixation does not inhibit the activity of collagenase, but the nephrons and collecting tubules are too brittle for dissection although good nuclear staining is possible. Acetone-fixation does not inhibit collagenase, the nephrons and collecting tubules are much easier to dissect and nuclear staining is not impaired. The addition of 25 per cent glacial acetic acid to either alcohol or acetone for fixation further improves the macerated tissue for microdissection.

Slices of alcohol–acetic acid-fixed kidney[6], about 1 mm. thick, are washed for 4 hr. in running water and are then immersed in phosphate buffer at *p*H 7 containing 0·25 mgm./ml. collagenase (Collagenase *ABC* Form II obtained from Agricultural Biochemicals Corporation, New York) and 0·1 mgm./ml. chloramphenicol. After 24 hr. at 37° C. the macerated tissue is transferred to formol saline. After microdissection, portions of nephron or collecting tubule that require staining are mounted on a slide under a coverslip and stained by drawing Mayer's hæmatoxylin through with blotting paper. After a few minutes the stain is rinsed away with Scott's tapwater and the nuclei are clearly stained in pale cytoplasm.

Although collagenase-macerated material is not so easy to dissect as acid-macerated tissue, the method, by allowing nuclear staining, yields valuable information not otherwise obtainable.

NANCY J. HAYWARD

Department of Pathology,
University of Melbourne.

[1] Oliver, J., MacDowell, M., and Tracy, A., *J. Clin. Invest.*, **30**, 1307 (1951).
[2] Darmady, E. M., and Stranack, F., *Brit. Med. Bull.*, **13**, 21 (1957).
[3] Neuman, R. E., and Tytell, A. A., *Proc. Soc. Exp. Biol. N.Y.*, **73**, 409 (1950).
[4] Robb-Smith, A. H. T., "Nature and Structure of Collagen", edit. by Randall, J. T., 21 (Butterworths, London, 1953).
[5] Keech, M. K., *J. Path. Bact.*, **77**, 351 (1959).
[6] Clarke, J. L., *Phil. Trans. Roy. Soc.*, B, **141**, 607 (1851).

Culture of Human Leucocytes on the Chorio-allantoic Membrane of the Chick

A NEW technique has been developed for the culture of human leucocytes and other cells.

Suspensions of cells of the 'buffy coat' of heparinized human blood were introduced under sterile conditions into diffusion chambers consisting of two sheets of membrane filter ('Oxoid'), 2 cm. in diameter, cemented to a polystyrene ring. The inoculated chamber was sealed and dropped on to the chorio-allantoic membrane of the seven-day chick embryo through a slot in the egg-shell. Eggs were incubated at about 39° C. Cultures were examined at intervals to determine the state of the cells. After removal from the egg the filter disks were cut free from the polystyrene ring, placed on slides and stained with acetic orcein.

After two days of incubation many macrophage-like cells were present on the inside of both upper and lower disks of the chamber, but primarily on the upper disk. The fluid in the chamber contained mostly small lymphocytes and polymorphonuclear leucocytes which were also found on the bottom disk but apparently not attached. Present on the bottom disk was also a considerable number of large mononuclear cells which appeared to be attached to the membrane filter.

Cell divisions were first observed after four or five days of incubation and only in cells which seemed to be of the large mononuclear class. Divisions were observed in isolated cells (Fig. 1*a*) as well as in cells which were part of a group. Dividing cells were found only on the inside of the bottom disk of the chamber, that is, on the membrane filter which was in direct contact with the chorio-allantoic membrane of the chick. At five days most of the cells on the upper disk of the chamber were dead while the fluid in the chamber still contained healthy looking small lymphocytes and polymorphonuclear leucocytes. No human erythrocytes were left by this time. Chick cells were effectively excluded from the inside of the chamber.

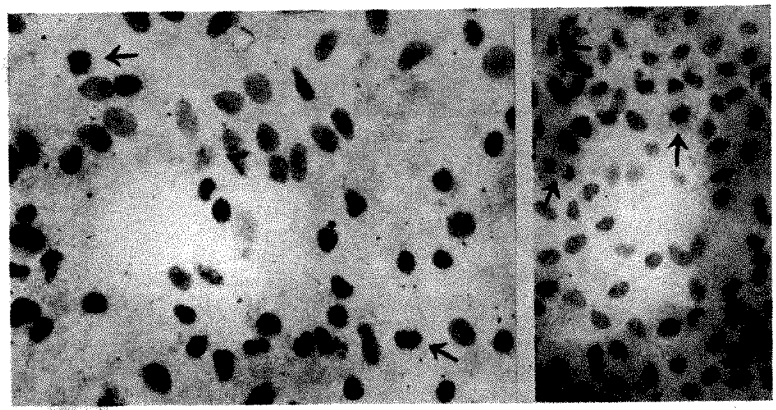


Fig. 1. Human leucocyte cultures. Arrows point to dividing cells. *a*, 7 days old; *b*, 14 days old

By seven days the number of cells in division was substantially increased and the cells were, for the most part, assembled into a nearly continuous sheet, epithelioid in character.

At five, seven or eight days, chambers were transferred to a new host and examined five or six days later (twelve to fourteen days from the start of the cultures). At this time the only cell-type remaining was a large epithelioid-like mononuclear cell found exclusively on the bottom disk of the chamber; this cell was several times larger than uncultured blood monocytes. All small lymphocytes and polymorphonuclear leucocytes had disappeared from both fluid and disks of the chamber and no debris was present. The frequency of divisions was higher than before (Fig. 1*b*), that is, of the order of 2 per cent.

Human foreskin fibroblasts and some embryo chick cells, cultured by the method reported above, also have yielded promising results. The technique may prove particularly useful for culturing cells which are ordinarily refractory to primary *in vitro* cultivation.

This work, part of a programme supported by the U.S. National Institutes of Health (*RG*. 5804), was done while I was Special Research Fellow (*CF*4028–*C*2) of the U.S. National Cancer Institute, on leave from the Department of Biology, Massachusetts Institute of Technology.

EUGENE BELL

Department of Genetics, The University,
Glasgow. Dec. 24.

Decomposition of Humic Acid by Fungi

ALTHOUGH there have been a number of publications dealing with the utilization of humic acid by microorganisms, these papers have, at the most, reported that some humic acid preparations may serve as a source of nitrogen[1,2]. No convincing evidence appears to have been published concerning the destruction or utilization of the non-nitrogenous portion of the humic acid.

As the result of a prolonged series of percolation experiments, we have isolated a number of organisms capable of decomposing humic acid. Of these the two most active are fungi and have been provisionally referred to the genera *Spicaria* and *Polystictus*. After successful tests had been completed with the presumed *Polystictus*, the Basidiomycetes, *Polystictus versicolor*, *Hypholoma fasciculare* and *Trametes rubescens*, were also tested and found to decompose the humic acid. We have previously[3] discussed the difficulties associated with investigations concerned with the microbiological utilization of humic acid, but in the work reported here it is considered that there is evidence of a genuine biological decomposition of the humic acid molecule.

The humic acid used was extracted from the B_1 horizon of a podzol soil from Delamere Forest, Cheshire, by means of 50 per cent v/v lactic acid. The extract was passed through an ion exchange column, precipitated with hydrochloric acid and then purified by dialysing, first against dilute hydrochloric acid and then distilled water. The humic acid was then dried *in vacuo* at 45° C. An analysis gave the following percentage composition: carbon 50, hydrogen 3·9, oxygen 38, nitrogen 0·4, methoxyl 1 and ash 1·5. The basic medium used throughout was the one on which the effect was first observed and may not be optimal. It contained dihydrogen potassium phosphate, 0·4; dipotassium hydrogen phosphate, 0·6; magnesium sulphate, 0·5; potassium chloride, 0·5; sucrose, 20 gm. per litre, with trace elements and Fries's vitamin solution added. 200 μgm. per litre of vitamin B_{12} was also included.

Growth of the active fungi on agar containing sufficient humic acid (0·12 per cent) to produce a dark brown medium gave a clear zone associated with the fungal mycelium. There was no evidence of any accumulation of the humic acid by the mycelium as had been observed previously[3] with fungi such as *Penicillium* spp. In Petri-dish culture complete clearing of the medium occurred with *Polystictus* in four weeks.

Quantitative studies have been carried out using soil perfusion columns and large-scale cultures in penicillin flasks. At the end of the experiment the humic acid remaining in the perfusate or medium respectively was recovered. In addition to this the soil or mycelium in each case was treated with warm 1 per cent potassium phosphate solution to remove all absorbed humic acid, since it is known that not only fungal mycelium[3] but also soil colloids[4] will absorb considerable quantities of humic acid. The two extracts were combined and the humic acid precipitated and removed for final purification, drying and weighing.

The soil percolation columns contained sterile soil and were inoculated with either a spore suspension of *Spicaria* or a mycelial suspension of *Polystictus*. The results of the recovery of humic acid after a period of eight weeks are given in Table 1 and are compared with a similarly treated uninoculated control column. It can be seen that a considerable loss of the humic acid has occurred in comparison with the control.

The penicillin flasks contained 500 ml. of medium, but with the addition of 0·25 per cent agar and 0·039 per cent humic acid. They were inoculated and incubated at 25° C. for six weeks. The loss of humic acid is shown in Table 2.

Table 1. RECOVERY OF HUMIC ACID FROM SOIL PERCOLATION COLUMNS AFTER EIGHT WEEKS

	Humic acid (mgm.)		Loss (per cent)
	Added	Extracted	
Control	81	77	4·9
Spicaria	66	44	33·3
Polystictus	77	44	42·8

Table 2. RECOVERY OF HUMIC ACID FROM PENICILLIN FLASK CULTURES AFTER EIGHT WEEKS

	Humic acid (mgm.)	
	Added	Recovered
Control	195	210
Spicaria	195	162
Polystictus	195	70

The possibility was considered that the humic acid may have been reduced to a leuco form which was not precipitated by acids. Tests showed that this was not so and in any event the strong oxidase activity of *Polystictus*[5] makes this possibility very remote.

The ability of Basidiomycetes to decolorize humic acid suggests a similarity to the bleaching effect on malt agar reported by Nobles[6] and Cartwright and Findlay[7]. The colour of malt agar is due to the caramelized carbohydrates and is therefore akin to saccharo-humic acid. Tests with saccaro-humic acid prepared from sucrose with hydrochloric acid have shown that this is also decomposed by *Spicaria* and *Polystictus*. However, this does not necessarily mean similarity in structure between the two humic acids in view of the ability of *Polystictus versicolor*[8] to decolorize a wide range of organic materials including organic dyes.

The work described in this communication was carried out as part of a project for the chemical and microbiological investigation of humus in soil, made possible by a grant from the Nuffield Foundation. Our thanks are also due to Dr. F. M. Dean for his help and advice on the chemical aspects of the work and to Miss D. S. Griffiths for technical assistance.

ALAN BURGES
PAMELA LATTER

Hartley Botanical Laboratories,
University of Liverpool.

[1] Flaig, W., and Schmidt, H. L., *Archiv Mikrobiol.*, 27, 1 (1957).
[2] Schönwälder, H., *Archiv Mikrobiol.*, 30, 162 (1958).
[3] Burges, A., and Latter, P., in "Symposium on Ecology of Soil Fungi" (Liverpool Univ. Press) (in the press).
[4] Evans, L. T., and Russell, E. W., *J. Soil Sci.*, 10, 119 (1959).
[5] Boulter, D., and Burges, A., *Experientia*, 11, 188 (1955).
[6] Nobles, M. K., *Can. J. Res.*, C, 26, 281 (1948).
[7] Cartwright, K. St. G., and Findlay, W. P. K., "Decay of Timber and its Prevention", 179 (H.M. Stationery Office, 1946).
[8] Preston, A., and McLennan, E. I., *Ann. Bot.*, N.S., 12, 53 (1948).

A Method for Characterizing *Pseudomonas solanacearum*

Pseudomonas solanacearum (E. F. Smith) is an important and widespread bacterial pathogen of economic plants in tropical and warm temperate zones[1]. It has been shown recently that the cells of *P. solanacearum* grown on an appropriate medium are intensively sudanophilic, due to the presence of massive inclusions of poly-β-hydroxybutyric acid[2,3]. Formation of the polymer is known to be a characteristic of certain saprophytic pseudomonads[2,4,5]. A further study was made to ascertain whether such a distinctive character could be diagnostic.

Plant pathogens from the genera *Xanthomonas*, *Pseudomonas*, *Agrobacterium*, *Erwinia*, and *Corynebacterium* were tested for production of a sudanophilic cell component by growing them on a peptone medium containing glucose, sucrose, or glycerol, then staining with sudan black *B*[6], followed by extraction of the dried cells in chloroform to confirm the presence of poly-β-hydroxybutyric acid[2]. The results are summarized in Table 1.

Table 1. DIFFERENTIATION OF SOME PLANT PATHOGENIC BACTERIA ON THE BASIS OF FORMATION OF POLY-β-HYDROXYBUTYRATE INCLUSIONS

Bacteria	Host plants	No. of cultures examined	Cells containing prominent sudanophilic inclusions (poly-β-hydroxy-butyric acid)
Pseudomonas	Numerous	63 strains (33 spp.)	−
*P. solanacearum**	Solanaceae Musaceae, etc.	43	+
P. caryophylli	Carnation (*Dianthus caryophylli*)	3	+
P. stizolobii	Clover (*Trifolium* spp.) and velvet bean (*Stizolobium deeringianum*)	2	+
P. marginata	*Gladiolus* spp.	4	+ (2/4)
P. viburni	*Viburnum* spp.	1	+
Erwinia†	Numerous	13 strains (4 spp.)	−
Corynebacterium‡	Numerous	13 strains (9 spp.)	−

* The collection of *P. solanacearum* included 22 strains from solanaceous hosts (9 from potato) and 9 strains from musaceous hosts.
† Including *E. carotovora* var. *atroseptica* (blackleg of potato).
‡ Including three strains of *C. sepedonicum* (ring rot in potato).
In addition, 44 strains from 18 species of *Xanthomonas* and 10 strains from 6 species of *Agrobacterium* were examined. Relatively small sudanophilic inclusions were found in five strains of *X. albilineans* and in one strain of *A. tumefaciens*. The concentration of poly-β-hydroxybutyric acid was about 1 per cent of the cell dry weight formed on 2 per cent sucrose/peptone medium. Sudanophilic inclusions were not observed in the other cultures of *Agrobacterium* or *Xanthomonas*.

The 43 cultures of *P. solanacearum* were of wide geographical distribution and included strains from Brazil, Central America, southern United States, Israel, Cyprus, Southern Rhodesia, Uganda, Kenya, and Mauritius, as well as isolates from seed potatoes imported in 1959 from Egypt into Scotland and Sweden. The morphology and consistency of colonies of *P. solanacearum* on solid medium are known to be correlated with virulence in solanaceous hosts[7]; this collection included those which were predominantly opaque and fluidal (virulent), and also those which were exclusively translucent and non-fluidal (avirulent or reduced virulence), but production of the polymer was characteristic of all strains of the pathogen. In stained preparations of fluidal and non-fluidal colonies grown on the sucrose/peptone medium defined below, it was observed that cells from the former colony type stained more uniformly with sudan black *B* than non-fluidal cells. Two strains of *P. solanacearum*, *F*2 from tomato and *RE* from banana, showing in culture a clearly defined, apparently irreversible, change in colony morphology from fluidal (smooth) to non-fluidal (rough), were examined in order to correlate colony morphology and virulence with amount of poly-β-hydroxybutyric acid. The difference in intensity of staining with sudan black *B* was reflected in the quantity of polymer extracted from the cells (Table 2). Strain *RE* had previously been shown to be virulent in the fluidal form for banana and avirulent in the non-fluidal form. The same result was obtained for strain *F*2 in tomato[8,9].

Table 2. Correlation between Colonial Morphology and Poly-β-hydroxybutyric Acid Content in *Pseudomonas solanacearum*

Strain	Colony type	Fluidal (smooth)			Non-fluidal (rough)		
	Age of cultures (hr.)	Cell dry weight (mgm./plate)	Polymer (mgm./plate)	Percentage polymer in cell (dry weight)	Cell dry weight (mgm./plate)	Polymer (mgm./plate)	Percentage polymer in cell (dry weight)
F2 (from tomato)	24	16·3	3·3	20·2	23·0	3·0	13·0
	48	40·0	14·3	35·7	29·5	8·5	28·8
	72	40·7	19·3	47·4	30·5	8·8	28·9
RE (from banana)	36	17·3	4·0	23·1	21·0	3·3	15·7
	60	32·8	13 0	39·6	28·3	7·5	26·5
	84	37·1	18 0	48·5	28 8	7·0	24·3

Poly-β-hydroxybutyric acid was extracted with chloroform from the acetone-dried cells obtained from the surface of three or four 20-ml. quantities of solid medium in 9 cm. diameter Petri dishes inoculated over the whole surface. Incubation temperature, 30° C. Concentration of sucrose in medium, about 20 mgm./ml. (see text for complete composition).

The following medium was found to be satisfactory for detection of poly-β-hydroxybutyric acid and observation of colony variants in *P. solanacearum* (amounts in gm./litre of distilled water): sucrose (B.D.H., Ltd., laboratory reagent), 20·0; peptone (Oxo, Ltd., London), 5·0; dipotassium hydrogen phosphate, 0·5; crystalline magnesium sulphate, 0·25; agar powder (Davis), 20·0, *p*H adjusted to 7·2–7·4 with 40 per cent sodium hydroxide, autoclaved at 15 lb. pressure for 20 min.

In systematic bacteriology detection of poly-β-hydroxybutyric acid has proved to be a valuable ancillary test; in plant pathology there may also be applications. The milky exudate from the infected vascular bundles of potato, tomato, and banana, from which almost pure cultures of *P. solanacearum* have since been obtained, has been shown to be intensely sudanophilic. The technique may prove useful, for example, in differentiating in plant tissue the three bacterial pathogens of potato: *P. solanacearum* causing brown rot, *Erwinia carotovora* var. *atroseptica* causing blackleg, and *Corynebacterium sepedonicum* causing ring rot, and possibly in the field diagnosis of other diseases.

Previous work has shown that poly-β-hydroxybutyrate inclusions are not formed in representative species of several genera of the Enterobacteriaceae, to which in the present work the genus *Erwinia* is added[3,10]. The absence of the polymer from all but one strain of one species of *Agrobacterium* contrasts with *Rhizobium*, in which massive inclusions are formed both in culture and in the bacteroids of root nodules[4,5].

I am grateful to Dr. W. J. Dowson, Botany School, Cambridge, for the opportunity to examine the bacteria maintained in his laboratory, and for his advice and encouragement. Many of the bacteria examined were obtained through the courtesy of Mr. R. A. Lelliott, curator of the National Collection of Plant Pathogenic Bacteria, Plant Pathology Laboratory, Harpenden.

A. C. Hayward

Commonwealth Mycological Institute,
Kew, Surrey.

---

[1] Kelman, A., Tech. Bull. N.C. Agric. Exp. Sta., No. 99 (1953).

[2] Forsyth, W. G. C., Hayward, A. C., and Roberts, J. B., *Nature*, 182, 800 (1958).

[3] Hayward, A. C., Forsyth, W. G. C., and Roberts, J. B., *J. Gen. Microbiol.*, 20, 510 (1959).

[4] Morris, M. B., and Roberts, J. B., *Nature*, 183, 1538 (1959).

[5] Doudoroff, M., and Stanier, R. Y., *Nature*, 183, 1440 (1959).

[6] Burdon, K. L., *J. Bact.*, 52, 665 (1946).

[7] Kelman, A., *Phytopath.*, 44, 693 (1954).

[8] Spence, J. A., and Hayward, A. C. (unpublished work).

[9] Anon., *Rev. App. Mycol.*, 38, 294 (1959).

[10] Hayward, A. C., *J. Gen. Microbiol.*, 21, ii (1959).

True's Beaked Whale from the South-East Coast of South Africa

Mesoplodon mirus True, True's beaked whale, is known from fourteen stranded specimens from the shores of the North Atlantic, the most northerly specimen being from the Outer Hebrides and the most southerly from Florida[1]. On May 21, 1959, a 17 ft. 6 in. beaked whale was washed up at Wilderness, 170 miles eastwards along the coast from Cape Agulhas, the southernmost tip of Africa. The skeleton of this whale was saved from the axes of the health authority's disposal squad by Mr. B. L. Cairncross, a local naturalist, and presented to the South African Museum. This whale proves to be an adult male True's whale. Dr. F. C. Fraser has kindly compared photographs of this specimen with the example of True's whale in the British Museum (Natural History), and confirms this identification, stating, however, that the lower jaw of the South African specimen appears deeper and more massive than the British Museum example.

Moore and Wood[1] have regarded this species as primarily a western Atlantic species, occurring north of latitude 35° N., and consider the single Florida specimen (latitude 29° 28′ N.) reported by them as probably a stray carried southward of its normal range by the south-flowing current inshore of the Gulf Stream. The finding of the present specimen in the Indian Ocean greatly extends the range of the species, possibly indicating a southern variety. It also shows, however, that the beaked whales are so little known, particularly in areas where coast lines are very poorly covered for strandings as is the case over most of the Indian Ocean, that any generalizing as to distribution is really guesswork at present.

This specimen will be fully described and figured elsewhere.

F. H. Talbot

South African Museum,
Cape Town.

---

[1] Moore, J. C., and Wood, F. G., *American Mus. Novitates*, No. 1831, 1 (June 21, 1957).

A Bivalve Gastropod

In *Nature* of March 12, p. 749, Drs. L. R. Cox and W. J. Rees reviewed a paper by the Japanese authors Kawaguti and Baba on a bivalved gastropod they had described under the generic name *Tamanovalva*. I should like to put on record a further occurrence of this remarkable group of molluscs. A single left valve (now in the Stanford University Collection, California) of what is probably a new species, with the characteristic spiral nucleus and central adductor muscle scar, was collected on Espiritu Santo Island, near La Paz, Gulf of California, in beach drift, on November 1, 1959.

The earliest generic name for this group of bivalved gastropods may prove to be *Berthelinia* Crosse, 1875 (*Journal de Conchyliologie*, vol. 23, p. 79), the type species of which, *B. elegans*, is from the Eocene of France. Specimens in the Paleontology Museum, University of California, have been available to me for study. I can see no significant differences in the shells between *Berthelinia* and the Recent forms, *Tamanovalva* from Japan and *Edenttellina* from Australia (until recently the latter had been assumed to belong to the Pelecypoda). That this opisthobranch gastropod group should have originated in the Paris Basin during Eocene time is not implausible, for many other molluscan groups now having a limited distribution in the Pacific Ocean flourished there during the early Tertiary. Whatever generic name is eventually accepted for these bivalved gastropods, the range of the group seems to extend back in time at least to mid-Eocene and in the modern seas from Japan to south-eastern Australia and to tropical West America.

A. Myra Keen

Department of Geology,
Stanford University,
Stanford,
California.

Developments in the Propagation of Clones of *Hevea brasiliensis* by Cuttings

Clones of *Hevea brasiliensis* are normally bud-grafted on seedling rootstocks. In an attempt to overcome the disadvantages inherent in this practice, the Rubber Research Institute of Malaya is conducting an investigation of methods of establishing clones as trees growing on their own roots. Encouraging results are being obtained by rooting leafy clonal cuttings under special conditions which include the application of water as a mist spray.

Two clones recommended for large-scale planting in Malaya, *PB* 86 and *GT* 1, are being rooted with up to 90 per cent success. Other less-widely distributed clones have rooted similarly, including some of the hybrids of *Hevea brasiliensis* and *H. benthamiana*. It is now possible to obtain sufficient clonal material to investigate the stock–scion relationships in *Hevea*, and to improve the accuracy of other botanical and nutritional experiments. Furthermore, should these self-rooted trees prove satisfactory in the plantation itself, the mist-spray propagation techniques will find large-scale commercial application—either in propagating high-yielding clones on their own roots, or in raising selected clonal rootstocks for panel- or crown-grafted clonal scions.

In common with many forest trees, cuttings from young seedlings of *Hevea brasiliensis* root readily, while those from buddings do not[1]. As the seedling ages so rooting ability declines, in rubber quite sharply[2]. Some progress in the production of uniform material was made by Wiersum[3], who by 'stumping' a young seedling (that is, by cutting it back very severely) and taking cuttings from the resulting sprouts obtained 40 rooted plants from one individual. McIndoe[4] also found that cuttings from the lower 3 ft. of seedling trees root readily and that this process can be repeated with the vegetative progeny. He hopes that this high-rooting capacity may persist, but the performance and secondary characteristics of such untested material are unknown and the method is limited to experimental use.

Levandowsky[5] first reported the rooting of commercial budded clones in some quantity by leafy cuttings. While still attached to the parent 'stump', each shoot was wounded by ringing the bark. Some days later these shoots were removed, together with the portion of callused tissue at their base, and inserted in the rooting medium under a continuous mist spray.

Experiments at this Institute designed to study the effect and interplay of the various factors have now shown that the ringing operation is unnecessary. A more important factor is the efficiency of atomization of the spray, accomplished by raising the pressure to 50 lb. per sq. in. and the use of special nozzles. The present procedure in propagating *Hevea* by leafy cuttings is as follows. Bud-wood stems are cut back to 30 in. above the graft union, and the shoots arising from the latent buds are used as cuttings. Shoots from the top of bud-wood stems have also rooted well, and with certain clones even leafy shoots from trees in tapping have been used with success. Cuttings are selected which have healthy, fully expanded and mature but not senescent leaves; the terminal bud must not be breaking into fresh growth. The source shoots are cut when about 15 in. long, the lower leaves removed and the shoots transported in polythene bags. In the propagation nursery their bases are trimmed to provide cuttings about 10 in. long. After immersion in water the coagulated latex at the cut end is peeled off and the basal inch dipped into 'Fermate' dust (kindly supplied by Messrs. E. I. Dupont de Nemours and Co., Inc.). The prepared cuttings are planted into beds 5 ft. wide containing a rooting medium, a 1 : 1 mixture by volume of sawdust and sand being suitable. Finely atomized water is applied through nozzles and switched off only at night or during rain. The beds are shaded to reduce the light intensity to about 50 per cent and are surrounded by a screen to prevent excessive drifting of the mist.

With some clones rooting begins after about 40 days, a number are less rapid in their rooting while in others there is a rapid deterioration of leaf condition accompanied by complete failure to root. When the roots are approximately 1 in. long the cuttings are planted into baskets containing John Innes Potting Compost No. 2 and placed at the sides of the rooting beds in the drift of the mist. After a further week the rooted plants are moved, and when sufficiently hardened and the roots well established, they are planted out.

Rooted cuttings of more than fifty clones have been produced and successfully planted, and their subsequent growth and rooting habit are being observed. An experiment to compare the growth of self-rooted clones with conventional bud-grafts on unselected seedlings stocks has been planted. Other related experiments are being planned.

Meanwhile attempts are being made to improve the rooting of other recommended clones. These include the production of source shoots in suitable condition for regenerative response, the use of growth regulating substances and other chemicals, and the determination of the optimal rooting environment.

Results of these studies will be published in due course.

We are obliged to Mr. C. E. T. Mann, director of the Rubber Research Institute of Malaya, for permission to publish this information and to Dr. F. R. Tubbs, director of the East Malling Research Station, for seconding one of us (R. J. G.) to the Rubber Research Institute of Malaya.

G. H. TINLEY

The Rubber Research Institute of Malaya,
Kuala Lumpur,
Federation of Malaya.

R. J. GARNER

East Malling Research Station,
Kent.

[1] Baptiste, E. D. C., *J. Rubb. Res. Inst. Malaya*, 9, 17 (1939).
[2] Gregory, L. E., *Turrialba*, 1, 201 (1951).
[3] Wiersum, L. K., Rep. Fourteenth Int. Hort. Congr. Scheveningen, 2, 1335 (1955).
[4] McIndoe, K. G., *Quart. Circ. Ceylon Rubb. Res. Sch.*, 34, 39 (1958).
[5] Levandowsky, D. W., "Propagation of Clonal *Hevea brasiliensis* by Cuttings" (Agriculture Division, United States Operations Mission to Viet-Nam, Saigon, Nov. 1958).

ENTOMOLOGY

Wetting Properties of Insect Cuticle

THE idea has long been current[1] that the tanning of insect cuticle by quinones makes it more 'hydrofuge'. It is certainly true that dry tanned gelatin is less easily wetted with water than the untanned protein. But it is doubtful if such a statement is meaningful, applied to a water-saturated protein, whether it be tanned or not. A more useful form of this original suggestion may be: the tanning of insect cuticle lowers its adhesion to water.

Recent experiments on the permeability of insect cuticle to water[2,3] suggest that the waterproofing is especially efficient when the waxes on the surface of the integument are packed in a solid monolayer, with the long aliphatic chains (*XY*, Fig. 1) pointing away from the cuticle surface, and with the polar endings (*YY*)—which are primarily hydroxyl groups—at the surface. The cuticle surface forming the substrate for such an orientated monolayer is not a simple protein, but a tanned lipoprotein[4]; it therefore now appears that the substrate has high adhesion to the hydrophilic, rather than to the aliphatic, ends of the polar molecules. Stated in this form, it would seem that tanned lipoprotein has marked hydrophilic affinities in circumstances where it might select either the hydrophilic or the lipophilic ends of polar molecules—the reverse of the thesis implied in the paragraph above.

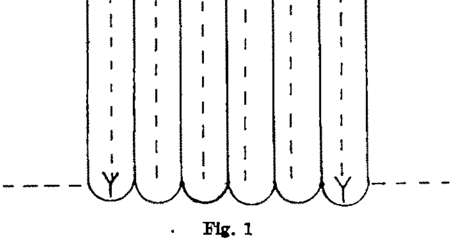


Fig. 1

Almost all substances, including solid paraffin wax, do become easier to wet after long exposure to water; but if the surface of a cockroach is washed in the surface of running water, whereby all its superficial unattached grease spreads away, the remaining surface is remarkably hydrofuge. From an assessment of the water-permeability, and of the permeability/temperature characteristics of such a washed animal, it would seem that only the orientated monolayer on its tanned cuticulin substrate remains behind[2], and that the extreme hydrofuge nature of this surface arises because such a monolayer will present an array of tightly packed —CH_3 groups (*XX*) to water placed on it—perhaps the surface with least adhesion for the water molecule. Recent experiments suggest that such a monolayer is likewise the structure over the surface of those hydrofuge areas of some aquatic insects, which can submerge for long periods, yet remain highly hydrofuge, as illustrated by their rapid shedding of water when they surface.

The evidence of recent studies on the permeability of these aquatic insects indicates, however, that they have an orientated monolayer of grease over their unwetted and over their readily wetted areas of surface as well. An examination of *Dytiscus* suggests that the cuticulin surface under the hydrofuge areas of grease is tanned, but that in the hydrophil areas of the natural cuticle, the underlying lipoprotein is not tanned. Now cuticulin and chorionin[5], which have large amounts of lipid condensed with protein, may well be expected to have a strong affinity for other lipoid materials, such as the aliphatic chains of polar greases—and much less affinity for hydroxyl groups. But the subsequent quinone tanning of a lipoprotein would appear to change this affinity, so that the surface then has high adhesion to the polar groups of the grease.

As a result of these observations and of physico-chemical experiments, the following thesis can now be advanced: a change in the affinity of cuticulin or of chorionin may be promoted by tanning it with quinones; as a result a polarized grease layer on such a surface will be reversed, and consequently the surface property of a greased lipoprotein will change from being exceptionally hydrophil to being extremely hydrofuge, through the tanning of the substrate.

Since residual grease films are difficult to eliminate, such a phenomenon may give rise to the suggestion contained in the first paragraph, and attributed to the property change of protein alone. However, the implications of such a mechanism are much more profound. It may not only explain the way in which the aquatic insect may differentiate its surface properties; but also it may, for example, provide a real explanation for unusual capillary activities which must take place in all insects. Thus, if a tube or sponge is composed of a lipoprotein with a reversed monolayer on its surface, capillary pressures in it will be very high, for the contact angle to water against the outwardly directed polar groups will be very small. On tanning, and change of the monolayer to normal orientation, the contact angle will become appreciably greater than 90°; little energy will therefore be required to empty such spaces. Such phenomena occur in the emptying of the tracheal system at eclosion[6] and at ecdysis[7], in the production of the air film of the plastron while submerged in water, and in the appearance of air in the aeroscopic sponges of egg-shell[8]; the authors quoted have repeatedly outlined the necessity for assuming that a mechanism is present which produces hydrofuge properties in a surface submerged in water, and have variously suggested that wax or its secretion, or the tanning of proteins, would prove essential to that unknown mechanism. The physico-chemical system now proposed would seem to satisfy these requirements and also to accommodate the associated evidence which has previously been described.

A full account of the experiments on which this suggestion is based, and of their probable implications for the physiological mechanisms of insects, will appear elsewhere.

J. W. L. Beament

Agricultural Research Council
Unit of Insect Physiology,
Department of Zoology,
Downing Street,
Cambridge. Dec. 2.

---

[1] Pryor, M. G. M., *Proc. Roy. Soc.*, B, **128**, 378 (1940).
[2] Beament, J. W. L., *J. Exp. Biol.*, **35**, 494 (1958).
[3] Beament, J. W. L., *J. Exp. Biol.*, **36**, 391 (1959).
[4] Wigglesworth, V. B., *Proc. Roy. Ent. Soc. Lond.*, B, **134**, 163 (1947).
[5] Beament, J. W. L., *Quart. J. Micro. Sci.*, **87**, 393 (1947).
[6] Sikes, E. K., and Wigglesworth, V. B., *Quart. J. Micro. Sci.*, **74**, 165 (1931).
[7] Wigglesworth, V. B., *J. Exp. Biol.*, **15**, 248 (1938).
[8] Wigglesworth, V. B., and Beament, J. W. L., *Quart. J. Micro. Sci.*, **91**, 429 (1950).

Effect of Relative Humidity on Hatching and on Toxicity of Ovicides to Eggs of the Red Spider Mite, *Tetranychus telarius* (L.) (Acarina : Tetranychidae)

Some information is already available on the relationship between relative humidity and hatching of eggs of *Tetranychus telarius* (L.)[1]. However, the information is based on data compiled from broad ranges of relative humidity and therefore does not enable an exact picture of the relationship to be seen.

In connexion with biological and toxicological studies in this laboratory on eggs of *T. telarius* it has been found convenient to induce mites to lay eggs on glass slides. This has made it possible to make an accurate study of the effects of relative humidity. By holding eggs in a particular relative humidity at 23° C. for the whole incubation period, the degree of resistance to desiccation or drowning over the whole range of relative humidities has been obtained. Results are given in Fig. 1.

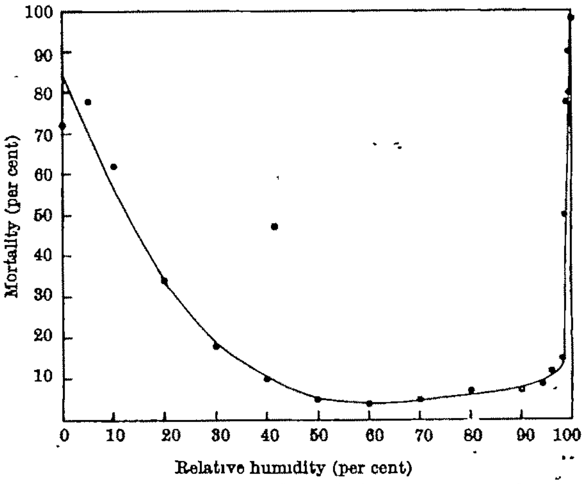


Fig. 1. Mortality of eggs of *T. telarius* in different relative humidities at 23° C.

With the red spider mite *Panonychus ulmi* (Koch), Beament[2] describes a change in the structure of the egg membrane which makes the egg 'waterproof' 6 hr. after it is laid. With *T. telarius* there appears to be no such complicating factor, the eggs having a certain resistance to desiccation and drowning from the moment of being laid.

Available information about the micro-climate on a leaf surface is unfortunately inconclusive. It can be assumed, however, that relative humidity can be high and in fact can reach saturation point. If such conditions of saturation or near saturation occurred for any prolonged period, it is clear that a high natural mortality of eggs could be expected.

Experiments with ovicides were carried out in relative humidities restricted to those which had little or no adverse effect on egg hatch. Freshly laid eggs of *T. telarius* were treated by dipping in ovicides (wettable powder formulations) and then incubated in different humidities at 23° C. The concentration of ovicide which produced 50 per cent mortality of eggs ($LC50$ = lethal concentration 50) was determined at each humidity. Regression lines of mortality against concentration, obtained at each humidity, were parallel. Several ovicides were tested and all showed a similar trend : a decrease in $LC50$ with an increase in relative humidity. Results obtained for one of them, 'Kelthane' (1,1-*bis*(*p*-chlorophenyl)-2,2,2-trichloroethanol), are given in Fig. 2.

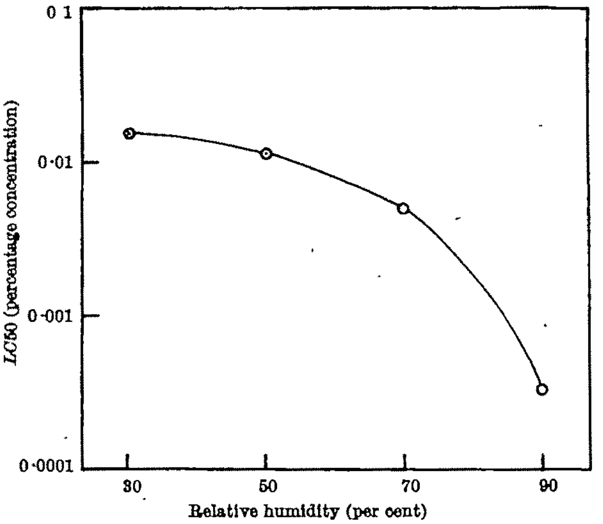


Fig. 2. Toxicity of 'Kelthane' to eggs of *T. telarius* incubated in different relative humidities. (An $LC50$ of 0·05 represents an application of ½ lb. active material per 100 gallons of water)

These results show that relative humidity must be considered as one of the significant factors affecting the performance of an ovicide.

A full report of this work is in preparation.

R. A. Harrison
A. G. Smith

Plant Diseases Division,
Department of Scientific
and Industrial Research,
Auckland,
New Zealand.

---

[1] Boudreaux, H. B., *J. Insect Physiol.*, **2**, 65 (1958).
[2] Beament, J. W. L., *Ann. App. Biol.*, **38**, 1 (1951).

Normal Susceptibility Levels of *Anopheles pharoensis* Theobald to DDT and Dieldrin

HOUSE spraying with residual insecticides, particularly with DDT and dieldrin, plays an important part in modern anti-malaria campaigns. The tolerance of malaria vectors to these toxicants is therefore of special interest. Assessments of the susceptibility of many different species of anopheline mosquitoes before and during spraying operations have been carried out in many parts of the world[1]. However, nothing seems to have been published on the normal resistance-level of *A. pharoensis*, a vector of malaria in several countries of Africa.

A number of tests have been carried out on this species in the village of Natsini, 10 km. outside the sprayed area of the Mass Malaria Control Campaign in Sokoto Province, Northern Nigeria. Wild females were obtained at night from a donkey-baited hut soon after they had engorged. In the following morning they were exposed for 1 hr. to filter papers impregnated with insecticide using the World Health Organization adult test method, a modification of the Busvine test[2,3]. The exposure-time was followed by a recovery-period of 24 hr., during which the mosquitoes were kept in unwaxed paper cups provided with cotton wool soaked in sugar solution. Then the results were read.

The temperature and humidity during the time of testing varied from 24° C. to 28·4° C., and 74 to 85 per cent respectively, and the range of temperature during the recovery-period was 20–30° C. The results obtained are shown in Table 1.

Table 1

Insecticide	Concentration (per cent)	No. of mosquitoes exposed	No. of mosquitoes dead	Mortality (per cent)
DDT	0·25	80	2	2
	0·5	240	30	12
	1·0	226	75	33
	2·0	307	218	71
	4·0	245	239	97
	4·0*	98	98	100
Control	—	163	0	0
Dieldrin	0·05	243	20	8
	0·1	288	100	35
	0·2	233	186	80
	0·4	227	223	98
Control	—	134	1	1

* Exposure time, 2 hr.

The median lethal concentrations (*LC*50) have been estimated graphically on the dosage-mortality lines drawn on logarithmic-probability paper. They were for DDT 1·5 and for dieldrin 0·14 per cent.

Susceptibility-levels, estimated for many different species of anopheline mosquitoes from untreated areas, have shown surprisingly little variation of the *LC*50[4]. It varies between 0·5 and 1·5 for DDT and between 0·05 and 0·15 per cent for dieldrin. The figures obtained in the present communication lie in the range of these variations and indicate a normal susceptibility of *A. pharoensis* to these insecticides.

F. KUHLOW

Mass Malaria Control Campaign,
Birnin Kebbi,
Sokoto Province,
Northern Nigeria.

[1] World Health Organization, *Bull. WHO*, 16, 874 (1957).

[2] Busvine, J. R., and Nash, R., *Bull. Entom. Res*, 44, 371 (1953)

[3] World Health Org., Tech. Report Series, 80, 30 (1954).

[4] World Health Organization, WHO/Mal/203 (1958).

Mortality and Viability of Insect Migrants High in the Air

ENTOMOLOGISTS have long been aware that vast numbers of insects are distributed up to thousands of feet in the air on any warm day[1]. The men who collected evidence of this assumed that the insects were alive[2–4]. However, the trapping methods they used killed most of the insects so that mortality and viability could not be assessed. Other entomologists have been less confident of the vitality of insects dispersing regularly by such flights, perhaps because of a belief that an ascent to, say, 5,000 ft. means a flight of many hours; this is not necessarily so[5]. Nevertheless, it is not generally accepted that this mode of transport is no more lethal than flight near the ground[6].

Insects have therefore been collected between 1,000 and 5,000 ft. at Cardington, Bedfordshire, England, with the kind co-operation of Mr. L. A. Speed and the staff of the Research and Development Establishment, to see what percentage of insects at these levels are alive and undamaged. The insects were caught in a vertical series of 6 nets, suspended from a balloon cable and opened for some hours between 09·00 and 16·00 hr. G.M.T. in June, July, August and September 1959. A mechanism opened the nets after ascent and closed them before descent[7].

Out of 1,610 insects caught, 1,571 (97 per cent) were alive and undamaged; 25 (2 per cent) were alive but damaged; 14 (1 per cent) were dead, when the nets were opened. Most of the damage to insects and some of the mortality were certainly caused by handling the nets. Mortality was probably also increased by the long time (up to 5 hr.) that some insects spent in the net after capture, exposed to the desiccating action of the wind. It may be assumed that the insects had, on average, completed half their aerial flight when they were caught, for the air almost clears of insects at night[1]. It can therefore be said with confidence that, of insects flying up to 1 mile high over southern England in mild summer weather, less than 2 per cent die in transit, except by predation or other means that leave no trace.

It is not possible to assess the viability of these insects quantitatively because it is often difficult or impossible to identify them at once and the pattern of reproductive behaviour is rarely known. However, some insects did reproduce, and living offspring were obtained from the following agricultural pests: cabbage aphid, *Brevicoryne brassicae* L.; peach-potato aphid, *Myzus persicae* Sulz.; bean aphid, *Aphis fabae* Scop.; frit fly, *Oscinella frit* L.; hessian fly group, *Mayetiola* sp., possibly *destructor* Say.

Many other insects, not yet identified, also reproduced successfully. Although not the smallest of insects, these include some of the most fragile. This seems to establish the viability of high-level migrants beyond reasonable doubt.

L. R. TAYLOR

Department of Entomology,
Rothamsted Experimental Station,
Harpenden.

[1] Johnson, C. G., *Sci. Prog. Twent. Cent.*, 39, 41 (1951).

[2] Glick, P. A., Tech. Bull. U.S. Dep. Agric. No. 673 (1939).

[3] Hardy, A. C., and Milne, P. S., *J. Anim. Ecol.*, 7, 199 (1938).

[4] Johnson, C. G., *J. Anim. Ecol.*, 26, 479 (1957).

[5] Taylor, L. R., *Proc. Linn. Soc.*, 169, 67 (1958).

[6] Andrewartha, H. G., and Birch, L. C., "The Distribution and Abundance of Animals", 109 (Chicago, 1954).

[7] Johnson, C. G., and Taylor, L. R., *Lab. Pract.*, 4, 235 (1955).

GENETICS

Homeostasis of the Sex Ratio in *Drosophila*

The ability of 150 larvæ to emerge as adults under 6 different temperature regimes for 3 inbred lines, their hybrids and the F_2 generation has been studied in *Drosophila melanogaster*[1]. This work revealed that interactions between genotype and environment were smallest in the F_1 generation and largest in the inbred lines. The F_1's therefore show a higher degree of stability or homeostasis than the inbred lines. The F_2 gave a genotype × environment interaction intermediate between the F_1 and the inbred lines, as might intuitively be expected because of segregation in the F_2.

The temperature regimes were 15° C., 24° C. for 8 hr. and 15° C. for 16 hr., 24° C., 24° C. for 8 hr. and 31° C. for 16 hr., 31° C., and 31° C. for 16 hr. and 15° C. for 8 hr. At 10 a.m. and 6 p.m., the replicates under the fluctuating temperatures were changed from one temperature to the other, so that the 16-hr. period represented the night and the 8-hr. period the day. The three inbred lines were Oregon (*OR*) and Sacramento (*SAC*), which were highly inbred by sib-mating, and Bikini (*BIK*), which has been mass-inbred since 1947. The *BIK* mass-inbred line was almost equivalent in homeostatic ability to the F_1 hybrids. This is perhaps because mass inbreeding permits the unconscious selection of heterozygotes more readily than under sib-mating.

While the data were being collected, sex ratios were noted throughout, and only recently have these been analysed. In Table 1, the percentage of females for each inbred line, F_1, and F_2, is given with a heterogeneity χ^2_5 testing the heterogeneity of the 2 × 6 contingency tables made up of the two sexes and the six temperature regimes.

Table 1. Percentage of Females and Heterogeneity χ^2 Tests

Inbreds	Females (per cent)	χ^2_5 for heterogeneity	Probability
OR	45·25	29·99	$P < 0·001$
SAC	48·97	9·42	$0·05 < P < 0·1$
BIK	50·41	2·15	$P > 0·9$
F_1's			
OR × *SAC*	51·88	9·00	$0·1 < P < 0·2$
SAC × *OR*	50·68	1·26	$P > 0·8$
BIK × *OR*	52·47	7·39	$0·1 < P < 0·2$
OR × *BIK*	51·80	3·50	$0·5 < P < 0·7$
BIK × *SAC*	51·91	5·62	$0·3 < P < 0·5$
SAC × *BIK*	52·38	1·18	$P > 0·9$
F_2's			
OR × *SAC*	52·51	12·55	$0·02 < P < 0·05$
SAC × *OR*	50·95	4·62	$0·3 < P < 0·5$
BIK × *OR*	51·37	11·29	$0·02 < P < 0·05$
OR × *BIK*	54·30	5·59	$0·3 < P < 0·5$
BIK × *SAC*	51·36	6·22	$0·2 < P < 0·3$
SAC × *BIK*	51·74	7·65	$0·1 < P < 0·2$

The *OR* and *SAC* inbred lines, which were inbred by sib-mating, were deficient in females and were relatively heterogeneous between temperatures, whereas the *BIK* mass inbred line gave 50·41 per cent females with no significant heterogeneity. Usually in *Drosophila* somewhat more females than males are expected[2], hence the *BIK* line is closer to the normal sex ratio than the *OR* and *SAC* lines. Furthermore, the *BIK* line showed no significant heterogeneity between temperatures, which again suggests its greater homeostatic ability compared with the *OR* and *SAC* lines.

All the F_1 crosses gave about 51 per cent females with no significant heterogeneity, thus demonstrating their superior homeostatic ability. The F_2's showed an excess of females, but with rather more heterogeneity than for the F_1 data, but less than the inbred lines. Similarly, as pointed out earlier, the smallest genotype × environmental interaction was obtained for the F_1, the largest for the inbred lines, and the F_2 interaction occupied a position intermediate between the F_1 and the inbred lines. Hence it may be said that the sex ratio data in this experiment agree with the magnitude of the genotype × environmental interactions observed. The behaviour of the sex ratio in the various inbred lines and crosses over the six temperature regimes therefore agrees with recent theories on the possible relationship of homeostasis and heterozygosity[3]. It must of course be emphasized that homeostasis and heterozygosity are not necessarily related in all situations[4].

In order to explain the deficiency of females in the *OR* and *SAC* inbred lines, it may be postulated that the homozygous genes of the *XX* females depress the viability of the lines somewhat more than the hemizygous genes of the *XY* males. The F_1's between these inbred lines gave considerably more flies than the inbred lines[1], and as about 51 per cent females were produced in the F_1 compared with 46 per cent in the inbred lines, the increase is made up of rather more females than males. Possibly this occurs because the F_1 females are heterozygous for the *X* chromosome, whereas the F_1 males are hemizygous.

If heterozygosity is related to homeostasis or stability, as occurs in many situations[3], then it is possible that the *XX* females would exhibit a greater degree of homeostasis than the *XY* males. To test this, the significance of genotype × environmental interactions was tested for each sex separately for the inbred lines, and the F_1 and F_2 generations. However, there was no suggestion of any difference between sexes. Hence it may be said that within the limits of accuracy of the data, there is no difference in homeostatic ability between the sexes. Consequently the *X* chromosome may not be of great importance in determining homeostatic ability, unless the *Y* chromosome in the males has an effect similar to an *X* chromosome.

P. A. Parsons

Department of Genetics,
University of Cambridge.

[1] Parsons, P. A., *Genetics* (in the press).

[2] Crew, F. A. E., *Amer. Nat.*, 71, 529 (1937).

[3] Lerner, I. M., "Genetic Homeostasis" (Oliver and Boyd, Edinburgh, 1954).

[4] Thoday, J. M., *Heredity*, 12, 401 (1958).

Genetic Basis of Two Melanin Inhibitors in *Drosophila melanogaster*

Mutants such as ebony (*e*) and black (*b*) in *Drosophila* increase the melanin content of the integument of the adult fly. The ability of inbred and mass-bred larvæ of the genotypes $e''e''$, $e''+$, and $++$ to survive under various concentrations of the two melanin inhibitors phenyl-thio-carbamide and silver nitrate mixed in the food will be discussed briefly here, but complete details with additional information will be presented elsewhere.

Phenyl-thio-carbamide is an organic sulphur compound which inhibits melanin formation by combining with copper ions, which are necessary for the action of the enzyme, tyrosinase[1]. The inhibitory action of silver nitrate, a heavy-metal compound, is presumably due to its interaction with the enzyme itself[1]. In the presence of sub-lethal doses of silver nitrate, flies are bleached to a yellow-white colour[2] and are often greatly reduced in size, but in the presence of sub-lethal doses of phenyl-thio-carbamide the flies are phenotypically unchanged except that some flies are slightly reduced in size.

Various concentrations of silver nitrate and phenyl-thio-carbamide were added to the medium on which larvæ not more than 12 hr. old were placed. The number of larvæ emerging as adults was recorded for mass bred $e''e''$, $e''+$ and $++$ genotypes (e'' = ebony″, $+$ = Oregon stock). Inbred lines of the same three genotypes were also tested. The inbred lines were produced by single pair mating individuals heterozygous for e'' for 17 consecutive generations. The ebony and wild-type homozygotes were then selected from the segregants of the seventeenth generation. Hence the three inbred lines should differ from each other genetically in the region of the ebony locus, but the remainder of the chromosomes ought to be almost identical genetically and nearly homozygous. In Table 1, some results are presented. Each entry in the table represents the number of adult flies emerging from 100 larvæ (4 replicates of 25 larvæ).

Table 1. NUMBER OF ADULT FLIES EMERGING FROM 100 LARVÆ

Treatment	Mass bred $++$	Mass bred $e''+$	Mass bred $e''e''$	Inbred $++$	Inbred $e''+$	Inbred $e''e''$
Control	89	95	91	87	91	86
0·25 per cent $AgNO_3$	16	22	42	77	88	89
0·30 per cent $AgNO_3$	—	—	2	—	—	2
0·02 per cent P.T.C.	81	87	84	77	86	81
0·03 per cent P.T.C.	40	36	30	5	7	7
0·04 per cent P.T.C.	32	19	—	—	—	—
0·08 per cent P.T.C.	9	19	—	—	—	—
0·25 per cent $AgNO_3$ + 0·02 per cent P.T.C.	35	37	22	48	6	35
0·30 per cent $AgNO_3$ + 0·03 per cent P.T.C.	100	68	94	100	87	96

$AgNO_3$, silver nitrate; P.T.C., phenyl-thio-carbamide.

Considering first the mass-bred genotypes we see that silver nitrate is most lethal to $++$ flies and phenyl-thio-carbamide to $e''e''$ flies. The two inhibitors are therefore opposite in their action. Mixtures of the two chemicals in the medium might therefore lead to $e''+$ flies emerging at higher concentrations than the two homozygotes. The table shows the results of two such tests. For 0·30 per cent silver nitrate + 0·03 per cent phenyl-thio-carbamide negative heterosis was observed. In fact, no mixture of silver nitrate and phenyl-thio-carbamide produced positive heterosis. Hence the two inhibitors appear to be complementary in their action on the heterozygote so that its viability is depressed most. Negative heterosis of this magnitude, where both the homozygotes survive, with very few or no heterozygotes, has evolutionary possibilities in the creation of isolating mechanisms. This situation suggests that by a suitable adjustment of the composition of the food medium, both $e''e''$ and $++$ could co-exist, but would be unable to exchange genes and hence they could diverge. Conditions are therefore created by which sympatric speciation can occur.

Another effect is noticeable at high concentrations of phenyl-thio-carbamide. At both 0·04 and 0·08 per cent phenyl-thio-carbamide, 19 $e''+$ flies emerge. However, at 0·04 per cent, 32 $e''e''$ flies emerge and at 0·08 per cent, 9 emerge. Results not recorded here show that this trend is valid for intermediate phenyl-thio-carbamide concentrations. Hence we have a change in dominance according to concentration of phenyl-thio-carbamide. At 0·04 per cent, emergence appears to be correlated with the degree of melanization of the flies, but at 0·08 per cent there is no such correlation, and another system appears to have arisen which permits the development of heterosis.

Considerably more of the inbred flies survived on 0·25 per cent silver nitrate than mass-bred flies and silver nitrate is again most lethal to $++$ flies. This general increase in survival compared with the mass-bred flies is probably due to the inbreeding system used. As $e''+$ is not much darker than $++$, it may be supposed that there would be a tendency for the darkest $e''+$ flies to be selected so as to be sure they were $e''+$. Such a selection did, in fact, appear to take place as the $++$ line extracted at the seventeenth generation of inbreeding was visibly darker than the $++$ mass-bred strain. Hence, as the flies were being inbred, selection was also being carried out simultaneously for increased melanin production. In subsequent generations, the melanin content of all genotypes would be increased, as a result of selecting dark $e''+$ flies. In the mass-bred stocks, there was a correlation between melanin content and ability to emerge, and this relation appears to occur in the inbred stocks if it is assumed that selection has favoured more extreme melanization. Perhaps the melanins protect the developing fly by interacting with silver ions by a detoxification process, so that selection for increased pigment synthesis increases the tolerance of flies to silver ions with a resultant increase in survival value for all the inbred genotypes. With phenyl-thio-carbamide, therefore, we would expect fewer inbred flies to survive as there has been selection for increased melanization, for phenyl-thio-carbamide was most toxic to the mass-bred $e''e''$ flies. Table 1 shows that at 0·04 per cent phenyl-thio-carbamide no inbred flies emerged and at 0·03 per cent very few emerged. Hence, it is evident that the ebony locus is not the only locus affecting emergence under the two melanin inhibitors, but there is a substantial background of modifiers on which selection has acted. Finally, when silver nitrate and phenyl-thio-carbamide were mixed in the medium, negative heterosis was often observed. Many combinations did not show negative heterosis, but in no case did positive heterosis occur. Since inbreeding has only increased the general melanin-level, the occurrence of negative heterosis is to be expected in some cases.

R. A. KROMAN*
P. A. PARSONS†

Department of Genetics,
University of California,
Davis. Jan. 5.

---

* Public Health Research Fellow of the National Cancer Institute, U.S.A.; present address—Long Beach State College, California.

† Present address: Department of Genetics, University of Cambridge.

[1] Lerner, A. B., and Fitzpatrick, T. B., *Physiol. Rev.*, 30, 91 (1950).

[2] Rapoport, J. A., *Amer. Nat.*, 81, 30 (1947).

Basic Chromosome Numbers in *Silene* and *Saponaria*

DURING the course of a chromosome survey of the north-west Indian angiosperms, I have found two new basic numbers in the Caryophyllaceae of the Panjab Plains.

Silene conoidea Linn. is a very common annual weed in this area. The species has been worked out from several selections and has revealed persistently

10 bivalents at metaphase 1 with perfectly normal meiosis. In view of the fact that more than 80 species of the genus *Silene*[1] possess the basic number 12, the present number ($n = 10$) is significant. There is, however, one species, *S. fortunei*[2], with $n = 15$. These facts suggest that, first, the presence of the haploid numbers like $n = 10$ and 15 in the genus indicates that the original basic number of this series is 5. *S. conoidea* is, therefore, tetraploid and *S. fortunei* is hexaploid. Hence, both these species are what may be called 'cryptic polyploids'. Here it may be of interest to mention that the present observations reveal that the grade of ploidy built on $x = 5$ is from $4x$ to $6x$, while on $x = 12$ it is from $2x$ to $16x$ [1].

Secondly, with the present observations the genus becomes dibasic ($x = 5$ and 12) and this at once raises the question about the probable constitution of $x = 12$, that is, whether it has been compounded from $x = 6$, or from $x = 5$ and 7. However, to date $x = 6$ and 7 have neither been discovered in any species of the genus, nor their presence surmised on even indirect grounds. In any event, the cytogenetical relationships between $n = 10$ in *S. conoidea* on one hand, and $n = 15$ in *S. fortunei* and species with $n = 12$ on the other, pose interesting problems. Furthermore, so far $x = 5$ has neither been found nor inferred on indirect grounds in any of the Silenoideae, but with the present observations one may be tempted to relegate $x = 15$, found in some genera of the subfamily, to only $x = 5$.

Lastly, in view of the overwhelming occurrence of $x = 12$ in the genus *Silene*, it is worthwhile to determine the biosystematical relationship of the species with $x = 5$, that is, whether the latter are genuine members of the genus.

Saponaria vaccaria Linn. is another very common annual weed. Several different samples of this species reveal the presence of $n = 15$ and $2n = 30$, which confirms the earlier findings of Mulligan[3]. Again this number is unique, since the prevailing situation in the genus is $n = 14$ [1]. Apparently, this genus also becomes dibasic with $n = 14$ and 15, and it is worthwhile to find out the cytogenetical relationship between the two numbers. Such a study would also reveal the true taxonomical relationship of the present taxon with the typical species of the genus *Saponaria*. Another important aspect is the biosystematic relationship of *S. vaccaria* with the genus *Vaccaria*. Such a study is needed, particularly because, first, the present results reveal that the genus *Vaccaria* exclusively possesses $n = 15$, and secondly, *S. vaccaria* has been in the past often treated taxonomically as a member of the genus *Vaccaria*.

The above aspects are being studied in detail and I shall be obliged for viable seeds of *Silene fortunei* and any species of *Saponaria*, *Vaccaria* and their allied genera.

I am grateful to Prof. P. N. Mehra for granting facilities and for his interest in the study and to Mr. Baldev Raj for technical help.

T. N. Khoshoo

Botany Department, Panjab University,
Amritsar (India). Jan. 8.

---

[1] Darlington, C. D., and Wylie, A. P., "Chromosome Atlas of Flowering Plants" (Allen and Unwin, Ltd., London, 1955). Cave, M. S., *et al.*, "Index to Plant Chromosome Numbers" (Calif. Bot. Soc., 1956, 1957 and Supplement); "Index to Plant Chromosome Numbers" (Univ. North Carolina Press, 1958).

[2] Heaslip, M. B., *Ohio J. Sci.*, **51**, 62 (1951).

[3] Mulligan, G. L., *Canad. J. Bot.*, **35**, 779 (1957).

PSYCHOLOGY

The Brain as Regulator

There has been some debate whether the brain is determinate or probabilistic in its behaviour. As a contribution to this question, the following argument shows that from one point of view the determinate system is demonstrably of greater efficiency than the probabilistic. The physiologist may therefore expect to find that natural selection has made the brain as determinate as possible.

If the brain is regarded as basically a means to survival, then a necessary condition for survival is that against the (moderately well-defined) set of disturbances that threaten the organism's existence the brain must so respond that the outcome of the combined action of disturbance and response keeps the organism's essential variables within normal limits[1-3]. The brain must, in other words, act as a regulator, homeostatic in the general sense. The sequence of disturbances that comes to the organism can then often be treated (algebraically at least) as an information source (in Shannon's sense[4]) having an entropy, $H(D)$ say. Similarly, the sequence of responses will have an entropy $H(R)$, and so will the sequence of values at the essential variables, $H(E)$. It is necessary for survival (though not sufficient) that $H(E)$ be kept small.

The most interesting case is that in which, if the organism does nothing, *all* the changes at D produce changes at E (that is, the organism is passively buffeted to full degree). In this case $H_R(E) = H_R(D)$, and it then follows[2] that $H(E)$'s minimum is given by $H(D) + H_D(R) - H(R)$. So far as $H_D(R)$ is concerned, the expression will be least if $H_D(R) = 0$. This relation gives a necessary condition that the brain must satisfy if it is to have maximal efficiency in generalized homeostasis.

The meaning of $H_D(R) = 0$ is readily specified. Of any source A, $H(A) = 0$ implies that the Markov chain must be such that when it reaches equilibrium the transitions that still occur are determinate (that is, have probabilities all 0 or 1). $H_D(R) = 0$ implies that this tendency to determinateness must hold for each value of D.

Thus, if the brain is survival-promoting by acts of regulation, it has maximal efficiency (other things being equal) if, under constant external conditions, it tends towards the deterministic way of behaving.

W. Ross Ashby

Burden Neurological Institute,
Bristol.

---

[1] Ashby, W. Ross, "Design for a Brain", 2nd ed., 64 (Chapman and Hall, London, 1960).

[2] Ashby, W. Ross, "Introduction to Cybernetics", 197, 208 (Chapman and Hall, London, 1956).

[3] Sommerhoff, G., "Analytical Biology" (Oxford University Press, London, 1950).

[4] Shannon, C. E., and Weaver, W., "The Mathematical Theory of Communication" (University of Illinois Press, Urbana, 1949).

A Differential Test of Arts/Science Aptitude

The increasing pressure of academic specialization raises the question of whether we can discover a test of differential aptitude for advanced work in arts and science subjects respectively. In a preliminary study, the performance of a large number of Cambridge undergraduates on a test of high-grade intelligence (*A.H.5*) has been analysed, with special reference to relative ability on the verbal, numerical and diagrammatic sections of the test[1,2]. Two differential scores were calculated as follows: 'Score *A*', diagrammatic minus numerical plus verbal; 'Score *B*', diagrammatic plus numerical minus verbal.

Two main results emerged. (*a*) If both differential scores were considered, a significant discrimination was found between arts and science students ($P =$ 0 001). (*b*) There were important differences in academic attainment between students with typical and atypical scores. The arts/science discrimination is shown in Table 1, where for reasons of convenience the distributions of scores have been divided into three groups: 'arts' scores, 'science' scores, and a 'neutral' group in which there was no pronounced discrimination. The group of arts students shown in Table 1 includes classicists, historians, linguists and students reading English. The group of science students includes mathematicians, physicists, engineers, botanists, zoologists and medical students. For reasons given below, it does not include students taking chemistry, biochemistry or metallurgy in Part 2 of the Tripos. With this one exception, students were classified in terms of the subject of the last Tripos taken, whether Part 1 or Part 2.

Table 1. DISCRIMINATION EFFECTED BY *A.H.*5 BETWEEN ARTS AND SCIENCE UNDERGRADUATES AT CAMBRIDGE

	'Arts' scores (per cent)	'Neutral' scores (per cent)	'Science' scores (per cent)
Arts students (n = 164)	66	28	6
Science students (n = 411)	7	45	48

From Table 1 it will be seen that the discrimination between arts and science students is very striking. The chances, for example, of a physicist having an 'arts' score, or a classicist having a 'science' score are as low as 1 in 20. The gist of the discrimination is as follows: arts students tend to score well on the verbal questions, and relatively poorly on the numerical and diagrammatic ones. The physical scientists (physicists, engineers, mathematicians) score well on the diagrammatic and numerical questions, and are relatively weak on the verbal ones. The biological scientists (botanists, zoologists and medical students) are relatively strong only on the diagrammatic questions. The only important exceptions are the students taking chemistry, biochemistry and metallurgy in Part 2 of the Tripos, who tend to be equally strong or weak on all three types of questions. Why this should be so is not at all clear.

Moreover, it was found that students with atypical scores (for example, a physicist with an 'arts' score) were significantly more likely than other students (*a*) to change subject in the middle of their undergraduate work, and (*b*) to gain a poor degree at the end of it. Further, those students with atypical scores who did change subject were four times as likely to choose a subject which was more rather than less concordant with their test results. (For all three differences, $P = 0{\cdot}001$.) On the strength of this evidence, we conclude that *A.H.*5 can validly be used as a test of arts/science aptitude, if given to undergraduates. The question then arises: Can *A.H.*5 validly be used at the age of sixteen, when the arts/science choice is crucial? Preliminary results suggest that such a use is feasible.

Samples of top-stream schoolboys have been tested at four schools, two public and two grammar. Each group tested was at a different stage of specialization, ranging from the highly specialized (some had never had a science lesson) to boys who had not specialized at all. It might be argued that the arts/science discrimination found among undergraduates was an effect of specialization rather than its underlying cause. If this were true, we should expect to find marked differences in the scatter of test scores both between schoolboys and undergraduates, and between specialized schoolboys and schoolboys who are unspecialized. Table 2 shows the standard deviations of both differential scores for five school samples, and for a representative sample of Cambridge undergraduates. It will be seen that the scatter of scores for all groups, unspecialized schoolboys and undergraduates alike, is remarkably similar. Further, Table 3 shows that the arts/science discrimination among partially specialized schoolboys is nearly as strong as that among a representative sample of undergraduates (including chemists, biochemists and metallurgists, and also the students reading geography, economics and law). Although promising, these results are no proper substitute for a follow-up study and should be viewed with caution.

Table 2. EFFECTS OF ACADEMIC SPECIALIZATION ON THE STANDARD DEVIATION OF DIFFERENTIAL SCORES IN SIX DIFFERENT SAMPLES

	Average age	N	'Score *A*'	'Score *B*'
School *A*	14·3	59	4 30	5·69
School *A*	17·1	58	3·83	5·77
School *B*	15 9	42	3·61	5 68
School *C*	16·0	50	4·29	5 18
School *D*	16·2	65	4·08	5·77
Cambridge	21·0	100	4·19	5·72

Table 3. ARTS/SCIENCE DISCRIMINATION AMONG SCHOOLBOYS COMPARED WITH THAT AMONG CAMBRIDGE UNDERGRADUATES

	'Arts' scores (per cent)	'Neutral' scores (per cent)	'Science' scores (per cent)
Schoolboys (n = 212)			
Arts	40	39	21
Science	10	38	52
Undergraduates (n = 603)			
Arts	55	33	12
Science	9	46	45

The help and encouragement of Dr. A. W. Heim and Prof. O. L. Zangwill are gratefully acknowledged.

L. HUDSON

Psychology Laboratory,
Cambridge.

---

[1] Heim, A. W., *Brit. J. Psychol*, **37**, 70 (1947).

[2] Heim, A. W., "Manual for the Group Test of High-Grade Intelligence *A.H.*5" (National Foundation for Educational Research, 1956).

Letter Structure of the English Language

INFORMATION regarding the sequential dependencies among letters in the English language is of interest not only in connexion with linguistics and cryptography, but also because of its value for communication theory and for the psychology of language[1,2].

Only two sets of such data have hitherto been published. One[3] is based on the King James version of the Bible, and the other[4] on an unspecified source. As the source may be an important variable, we have analysed two samples of modern English. The first represents written language and comprises all the words in the editorial columns of *The Times* newspaper

Table 1. DIGRAM FREQUENCY FOR WRITTEN ENGLISH

Second Letter

First Letter	Space	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	Total
Space	0	1,544	739	563	839	815	520	288	514	1,089	36	33	310	407	325	987	571	43	348	816	2,663	150	74	322	0	55	0	13,592
A	319	0	181	192	170	0	31	92	0	109	10	61	491	110	843	2	89	0	609	449	735	28	163	32	5	151	2	4,884
B	6	58	7	0	0	415	0	0	0	45	9	0	134	0	0	104	0	0	69	17	15	118	5	0	0	77	0	1,079
C	46	196	0	35	0	297	0	0	254	128	0	48	51	0	0	354	0	3	58	5	189	55	0	0	0	19	0	1,738
D	1,102	69	1	0	24	857	0	14	1	159	2	0	24	19	2	95	1	1	26	52	0	62	6	0	0	35	0	2,052
E	3,030	368	4	202	444	222	76	52	10	113	1	6	283	199	769	17	92	23	1,001	613	196	9	129	84	98	140	0	8,181
F	604	99	0	2	0	88	71	0	0	128	0	0	23	0	0	247	0	0	76	0	32	56	0	0	0	4	0	1,430
G	351	65	0	0	1	182	0	24	111	61	0	0	18	1	23	109	0	0	85	23	9	28	0	0	0	10	0	1,101
H	321	637	2	0	0	1,751	1	0	1	382	0	0	8	1	7	271	0	0	21	9	61	21	0	0	0	13	0	3,502
I	5	116	41	303	156	151	99	101	1	2	0	31	284	138	1,125	338	36	0	160	654	614	3	144	0	17	0	18	4,537
J	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	19	0	0	0	0	0	67
K	91	4	0	0	1	131	0	0	0	28	0	0	6	0	22	0	0	0	0	11	0	0	0	2	0	0	0	296
L	583	226	0	8	166	408	34	4	0	268	0	11	369	10	2	180	12	0	14	36	63	32	21	6	0	268	0	2,666
M	201	289	35	2	1	440	3	0	0	162	0	0	5	65	3	201	119	0	1	59	1	67	0	0	0	11	0	1,615
N	1,216	144	0	215	558	843	31	483	8	147	4	24	35	30	40	281	2	3	0	268	495	24	16	10	0	58	0	4,380
O	650	39	52	57	74	20	544	38	2	52	5	33	148	320	825	106	74	1	599	142	202	446	128	191	2	21	1	4,772
P	56	191	2	0	0	209	0	0	14	52	0	0	127	11	0	205	70	0	231	27	31	52	0	0	0	5	0	1,283
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	0	0	0	0	0	75
R	706	284	12	26	96	1,011	4	43	9	306	0	39	59	88	105	312	28	0	38	211	189	49	39	6	0	116	0	3,771
S	1,741	90	0	30	2	440	9	0	140	259	0	8	34	29	2	172	92	1	3	171	571	154	0	9	0	19	0	3,976
T	1,525	240	0	9	0	504	3	1	2,171	562	0	0	70	24	6	583	0	0	208	177	95	110	0	44	0	86	0	6,418
U	6	52	50	83	20	74	4	65	0	49	0	0	181	58	222	5	53	0	218	187	229	0	2	0	1	3	0	1,562
V	0	44	0	0	0	584	0	0	0	122	0	0	0	0	0	22	0	0	1	0	0	2	0	0	0	2	0	727
W	156	168	1	0	0	190	0	0	269	220	0	2	3	0	52	135	0	0	4	18	1	0	0	0	0	0	0	1,209
X	9	7	0	8	0	12	0	0	0	18	0	0	0	0	0	1	44	0	0	0	23	1	0	0	0	0	0	128
Y	918	4	2	3	0	58	0	1	2	15	0	0	2	15	7	17	5	0	1	36	4	0	0	3	0	0	0	1,098
Z	0	5	0	0	0	14	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	21
Total																												76,150

(1) The number of words in the sample is given by the space row total. (2) The number of letters in the sample is given by the grand total less the space total.

Table 2. DIGRAM FREQUENCY FOR CONVERSATIONAL ENGLISH

Second Letter

First Letter	Space	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	Total
Space	0	1,809	807	617	684	195	410	431	1,085	1,875	87	218	387	732	437	835	296	49	260	1,301	2,253	135	112	1,218	0	333	0	17,116
A	366	0	153	88	166	0	66	70	10	121	0	101	451	87	1,055	1	79	0	394	367	650	64	221	54	2	292	1	4,859
B	12	57	2	0	0	372	0	0	0	46	1	0	66	0	0	194	0	0	51	7	7	221	1	0	0	29	0	1,066
C	5	255	0	6	0	140	0	0	168	36	0	87	29	0	0	325	0	0	25	1	100	35	0	0	0	6	1	1,189
D	1,463	111	8	1	20	202	8	6	0	169	0	2	21	8	125	389	0	0	34	30	0	11	13	1	0	30	0	2,652
E	2,975	391	5	103	338	337	46	20	5	45	1	10	406	104	449	38	73	0	1,060	506	271	0	130	41	50	95	0	7,479
F	406	74	0	0	0	86	46	0	0	86	0	0	12	0	0	183	0	0	72	1	60	45	0	0	0	0	0	1,071
G	609	86	0	0	0	187	0	10	237	68	0	0	20	1	4	253	0	0	30	26	1	12	0	0	0	0	0	1,494
H	444	866	2	0	11	1,616	1	0	1	484	0	0	3	3	0	323	0	0	22	0	201	19	0	0	0	44	0	4,040
I	664	29	20	109	237	112	134	130	0	1	0	93	254	266	1,102	51	16	0	92	402	723	0	105	0	3	0	0	4,543
J	0	1	0	0	0	3	0	0	0	1	0	0	0	0	0	13	0	0	0	0	0	77	0	0	0	0	0	95
K	290	0	0	0	0	288	6	0	0	78	0	0	3	1	162	0	0	0	0	49	2	0	0	7	0	2	0	888
L	723	126	2	2	282	290	33	0	0	220	0	37	721	12	0	166	20	0	3	37	28	28	4	44	0	285	0	3,013
M	330	167	22	0	1	520	2	0	0	112	0	0	0	42	1	176	28	0	5	26	0	101	0	0	0	82	0	1,615
N	861	36	1	79	691	380	15	655	5	139	4	145	39	0	23	476	3	0	0	77	668	14	5	1	1	119	1	4,388
O	1,049	10	13	65	101	40	273	13	143	71	0	82	120	276	687	290	83	0	486	76	293	1,443	54	350	1	21	0	6,042
P	128	63	0	0	0	178	0	0	15	37	0	0	80	0	0	113	81	0	85	47	12	32	0	0	0	15	0	886
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	50
R	944	132	4	9	96	678	13	36	24	245	0	46	33	18	71	162	9	1	87	186	64	41	5	2	0	205	0	3,111
S	1,501	180	2	20	8	510	1	0	405	118	1	16	12	8	71	257	67	0	0	82	400	126	0	12	0	10	0	3,802
T	2,470	192	0	10	0	448	8	0	1,612	232	0	0	65	8	14	775	3	0	78	225	132	34	0	17	0	21	0	6,344
U	604	11	16	65	24	18	4	123	0	55	0	0	286	46	139	0	105	0	294	247	437	0	10	0	0	4	0	2,488
V	0	5	0	0	0	592	0	0	0	62	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	663
W	331	327	0	0	1	258	5	0	326	204	0	1	0	0	48	223	0	0	21	16	0	0	0	0	0	3	0	1,764
X	3	4	0	12	0	3	0	0	4	2	0	0	0	0	0	0	22	0	0	0	7	0	0	0	0	0	0	57
Y	938	7	9	3	2	125	0	0	0	36	1	0	5	3	0	800	1	0	12	98	43	0	3	17	0	0	0	2,098
Z	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3
Total																												82,766

for five successive days. The second sample, representing conversational language, is the text of the British Broadcasting Corporation's radio serial "Mrs. Dale's Diary", also for five successive days. In both cases names of persons and foreign place names were excluded.

The analysis was made by a National–Elliott 405 electronic computer at the G.P.O.'s London Electronic Agency for Pay and Statistics (*Leaps*). Two programmes have been written. One gives digram frequencies, counts being printed for all possible digrams; letter frequencies and a word count are obtained as by-products. The second programme gives trigram frequencies; the printed results give counts only for those trigrams occurring in the sample analysed.

Tables 1 and 2 show respectively the digram frequencies of the two samples. Copies of the trigram results are available from us. With the material now at hand, words can be generated which are either zero-, first-, second- or third-order approximations to either written or spoken English.

A. D. BADDELEY
R. CONRAD

Medical Research Council
Applied Psychology Research Unit,
Cambridge.

W. E. THOMSON

Post Office Research Station,
Dollis Hill.

[1] Shannon, C. E., and Weaver, W., "The Mathematical Theory of Communication" (Univ. of Illinois Press, Urbana, 1949).

[2] Miller, G. A., "Language and Communication" (McGraw-Hill, New York, 1951).

[3] Newman, E. B., and Gerstman, L. S., *J. Exp. Psychol.*, **44**, 114 (1952).

[4] Pratt, F., "Secret and Urgent, the Story of Codes and Ciphers" (Robert Hale, Ltd., London, 1939).

A Possible Fundamental in the Behaviour of Young Nidifugous Birds

THE great output of papers over the past few years on the phenomenon of imprinting has recently been reviewed by Hess[1] and this has been brought up to date by Thorpe[2].

Although it seems that imprinting may not necessarily be irreversible, and in fact may not be very different from other types of learning[2,3], it is still convenient to define it as "the process whereby certain juvenile birds become psychologically fixed upon the parent during the first very few days after hatching". Analyses of processes in young nidifugous birds covered by this broad definition have shown that imprinting may occur in response to a parent-object moving away from the juvenile or to various other visual stimuli including 'retinal flicker'[1,4,6], or to various acoustic stimuli[4,5].

All such analyses, however, utilize juveniles hatched in incubators or by the normal female not under detailed observation, that is, the analyses begin after the first possible stimulus-response period, the time of actual hatching, is over. In other words, incubator-raised juveniles may be 'incomplete' with respect to an appetitive behaviour-consummatory act complex involving the parent bird, and normally hatched birds will be 'complete' in this respect. Such a difference in experimental material may well result in differences in response; an unknown variable may have been operative.

Results suggesting this have been obtained in the course of work on eider ducklings (*Somateria mollissima*) in the Canadian arctic during the summers of 1958[7] and 1959[8]. Twelve eider ducklings imprinted to myself in varying degrees have been raised naturally in the field to at least one week old. After this some were raised on prepared food, some 'escaped', and some died. Most of the observed behaviour patterns have been checked by comparison with wild eiders of the same age at the same time and place. On the authority of Haldane[9], 20 randomly selected juveniles are regarded as enough for ethological statistical validity.

One of the most significant behaviour patterns observed is one which occurs immediately upon hatching. I propose to call this the 'brooding reflex' because it seems to be the mechanism whereby the newly hatched duckling orientates itself to the position of optimum warmth and mechanical protection beneath the female. It involves an active search by the duckling for a feeling of enclosure around the head or part of the head. In this way the duckling investigates its surroundings, the appetitive behaviour being a search for a space into which it can thrust its bill or head. Thus, a duckling a few seconds after hatching on my hand would actively follow my other hand once I had held its head between finger and thumb. A state of rest, or even of sleep, could be released in the ducklings merely by providing this contact stimulus on two sides of the head or bill. A higher degree of enclosure was even more significant, as long as the bird was warm and could breathe and wriggle. All the ducklings in my care showed this response to a constant degree, but more significant perhaps, is the fact that I found that I could release a similar quiescence in wild juveniles. To date, this response has been positive in every nidifugous juvenile I have handled including the imprinted eiders and three imprinted red-breasted mergansers (*Mergus serrator*), and varying numbers of wild juveniles of eider, old-squaw (*Clangula hyemalis*), Canada goose (*Branta canadensis*), ringed plover (*Charadrius hiaticula*), and purple sandpiper (*Erolia maritima*).

It seems that the 'brooding reflex' may be of widespread occurrence within the Anatidae, and even among nidifugous birds in general. Whether it is regarded as a conditioning immediately preceding imprinting, or as an integral part of the full imprinting process, it would appear to be a fundamental behaviour activity which has previously been overlooked.

Detailed results of these studies will be published in due course. The work was carried out with the financial support of a Carnegie Arctic Research Scholarship and field grants from the Banting Fund of the Arctic Institute of North America, and the physical assistance of Mr. C. W. Nicol, all of which I gratefully acknowledge.

PETER M. DRIVER

Zoology Department,
McGill University,
Montreal.

[1] Hess, E. H., *Science*, **130**, 133 (1959).

[2] Thorpe, W. H., *Ibis*, **101**, 337 (1959).

[3] Thorpe, W. H., "Learning and Instinct in Animals", 116 (London, 1956).

[4] Klopfer, P. H , *Ecology*, **40**, 90 (1959).

[5] Fabricius, E., *Acta Zool. Fenn.*, **68**, 1 (1951).

[6] James, H., *Canad. J. Psychol.*, **13**, 59 (1959).

[7] Driver, P. M., *Arctic*, **11**, 191 (1958).

[8] Driver, P. M., Ph.D. thesis (in preparation).

[9] Spurway, H , and Haldane, J. B. S., *Behaviour*, **6**, 34 (1958)

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 2

University College (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Prof. Z. M. Bacq (University of Liège) "The Enzymatic Inactivation of Adrenalin and Noradrenaline".*

British Society for the History of Science (in the Council Room (second floor) of the Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Prof. L. Pearce Williams. "Faraday and the Atomic Theory".

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W 1), at 5.30 p.m.—Mr. C. E. Tharratt: "Problems in the Launching of Black Knight", illustrated by lantern slides and a film.

University College (in the Embryology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Jorge Dias (University of Lisbon): "The Makonde People: Conflicts of Culture".* (Further lecture on May 5.)

Society of Chemical Industry, London Section (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Annual General Meeting followed by Dr. H. Baines: "The Use of Photography in Industry".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Sir Olaf Caroe, K.C.S.I., K.C.I.E.: "The Geography and Peoples of the Himalayan and Karakoram Frontiers".

Monday, May 2—Wednesday, May 4

Institute of Physics, Non-Destructive Testing Group (joint meeting with the Société Française de Métallurgie, at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1)—Conference on "Physical and Structural Aspects of Non-Destructive Testing of Metals".

Tuesday, May 3

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Teaching and Learning Machines" opened by Mr. C. E. G. Bailey.

Plastics Institute (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Annual General Meeting, followed by a speaker from the Plastics Industry of the U.S.S.R.

Antiquarian Horological Society (at the Science Museum, South Kensington, London, S.W.7), at 7 p.m.—Annual General Meeting, followed by an illustrated talk on Mr. B. Hawkins' collection.

Tuesday, May 3—Wednesday, May 4

Society for Analytical Chemistry (in conjunction with the Iron and Steel Institute and the Institute of Metals, at Denison House, 296 Vauxhall Bridge Road, London, S.W.1)—Symposium on "The Determination of Gases in Metals".

Tuesday, May 3—Thursday, May 5

Iron and Steel Institute (at the Royal Commonwealth Society, Caxton Hall, and Church House, London)—Annual General Meeting, 1960.

Wednesday, May 4

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Dr. Ragnor Fjørtoft (Oslo): "The General Circulation of the Atmosphere" (Symons Memorial Lecture).

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. Philip Chantler: "Europe's Energetic Forecasting".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. L. Pearce Williams: "Michael Faraday and the Evolution of the Concept of Electric and Magnetic Fields".

Thursday, May 5

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. S. Ainsworth, Mr. Q. H. Gibson and Prof. F. J. W. Roughton, F.R.S.: "The Kinetics of the Reactions of Sheep Hæmoglobin with *Iso*cyanides"; Mr. R. H. Dadd: "Some Effects of Dietary Ascorbic Acid on Locusts".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. H. R. Hewer: "Expedition to North Rona, October 1959"; Mr. N. W. Simmonds: "Useful and Ornamental—a Miscellany of Tropical Plants".

Institute of Refrigeration (joint meeting with the Institution of Heating and Ventilating Engineers, at the Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Mr. B. A. Phillimore and Mr. S. J. Jones: "The Demand for Cooling in the Modern Passenger Liner".

Institution of Electrical Engineers, Utilization Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. S. J. Emerson Annual Lecture on "Safety in the Utilization of Electricity".

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 5.30 p.m.—Annual General Meeting.

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. A. Butenandt: Adolf Windaus Memorial Lecture.

Friday, May 6

Institution of Electrical Engineers, Medical Electronics Discussion Group (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Methods of Recording Measurements—Digital or Analogue" opened by Mr. W. J. Perkins.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Research Biophysicist (preferably with experience of protein structural studies) in the Immunology Department, to investigate the structure and interactions of antibodies and antigens—The Secretary, St. Mary's Hospital Medical School (University of London), Paddington, London, W.2 (May 4).

Senior Lecturer (graduate, with experience in either personnel management, industrial communications, or teacher training) in Psychology—The Registrar, Royal Technical College, Salford 5 (May 6).

Reader in Geophysics—The Secretary, The University, Exeter (May 7).

Senior Lecturer in Solid State Physics—The Secretary, The University, Exeter (May 7).

Senior Lecturer (with high qualifications and wide experience) in Physics, to teach to honours degree level; and an Assistant (Grade B) in Physics—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (May 7).

Senior Research Student in either Engineering or Chemical Engineering or Metallurgy—The Registrar, University College, Singleton Park, Swansea (May 7).

Lecturer or Assistant Lecturer (with an honours degree in philosophy) in Philosophy—The Registrar, University of Malaya in Kuala Lumpur, Pantai Valley, Kuala Lumpur (May 10).

Assistant in the Department of Zoology—The Secretary, The University, Edinburgh (May 14).

Lecturer (Grade II) in Physics; a Research Associate in Low Temperature Physics; and a Research Associate in Theoretical X-Ray Crystallography in the H. H. Wills Physical Laboratory—The Registrar, The University, Bristol 8 (May 14).

Lecturer (with special qualifications in physiological psychology) in Psychology—The Registrar, The University, Sheffield (May 14).

Senior Lecturer or Lecturer in Mathematical Logic—The Registrar, The University, Manchester 13 (May 14).

Staff Tutor in Science (Physical Scientist)—The Registrar, The University, Sheffield 10 (May 14).

Temporary Assistant Lecturer or Lecturer in Sociology or Social Anthropology—The Registrar, The University, Hull (May 14).

Demonstrator in Physical Chemistry—Head of the Physical Chemistry Laboratory, The University, South Parks Road, Oxford (May 15).

Fellow in Physical Chemistry—St. Catharine's College Planning Office, 42 Banbury Road, Oxford (May 15).

Lecturer and an Assistant Lecturer (with research experience in pure mathematics and preferably with qualifications in analysis) in Mathematics—The Registrar, University College of North Wales, Bangor, North Wales (May 16).

Lecturer (Grade II) in Pure Mathematics—The Registrar, The University, Bristol 8 (May 16).

Lecturer in Applied Mathematics—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (May 16).

Regius Chair of Moral Philosophy in the University of Aberdeen—The Private Secretary, Secretary of State for Scotland, St. Andrew's House, Edinburgh 1 (May 20).

Lecturers (3) and Assistant Lecturers (3) in the Department of Chemistry—The Registrar, The University, Sheffield (May 21).

Lecturer in Physiology—The Secretary, The University, Aberdeen (May 23).

Assistant Lecturer in the Department of Applied Mathematics and Theoretical Physics—Secretary of the Appointments Committee of the Faculty of Mathematics, The Arts School, Bene't Street, Cambridge (May 25).

Student Demonstrator (graduate) in the Department of Botany, University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 25).

Assistant Lecturers (2) in Zoology—The Registrar (Room 22, O.R.B.), The University, Reading (May 28).

Lecturer or Assistant Lecturer (with special experience in food microbiology) in the Department of Microbiology—The Registrar (Room 22, O.R.B.), The University, Reading (May 28).

Senior Assistant Librarian (suitably qualified academically and professionally), to take charge of the Library of the Faculties of Agriculture and Engineering, University College of the West Indies, Trinidad—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 30).

Chair of Mathematics in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, May 31).

Lecturer or Senior Lecturer in Genetics and Plant Breeding; an Assistant Lecturer in Botany; and a Demonstrator in Zoology—The Registrar, Wye College (University of London), near Ashford, Kent (May 31).

Lecturer (science graduate, with experience in bacteriology, immunology or virology, and in research methods) in Microbiology at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, May 31).

Professor of Mathematics or Applied Mathematics at the University of Natal, Durban, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, May 31).

Research Fellow (with a Ph.D. degree or equivalent experience) in the Chemistry Department, for fundamental work on compounds potentially useful in the paint industry—The Professor of Chemistry, The University, Hull (May 31).

Senior Research Fellow (graduate in agricultural chemistry, biochemistry or physiology, with some experience of research in animal nutrition) in Poultry Nutrition—The Secretary, University of Nottingham School of Agriculture, Sutton Bonington, near Loughborough (June 1).

Executive Assistant (with experience in administration and control of non-academic staff, and in writing and editing) in the School of Physics, University of Sydney, to assist the Head of the School in the administration of the School and the Nuclear Research Foundation, and to edit and write the major portion of the Foundation's publication *The Nucleus*—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, and the Registrar, University of Sydney, Sydney, N.S.W., Australia (June 3).

Lecturer/Senior Lecturer in Biochemistry at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 3).

Lecturer in the Department of Physics—Prof. P. M. S. Blackett, F.R.S., Physics Department, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7 (June 14).

Lecturer or Senior Lecturer in Psychology at the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 15).

Edwin Cuthbert Hall Chair of Middle Eastern Archæology in the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

Senior Lecturer or Lecturer in Applied Chemistry at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, June 30).

Experimental Officer (at least 28, with a degree in engineering, H.N.C. or equivalent qualifications, and experience of research work) at the National Institute of Agricultural Engineering, to work in co-operation with the Department of Hop Research, Wye College (University of London) on engineering problems connected with the mechanization of hops and hop drying—The Secretary, National Institute of Agricultural Engineering, Silsoe, Beds.

Lecturer in Mathematics—The Registrar, Bradford Institute of Technology, Bradford 7.

Research Assistant (with a first- or second-class honours degree in biochemistry), to assist with investigations into disturbances of calcium metabolism—The Director, Metabolic Disturbances in Surgery Research Unit, The General Infirmary, Leeds.

Senior Lecturer or Lecturer in Bacteriology and Parasitology at the University of Khartoum—The Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Solid State Scientists, Scientific Officers (with at least a first- or good second-class honours degree and preferably with post-graduate experience in solid state studies), in the Metallurgy Division, to study the basic mechanisms giving rise to the physical properties of certain nuclear ceramics in both single crystal and polycrystalline form—The Group Recruitment Officer (1639/34), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Didcot, Berks.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Field Studies Council. Annual Report, 1958–1959. Pp. 34+4 plates. (London: Field Studies Council, 1960.) [172

Choice of Careers No. 81: Forestry. Second edition. Pp. 36. (London: H.M. Stationery Office, 1959.) 1*s*. 9*d*. net. [172

Building Research Station Digest No. 130 (January, 1960): Supersulphate Cement. The Cracking of Asbestos-Cement Sheets. Pp. 4. (London: H.M. Stationery Office, 1960.) 4*d*. [172

Department of Scientific and Industrial Research. Fuel Research 1958: Report of the Director of Fuel Research for 1958. Pp. iv+35. (London: H.M. Stationery Office, 1959.) 2*s*. 6*d*. net. [172

Ministry of Agriculture, Fisheries and Food. Bulletin No. 174: Poultry Nutrition. By Dr. W. Bolton. Pp. v+90. (London: H.M. Stationery Office, 1959.) 5*s*. net. [172

Ministry of Agriculture, Fisheries and Food. Fishery Investigations, Series II, Vol. XXII, No. 9: Echo Sounding Experiments in the Barents Sea. By I. D. Richardson, D. H. Cushing, F. R. Harden Jones, R. J. H. Beverton and R. W. Blacker. Pp. vi+57. (London: H.M. Stationery Office, 1959.) 20*s*. net. [172

Cement and Concrete Association. Concrete Facing Slabs. By J. Gilchrist Wilson. Third (revised) edition. Pp. 30. (London: Cement and Concrete Association, 1959.) [172

Forestry Commission. Forest Record No. 39: Collection of Cones from Standing Trees. By D. T. Seal. Pp. 33. (London: H.M. Stationery Office, 1959.) 3*s*. 6*d*. [172

Newmarket Transistors Limited. Application Notes. Pp. 120. (Newmarket: Newmarket Transistors Limited, 1960.) [172

University of Birmingham. Report of the Vice-Chancellor and Principal for the Calendar Year 1959. Pp. 28. Report of the Proceedings of the Council of the University for the year ended 31st December, 1959. Pp. 18+4 plates. Accounts for the year ended 31st July, 1959. Pp. 35. University Research Committee Thirtieth Annual Report (Session 1958–1959). Pp. 123. (Birmingham: The University, 1960.) [172

University of Leeds. Annual Report of the Librarian, Session 1958–1959. Pp. 12. (Leeds: The Brotherton Library, The University, 1959.) [172

Other Countries

Publikationer fra det Danske Meteorologiske Institut. Communications Magnétiques, etc. No. 24: Local Aurorae in the Morning Hours at Godhavn. By K. Lassen. (A paper presented at the Auroral Conference in Uppsala, 25–26 August 1958.) Pp. 15. (Charlottenlund: Danske Meteorologiske Institut, 1959.) [172

World Health Organization. Technical Report Series. No. 166: Effect of Radiation on Human Heredity—Investigations of Areas of High Natural Radiation. (First Report of the Expert Committee on Radiation.) Pp. 47. 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars. No. 178: Requirements for Biological Substances. 1: General Requirements for Manufacturing Establishments and Control Laboratories. 2: Requirements for Poliomyelitis Vaccine (Inactivated). (Report of a Study Group.) Pp. 30. 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars. No. 179: Requirements for Biological Substances. 3: Requirements for Yellow Fever Vaccine. 4: Requirements for Cholera Vaccine. (Report of a Study Group.) Pp. 46. 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars. No. 180: Requirements for Biological Substances. 5: Requirements for Smallpox Vaccine. (Report of a Study Group.) Pp. 24. 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1959.) [172

Osservatorio Astrofisico di Arcetri. Annuario per il 1960. Pp. 61. (Firenze: Coi Tipi dell'Istituto Geografico Militare, 1959.) [172

Seventh Annual Report of the West African Institute for Oil Palm Research, 1958–1959. Pp. 140. (Benin City: West African Institute for Oil Palm Research; London: Crown Agents for Oversea Governments and Administrations, 1959.) 2*s*. 6*d*. [172

Anuario del Observatorio Astronómico de Madrid para 1960. Pp. 406. (Madrid: Observatorio Astronómico, 1960.) [172

Australian Atomic Energy Commission Research Establishment. Pp.12. (Sydney: Australian Atomic Energy Commission, 1960.) [172

United States Department of Commerce: National Bureau of Standards. Applied Mathematics Series, No. 57: Basic Theorems in Matrix Theory. By Marvin Marcus. Pp. iv+27. (Washington, D.C.: Government Printing Office, 1960.) 15 cents. [172

United States Department of Commerce: Coast and Geodetic Survey. Publication 62-2: Geodimeter Manual. By Austin C. Poling. Pp. vi+70. (Washington, D.C.: Government Printing Office, 1959.) 45 cents. [172

International Atomic Energy Agency, Vienna. *Atomic Energy*, No. 6. (A Chronological List of Conferences, Meetings, and Training Courses.) Pp. 25. (Vienna: International Atomic Energy Agency, 1960.) [172

British Guiana: Geological Survey. 5th Inter-Guiana Geological Conference—Addresses to the Opening Session. Pp. 11. (Georgetown: Geological Survey, 1959.) [172

Institut de France. Académie des Sciences Annuaire pour 1960. Pp. 251. (Paris: Gauthier-Villars, 1960.) [172

Institut Royal des Sciences Naturelles de Belgique. Expédition Océanographique Belge dans les Eaux Côtières Africaines de l'Atlantique Sud (1948–1949). Résultats Scientifiques. Vol. 4, Fascicule 3B: Poissons. V: Téléostéens Acanthoptérygiens (Deuxième partie). Par Max Poll. Pp. 417+7 planches. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1959.) [172

United States Department of the Interior: Geological Survey. Bulletin 1028–L: Geology of Umnak and Bogoslof Islands, Aleutian Islands, Alaska. By F. M. Byers. Pp. viii+267–369+plates 39–51. Bulletin 1028–M: Geology of Southern Adak Island and Kagalaska Island, Alaska. By George D. Fraser and George L. Snyder. Pp. vi+408+plates 52 and 53. Bulletin 1028–N: Some Effects of Recent Volcanic Ash Falls, with special reference to Alaska. By Ray E. Wilcox. Pp. vi+409–476+plates 54–58. 30 cents. Bulletin 1069: Geology of the Thomas Range Fluorspar District, Juab County, Utah. By M. H. Staatz and F. W. Osterwald. Pp. v+97+12 plates. Bulletin 1072–G: Coal Resources of Trinidad–Aguilar Area, Las Animas and Huerfano Counties, Colorado. By R. L. Harbour and G. H. Dixon. Pp. iv+489+plates 10–14. Bulletin 1079: Geology of the Charleston Phosphate Area, South Carolina. By Harold E. Malde. Pp. v+105+10 plates. 1.75 dollars. Bulletin 1082–C: Iron-Ore Resources of the United States including Alaska and Puerto Rico, 1955. By Martha S. Carr and Carl E. Dutton. Pp. iv+134+plate 2. 75 cents. Bulletin 1087–A: Geology of the Garo Uranium-Vanadium Copper Deposit, Park County, Colorado. By V. R. Wilmarth. Pp. iii+21+5 plates. Bulletin 1087–C: Uranium Resources of the Green River and Henry Mountains Districts, Utah—a Regional Synthesis. By Henry S. Johnson, Jr. Pp. iv+59–104+plates 6–9. 1 dollar. Bulletin 1087–E: Stratigraphy and Uranium Content of the Chattanooga Shale in North-eastern Alabama, North-western Georgia and Eastern Tennessee. By Lynn Glover. Pp. iv+133–168+plates 14–18. 1 dollar. Bulletin 1097–A: Evaluation of the Lead-Alpha (Larsen) Method for Determining Ages of Igneous Rocks. By David Gottfried, Howard W. Jaffe and Frank E. Senftle. Pp. iv+63+plate 1. 35 cents. Bulletin 1106–C: Geophysical Abstracts, No. 178 (July–September, 1959). By Dorothy B. Vitaliano, S. T. Vesselowsky and others. Pp. iii+261–406. 40 cents. (Washington, D.C.: Government Printing Office, 1959.) 192

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

HUMAN PROBLEMS OF INNOVATION IN INDUSTRY

DURING the past two or three decades, there has been a quickening of technological change in British industry. Associated with this change, both as cause and effect, there has been a marked increase in the number of industrial scientists whose role is not merely to perform tests, answer specific practical questions, or evolve minor improvements, but also to innovate, to open up new possibilities whether of production or use. To an unprecedented extent, technical innovation is becoming a 'resource' of industrial firms, like the manual skill of operators or the administrative skill of managers.

This injection of a new element, this resort by firms to research and development as a continuing activity, calls for changes in the structure and method of management. The kind of management organization and practice, including relationships between different levels of management, which will work well when a business is running on an even keel, will not work where technical methods are rapidly changing.

A brief account by Honor Croome describes a study made by Tom Burns and G. M. Stalker between 1955 and 1957 in certain Scottish firms which entered a new business field involving rapid technological development*. It examines the strains which consequently arose in the field of management, and especially the difficulties which were encountered in acquiring the new resources of "Research and Development", and fitting a newly recruited or newly expanded research and development group into the managerial structure.

The firms were mostly those taking part in the scheme initiated by the Scottish Council (Development and Industry) to stimulate the growth of the electronics industry in Scotland. Behind the scheme, and bulking large in its founders' minds, was a particular war-time experience: that of the collaboration between the Telecommunications Research Centre, serving officers of the Royal Air Force and Air Staff officers.

The scheme was formally designed to bridge the gap between the users of electronic products—initially, the Service departments and the Ministry of Supply—and those firms which, although potential producers, had no adequate research team or laboratories and no experience in handling development contracts. One big firm, Ferranti, Ltd., of Edinburgh—which had special expertize in electronics and was the reason for choosing this rather than some other 'growing point' of technology for the experiment—agreed to perform the functions of intermediary, or 'staging point'.

The first contact is generally between the Scottish Council and the management of a particular firm; the initiative may come from either side. The firm is told about possibilities and procedures, and its management is invited to examine the Ferranti laboratory and possibly some Government research stations. There follows a discussion between its management, Ferranti, Ltd., the Scottish Council, and one of the Defence Ministries, with the view of picking a development contract which suits the firm's present activities, technical capacities, and future plans. A suitable contract is one which can be handled by the firm and Ferranti, Ltd., between them. When this is arranged, the new firm engages a number of design engineers, who then work alongside the Ferranti group attached to the contract. When the new team has sufficiently grasped the requirements, the special techniques, and the methods of co-operation involved, it carries on until the contract is fulfilled.

To the participating firms the main merit of the scheme lies in its efficacy as a pump-priming operation. The initial share of a development contract can justify recruiting a design team. By working alongside Ferranti's, that team can gain invaluable experience in appreciating the requirements, the special techniques and the appropriate methods of working together. The last phase, the one that really matters, is that in which this experience is used to exploit the potentialities of electronics in the firm's own sector of industry and its own markets. Such exploitation demands more than the technical designer's expertize. It calls for the appraisal of factors which lie outside his special function. Management has to consider the firm's productive resources; present and future market needs; the capital resources which might be required, and also the sources from which, and the conditions under which, these could be raised; the stresses which the finances, the employees, and the organization of the firm can bear. It has to assess the potentialities of the new techniques; the ability of the design team to evolve in time a product which can be manufactured; the abilities, too, of the draughtsmen, planning engineers, estimators, craftsmen, foremen, inspectors, salesmen and others. Wherever technical innovation is introduced as a 'resource', it affects every aspect of management and every manager throughout the firm; and in so doing it affects the relations of managers with one another.

It was found in the present case that, in the presence of rapid technical change and the strains which it imposes, two natural human reactions can be recognized and guarded against. One is the impulse to scurry back for safety to the 'mechanical' system, the authority of the chief and the book of rules. The other is to blame the personal defects and shortcomings of the individuals involved. Whether or not they contribute to the trouble, it has deeper causes.

These are negative prescriptions. Positive prescriptions must be differently interpreted in every firm. The first and most general requirement is that management should constantly re-examine what the firm is supposed to be doing, with the conscious aim of adapting operating methods and the structure of managerial relationships to their present task. If the task of the firm can be carried out by a number of people, each with a set of responsibilities and correspondingly limited liabilities, each occupying a well-established place in a pyramid of authority, such a system is economical and effective and has the great advantage of imposing less wear and tear, stress and uncertainty on individuals. But when the firm is tackling new tasks, commercial or technical, this system of differentiated routine functions is not satisfactory. Delimitations must be made fluid, and responsibilities must be elastically shared. Every effort must be made to encourage the sense of the business as a whole, with objectives and goals common to all its members, rather than a complex of separate 'jobs'. The stronger this sense, the more recourse there should be to 'lateral' consultation, which should be recognized and facilitated and not regarded as a mere semi-legitimate supplement to the 'vertical' channels of command.

---

* Department of Scientific and Industrial Research. Problems of Progress in Industry No. 5: Human Problems of Innovation. Based on a study of some Scottish firms by Tom Burns and G. M. Stalker. Pp. 36. (London: H.M. Stationery Office, 1960.) 2s. 6d. net.

Putting these prescriptions into effect is partly a matter of organization and partly of establishing a code of good manners expressing—whatever the level of formality or informality—a spirit of co-operation and appreciation rather than the desire to score or to assert prestige. The firm should regard the continuous, deliberate re-casting of its structure, the establishment of 'organic' relationships, and the maintenance of a social climate in which these can flourish, as no less important a part of the innovating process than the building of laboratories and the recruitment of scientists and technologists.

CANCER RESEARCH IN THE U.S.S.R.

Pathogenesis and Immunology of Tumours

Edited by G. V. Vygodchikov. Translated from the Russian by R. Crawford. Pp. viii+258. (London and New York: Pergamon Press, 1959.) 80*s*. net.

THIS volume consists of a collection of papers in honour of Prof. L. A. Zilber's sixtieth birthday and is in no sense a text-book. Indeed it reads more like the annual report of the British Empire Cancer Campaign except that it does not cover so wide a field. It is unfortunate that the publishers did not give the date of its publication in the U.S.S.R., but the bibliography makes it virtually certain that most of the articles were written in 1953. Part one deals with the pathogenesis of tumours, parts two and three with immunological studies and there is a short section on investigations with electron microscopy.

A virus ætiology is widely favoured in the U.S.S.R. and one of the most interesting articles is that of Timofeevskii and Benevolenskaia on tissue culture studies. It is claimed that the mammary tumour milk agent can be propagated in cultures of mouse tissues as well as those of other species. The authors favour the idea that malignant transformation *in vitro* is due to viral activity. The milk agent itself did not produce malignant change in their hands but is said to stimulate growth. They produce some evidence that methyl cholanthrene and the milk agent act synergically to produce malignant change. The article is critically written, and readers must bear in mind that it is seven years old. A very scholarly review on the viruses of fowl leukoses by V. A. Parnes is curiously included in the next section.

Zilber and his school are best known for their serological work. A technique much used by them is to sensitize guinea pigs against a tumour, to de-sensitize with normal tissue or other pertinent antigen and then to challenge with the homologous antigen. Points of interest concern the ability to absorb rabbit papilloma virus with rabbit red cells, leaving a preparation free of virus but containing other tissue components. V. A. Artamonova has exploited this to demonstrate antigenic differences between papillomata and the resulting carcinomata. The same author claims to have isolated proteins from carcinomata that will neutralize the papilloma virus. There is a short and interesting article on the antigenic properties of human amyloid by V. A. Parnes. There are articles dealing with the antigenic properties of human tumours, and tumours from mice, rats and birds. Generally they show the presence of antigenic components present in neoplastic tissues that are absent from normal tissues; different types of neoplasm share some components but have some peculiar to themselves. In their article on the specific antigens of malignant tumours in man Gorodilova and Shershulskaia claim that specific antigens may sometimes be demonstrated on the red cells of patients with cancer of the lung, stomach, mammary gland and ovary.

Unless inbred strains can be used, claims to demonstrate tumour specific antigens tend to be suspect. One naturally wonders how far Lysenko might be responsible for the Russians being slower than some Western investigators to realize this. Probably he had no such influence. It appears that they simply failed to realize the impact of genetic research until they read T. S. Hauschka's review in *Cancer Research*, in 1952. It is quoted several times in this book and D. M. Levina directs attention to the desirability of further work with inbred strains. When I heard Prof. Silber speak in Amsterdam last June he emphasized the need to distinguish between transplantation antigens and tumour specific antigens. He has abandoned his anaphylactic technique in favour of gel diffusion methods. Work with inbred strains in Britain and the United States is now beginning to reveal tumour-specific antigens, so a great deal of the Russian work with other types of material may prove to be substantially correct.

P. A. GORER

EDUCATION IN SOCIOLOGY

The Social Purposes of Education

By K. G. Collier. (International Library of Sociology and Social Reconstruction.) Pp. xv+236. (London: Routledge and Kegan Paul, Ltd.; New York: Humanities Press, 1959.) 21*s*. net.

IT is not easy to decide at what level to consider this book. The title and the series in which it appears lead one to hope for a sustained and distinctive contribution to our thinking about the social purposes of education. But the author seems to renounce this, saying that a comprehensive treatment would involve command of several academic disciplines and is probably beyond the compass of a single person. He says that he writes primarily for teachers and student teachers, and so we expect a book rather of simple exposition. Yet towards the end of his preface he re-states his aim as being "to articulate the relations between these disciplines". This is a task that would scarcely seem to be that of a near text-book. Then he immediately re-phrases this as being equivalent to a "search for criteria by which to judge educational methods". These two things, though related, are surely not the same. One begins to wonder what kind of book is intended.

The result is a work that has some good things in it, and that calls on a commendably wide background of reading, but that does not satisfy. The first three sections involve some economics, some sociology, some psychology and some discussion of 'values'. The last section, called "Educational Principles", is rather like a chapter from a sensibly progressive hand-book for teachers, and one feels that one is now at a different level of discourse. An attempt is made to link the earlier and the later sections, but in a very general way and without rigour.

Even if the purpose of the book were the modest one of starting students to think about the social purposes of education, one wonders how the author could attempt this without either more philosophical penetration or serious study of comparative education and societies. Philosophically, the book is conceived from within a very limited framework. There are many incidental signs of this, the oddest being the statement that science sprang from Christian sources, those of late medieval Christendom, a surely inadequate account of the history of scientific thinking in human history. Again, the good teacher's aim to show his pupils the truth as he sees it "without obliging them to choose his solution" is equated with the words of the Collect, "Make us love that which Thou does command". This is the kind of looseness which is allowed to pass too often in 'uplifting' writing about education. There is a great difference between commanding people to accept what you ordain (and to like it to boot) and leaving them free to make their own choice. There is the same lack of penetration in discussion of acceptance of the evils from which we suffer. These, we are told, may be accepted with a good grace when seen as coming from God, but are the soil of "envy, hatred and malice and all uncharitableness" when seen as the work of man. The author is thinking not of the material cause of suffering but of the frame of reference in which it is seen; but if he had thought of Islam and the "will of Allah" for a moment instead of his own beliefs he would have seen that this framework has a bearing on the readiness to remedy remediable suffering. When one thinks of the less-developed areas of the world, it seems terribly inadequate to say that the cause of suffering lies within oneself. Some, but indeed not all, suffering is an 'unalterable reality'.

This leads one to note the most surprising omission of all. How can one study the social purposes of education without considering different methods and systems of education in different social settings? Mr. Collier has a reference or two to such writers as Margaret Mead and Ruth Benedict, but one would have thought it indispensable to consider the role of the school in American social history or the social conception of education in the U.S.S.R. in our own times, or the social function of education in primitive societies and the impact of change on this, or Greek ideas about education seen in relation to society in fifth-century Greece; or at least some of these.

There is much material in this book that could have contributed either to a handbook for British teachers on the theme of the social setting of their work and the problems of 'socializing' the young through the school, or to a more sustained inquiry into the nature of the problem as such. But the book as it is is not quite one thing or the other, and it must be confessed that it leaves one disappointed.

H. L. ELVIN

MATHEMATICS AND THE CONDUCTION OF HEAT IN SOLIDS

Conduction of Heat in Solids
By Prof. H. S. Carslaw and Prof. J. C. Jaeger. Second edition. Pp. x+510. (Oxford: Clarendon Press; London: Oxford University Press, 1959.) 84s. net.

THE theory covered by this book has a long history stretching back to the classical work of Fourier. It has undergone various stages of development covered by the subjects of Fourier series and integrals, Fourier–Bessel series, Laplace transforms and more recently integral transforms generally. The present work, the second edition, replacing the edition of 1947, gives a very comprehensive treatment of the theory and provides "as complete account as possible of the exact solutions and soluble problems of the subject". That the account is complete is very evident to the reader, who may be tempted into asking if there is much point in taking the analysis so far as is done in some cases.

The first 300 pages are devoted to the theory based on Fourier series. This includes the linear flow of heat in infinite and semi-infinite solids of various simple shapes. It concludes with an important new chapter on change of state, showing clearly how far it is possible to go with exact solutions and when recourse must be had to numerical methods. Melting and solidification are treated, and the practical importance of the results in problems such as ice formation, solidification of castings and the cooling of igneous rocks is pointed out.

Three chapters are given to the use of the Laplace transform method. These cover both linear flow and problems on the sphere and the cylinder, and emphasis is placed upon problems which may be solved more easily by this method than by the classical method. A practical problem which yields nicely to a theoretical treatment is the heating of a buried electric cable. Both short-circuit heating and constant-current heating are treated. The theory of heat regenerators and heat exchangers is also developed via the Laplace transform method, and there is a section on the theory of systems for automatic temperature control. It is perhaps a pity that more space is not devoted to these two topics, considering their great importance in chemical engineering. But the large number of references given will lead the reader to a more extended treatment.

The last two chapters are in the nature of surveys. They give accounts of the use of integral transforms and the use of numerical methods. The former has been developed in recent years, notably by Sneddon and by Tranter, and a crucial property of the transformations is that in many cases they reduce the Laplace equation in two variables to an ordinary differential equation. The chapter on numerical methods is a short one showing how the equation of heat-flow may be converted approximately into a set of difference equations which may be solved numerically. There is also a brief section on the use of relaxation methods. It seems a pity that more space was not given to the use of numerical methods; for the limitations of exact solutions in practical problems are much in evidence throughout the book (for example, in the chapter on change of state), and a very powerful tool, namely the electronic computer, is now available for obtaining solutions to problems formerly beyond the range of the numerical analyst. In my opinion the analysis (in terms of symbols) of practical problems is sometimes carried too far, and it would almost certainly save much time in future if those concerned with heat-flow in practical problems were to make use of numerical methods at an earlier stage than has been customary in the past.

This book, more than ever, will continue to be the standard reference work in its field. It is to be noted that there are now more than 700 references. The beginner needing a guide to the vast literature on the subject, and the research worker who wishes to see how far exact analysis will take him in a particular case, will find it essential to consult "Carslaw and Jaeger". L. S. GODDARD

COGITO ERGO SUM

Symbolic Logic and Intelligent Machines

By Edmund C. Berkeley. Pp. v+203. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1959.) 52*s*. net.

EDMUND BERKELEY'S previous book, "Giant Brains or Machines that Think", and its sequel are well-known introductions to the field of digital computers. The present book seeks to infuse life into the more recondite subject of mathematical logic.

Designers of computing systems differ in their regard for symbolic logic, and in particular Boolean algebra, as a practical tool, but nevertheless any but the merest tyro should have at least a working knowledge of the discipline.

As an introduction to Boolean algebra this book can be recommended, even though I join issue with Berkeley over the merits of Boole's own "Laws of Thought". This recommendation is possible because the latter book, although most readable, was written with an eye to the formal logic of the schools rather than as a design tool for switching circuits.

The first six chapters of Berkeley's book deal with formal logic and its application to switching. The treatment is basically that of Shannon, but the illustrative examples are of a light-hearted nature which will appeal to the non-specialist.

The first contact with 'intelligent' machines occurs in Chapter 7, where readers are invited to agree that intelligence is "the ability to learn from experience, to acquire and retain knowledge, and to respond quickly and appropriately to new situations, thus resulting in success in the performance of tasks". This definition could be questioned from a number of points of view, but, at the level at which the book is written, it is probably as good as any.

Unfortunately, the robot the actions of which satisfy this criterion of intelligence does not appear in subsequent pages of the book, and the reader may well doubt that a hall light, a syllogism machine, or a decimal adder justifies any claim that an intelligent machine exists. It is only fair to say that the author realizes this and, on page 97, attempts to clarify his position.

The remainder of the book is devoted first to an explanation of the way in which Shannon introduced the notion of time into switching algebra, which is very clearly written, and finally to the programming of Newton's method for evaluating a square root on a hypothetical digital computer *Zac*. This last chapter is a complete *non sequitur* and it is difficult to see why it was included.

In his preface the author invites comments and corrections. Unfortunately the number of misprints is too numerous for detailed mention, but it is impossible not to remark on the unsatisfactory nature of the circuit drawings. Surely it is not too much to expect the use of ruler and compasses and the adoption of standard notations for relay coils, and for rectifiers (for example, on Fig. 11·1); the same modicum of care might also have avoided such confusing situations as those shown in Fig. 14·6, where five change-over switches have both their sides connected to earth.

A. D. BOOTH

BIOCHEMISTRY AND MEDICINE

Biochemistry in Relation to Medicine

By C. W. Carter, Dr. R. V. Coxon, D. S. Parsons and Prof. R. H. S. Thompson. Third edition. Pp. xiii+628. (London and New York: Longmans, Green and Co., Ltd., 1959.) 50*s*. net.

THE last edition of this well-known text-book was published seven years ago, and this new edition shows many changes. To begin with, the number of authors has increased from two to four, and the character of the book has been somewhat altered by the omission of the practical sections. The authors feel that universities and medical schools prefer to plan their practical classes in their own way. The original chapters have been extensively revised to bring them up to date, and there are some excellent new chapters dealing with the digestive secretions and intestinal absorption. In the light of increasing knowledge, much more stress is put upon the nature and mode of action of the endocrine secretions, and problems of electrolyte balance and renal function have been given more prominence. All this has led inevitably to a considerable increase in the size of the book, but to offset this it can be said that a good deal of the new material covers topics which, hitherto, have usually been regarded as falling more within the province of physiology. To biochemists, used to seeing so much of their subject included under the heading of physiology in the text-books, it is gratifying to find that, with advancing knowledge of hormone action and so on, the tables are now being turned.

This book is written primarily for students reading for a degree in biochemistry or physiology as well as for medical students, but needs of postgraduate workers have also been kept in mind. It follows that the book contains far more detail than most 2nd M.B. students can be expected to cover in the limited time they have for biochemistry. Moreover, for them, the bibliography of more than fifty pages is quite unrealistic—a few selected references to reviews would be much less daunting. It was disappointing not to find any mention of the development of British anti-lewisite. Perhaps this was modesty on the part of one of the authors (R. H. S. T.), who was associated with this fine piece of war-time research of the Oxford School of Biochemistry; but the work is still of great interest, and it affords an excellent example of fundamental biochemical research which has led to valuable practical advances in medical treatment. Perhaps it might be included in future editions.

D. C. Harrison

CARDIAC NECROSES

The Chemical Prevention of Cardiac Necroses

By Prof. Hans Selye. Pp. x+235. (New York: The Ronald Press Company, 1958.) 7.50 dollars.

This extraordinary monograph reports work done by an anonymous team of investigators (acknowledgments are confined to secretarial staff) following the discovery in 1957 that a cardiomyopathy with necroses could be induced in rats by the administration of cortico-steroids and certain electrolytes; this condition was called "electrolyte-steroid-cardiopathy with necroses", but abbreviated to E.S.C.N.

It had been known for some 14 years beforehand that steroids administered with sodium chloride could induce a hyalinizing myocarditis (without necrosis) associated with periarteritis nodosa and nephrosclerosis. The new discovery excited interest because of the prominence of myocardial necrosis and the lack of the associated lesions just mentioned. The nature of this new lesion suggested to Prof. Selye a possible relationship with myocardial necrosis induced by other means, such as potassium deficiency, administration of digitalis or vitamin D sterols, in experimental animals and occurring for reasons unknown in man.

The experiments reported here show that steroids with both gluco- and mineralo-corticoid activity are necessary for the production of this condition. Sodium chloride has no effect on its development, unless the animals are also subjected to 'stress', but sodium phosphate, sulphate, or perchlorate will induce it in the animal previously treated with steroids. Other electrolytes, it appears, have a protective quality when administered simultaneously; the most potent of these are potassium and magnesium chloride.

The bulk of the book is devoted to reporting these experiments giving the detailed results of the innumerable permutations of steroids, electrolytes, both aggravating and protective, and various unpleasant sounding forms of 'stress' applied to series of rats. The rest of the book is given to an introductory review of the historical background and to discussion of the possible hypotheses applicable to the observed results. There is finally a prophetic chapter discussing the future significance of these results in relation to the possible use of simple electrolytes to prevent myocardial necrosis in man.

The experimental study was certainly ambitious and thorough, but in some respects seems to have been over-elaborated. Prof. Selye sees great relevance in his observations on rats to certain naturally occurring conditions in man, but it is difficult to accept this. The discussion which deals with this aspect of the work and which, perhaps not surprisingly, rejects other hypotheses in favour of regarding the necrotizing cardiopathies "As 'Diseases of Adaptation' caused by some derailment of the General Adaptation Syndrome" lacks conviction and is often specious.

The following passage seems characteristic of the book: "Since the discovery of the E.S.C.N. less than a year ago, more than 30,000 rats were used in this Institute for experiments designed to clarify certain aspects of this subject. It is evident that the complete evaluation of this enormous mass of material poses almost insuperable problems and many of our present hypotheses will undoubtedly have to be abandoned in the light of future research". One wonders if the death of the 30,000 was worth while.

D. C. Deuchar

WATER RESOURCES

Ground Water Hydrology

By Prof. David Keith Todd. Pp. xii+336. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 86s. net.

The increased demand for water in recent years, in the form of major water supply and irrigation schemes in all parts of the world, has accentuated the importance of the assessment and development of ground-water resources. This trend is by no means confined to under-developed countries. In England and Wales, for example, the estimated demand for water in 1965 is one and a quarter times that of 1955. In this sense, Prof. Todd's book is timely. Too long has ground-water been considered in a woolly, qualitative fashion by engineer and geologist. The need is for a quantitative assessment of ground-water resources and development potential. The recent application of the radioactive decay of tritium to the time dating of water is undoubtedly the key to quantitative work and marks the beginning of what may be a fruitful period of study.

This readable and well-presented text is addressed to a wide group—"students, specialists in hydraulics, geologists . . ." and is a comprehensive account of fundamentals, methods and problems in the field of ground-water hydrology. The reader is led very logically through the geology of occurrence of ground-water to the equations of seepage and flow into wells. While the subject-matter is familiar, the presentation is fresh and clear. It is inevitable that pure American practice is presented at times, as in the chapters on the construction of wells and the legal aspects of ground-water, but this is more than balanced by the American contributions in the form of "Basin Wide" development and artificial re-charge, for which work Prof. Todd is best known in Europe. Both these topics are new to text-books and they make a significant contribution to the value of the book.

The extent to which ground-water technology is indebted to the petroleum industry is shown by the two chapters on surface and sub-surface investigation techniques. Highly developed resistivity, seismic and magnetic methods are benefits derived from this wealthy relation.

The text is supported by well-chosen American data and an impressive array of some seven hundred references.

E. Miller

Thyroid Radioiodine Uptake Measurement

A Standard System for Universal Intercalibration. By Dr. Marshall Brucer. Pp. ix+323. United States Atomic Energy Commission. (Washington, D.C.: Office of Technical Services, Department of Commerce, 1959.) 3.50 dollars.

THE measurement *in vivo* of the radioactive iodine content of the human thyroid is a deceptively simple procedure. Determinations of this type have been made with increasing frequency during the past twenty years, and are now widely used in the course of clinical diagnosis and radioisotope therapy, as well as in numerous investigations of thyroid function. It has long been known, however, that the calibration involved in such measurements depended critically upon the spectral sensitivity and shielding of the counting equipment used, as well as upon its geometrical relationship to the thyroid and the effects of scattering and absorption of radiation in the neck tissues.

In the course of discussions at Oak Ridge in 1953, and of subsequent inter-calibration measurements, it became clear that many laboratories and hospital departments were relying on inappropriate and quite inadequate techniques of calibration, and that gross systematic errors were being made in the estimation of the radioiodine content of the gland and therefore in the percentage uptake of any dose, since the *in vitro* measurements of the dose were not subject to corresponding discrepancies. The present publication by Dr. Marshall Brucer describes at length the effects upon the observed counting-rate of the counter shielding and collimation, the counter type and spectral sensitivity, the thyroid position, the scattering and absorption of radiation by body tissues, and the body content of radioiodine at the time of the measurement.

The book gives the text of a series of lectures on uptake measurements, and preserves their bulk and narrative character, with numerous explanatory diagrams and a non-mathematical form, and without any attempt to achieve a compact or formal analysis which would in any case be awkward in so practical and applied a problem. The material discussed will be of considerable value to those concerned with similar *in vivo* measurements and whose methods have not been subjected to detailed examination of this type.

E. E. POCHIN

The Metabolism of Sulphur Compounds

By Leslie Young and George A. Maw. Pp. 180. (London: Methuen and Co., Ltd., 1958.) 16*s*.

THIS small book, one of the Methuen "Monographs on Biochemical Subjects", succeeds admirably in its object of giving a general survey of the metabolism of sulphur-containing substances. It directs attention to the great diversity of sulphur compounds in Nature, but deals, from the metabolic aspect, with many substances which have not been found in living organisms in addition to those of natural occurrence. The reader cannot fail to note the uncertainties which still exist regarding the precise course of the most important metabolic processes, such as the desulphuration of cysteine, the oxidation of this substance to sulphate, its conversion to taurine and finally its synthesis in micro-organisms. The formation of thiosulphate is also imperfectly understood. It is perhaps significant of the way in which the study of sulphur metabolism has developed that the authors have virtually restricted themselves to higher animals and micro-organisms and that the latter are dealt with in a single chapter. Although the authors state that plants and micro-organisms are responsible for the greater part of the interconversion of sulphur compounds in Nature, practically nothing is said of sulphur metabolism in plants; several unusual compounds which occur in plants are nevertheless mentioned. The authors, experts on their subject, have covered, however, the metabolism of sulphur compounds in higher animals in the widest possible manner, and are to be congratulated on producing a critical, well-written, informative and thoroughly documented introductory text-book.

G. D. GREVILLE

Health in Industry

By Donald Hunter. (Pelican Book A441.) Pp. 288+18 plates. (Harmondsworth, Middx.: Penguin Books, Ltd., 1959.) 4*s*.

THE history of occupational disease spreads over many years and, until comparatively recently, ailments like beat knee, 'stagmus', writer's cramp, grocer's itch and cotton-workers' throat were accepted as heavenly or other visitations about which little could be done. With the growth of the industrial revolution the number of diseases multiplied so much in factory, workshop and mine that few industrial workers were able to get through a life-time free from occupational disease.

Since the industrial revolution began in Britain, it was fitting that British doctors should first assume responsibility for the health of the workers. This interesting book by a senior physician to the London Hospital, and one who has had long experience in industrial medicine, describes the genesis of industrial medical services and the way they have developed. Rightly, the author emphasizes that in this field prevention is better than cure, and that responsibility for prevention rests not only upon doctors but also upon the Government, architects, management, trade unions and the workers they represent.

T. H. HAWKINS

Fertilizers and Profitable Farming

By Dr. G. W. Cooke. Pp. xviii+122. (London: Crosby Lockwood and Son, Ltd., 1959.) 15*s*. net.

IN this small book Dr. G. W. Cooke, head of the Department of Chemistry at the Rothamsted Experimental Station, has presented the substance of a series of lectures given to farmers. It is a straightforward account of how commercial fertilizers can be used to the greatest economic advantage. This has now become a matter of major concern to most arable farmers, and, though much of it is a matter of common sense rather than applied science, experimental results obtained in research fields and laboratories have supplied valuable quantitative data on which generalized recommendations about amounts, composition and application of fertilizers to different crops can be based. Dr. Cooke has used such data to make recommendations for fertilizing the principal British arable crops and grassland, and points out what adjustments are required for different conditions of soil and climate. The book is packed with useful information, but is too short to cover adequately operations on which British farmers spend £90 million a year. It deserves a better index than it has been given.

G. V. JACKS

THE INLAND FISHERY RESEARCH STATION, SAGANA, KENYA

By Dr. VERNON D. van SOMEREN, M.B.E.
Ministry of Forest Development, Game and Fisheries, Kenya

IN the period of reconstruction immediately following the Second World War, it was realized that future fisheries development in the Colonies must be based on scientific research, and to this end various developmental grants were made both by Her Majesty's Government in Great Britain, and by Territorial Governments, to enable fishery research stations to be established in various parts of the world.

In East Africa, such grants were the origin of two interterritorial fishery research stations under the ægis of the East Africa High Commission ; one dealing with marine fisheries off the East African seaboard and based in Zanzibar (East African Marine Fisheries Research Organization), the other dealing with freshwater fisheries mainly in the great lakes of East Africa, and based in Jinja, Uganda (East African Fisheries Research Organization).

On a territorial basis, grants from the Kenya Government enabled the establishment of two small freshwater research stations in Kenya Colony. One of these, the River Research and Development Centre, was situated on the slopes of Mt. Kenya about twenty miles from Nyeri at an altitude of about 6,000 ft., and has already been described[1]. After six years work, mainly on trout fisheries[2], this station had to be evacuated in 1953 as a result of the Mau Mau disturbances ; it was re-opened again in 1956 as a trout rearing station only.

The other research station was started as a small fish culture farm, based at Sagana, some sixty miles north of Nairobi, at an altitude of less than 4,000 ft. Before any large-scale development could take place here, it also was evacuated as a result of Mau Mau activity. It was, however, possible to re-open it again in late 1955, and it has since been expanded and developed as the Inland Fishery Research Station of this Ministry. Funds were made available both from Kenya development grants, and more recently, in 1959, under the Colonial Development and Welfare Acts of the United Kingdom.

The Station now occupies an area of some 180 acres, ideally situated on the main Nairobi–Nanyuki road, adjacent to Sagana railway station, and is at present developed to the extent of 18 one-acre ponds, 7 half-acre ponds, 8 quarter-acre ponds, 3 four-acre dams, 1 two-acre dam and numerous small breeding and experimental ponds, all well served by interconnecting roads.

The principal buildings include some housing, offices, stores and a main laboratory consisting of three rooms, a library room, stores and aquarium room. This latter has incorporated in it a long running-water channel, fed by the main pond supply furrow, and fitted with an underwater observation chamber ; in this the observation of river fish can be carried out, and spawning behaviour studied on various types of artificial bottom. There are five large static aquaria, and numerous smaller tanks.

The ponds themselves are supplied by a gravity furrow taken from the Ragati River, which runs through the grounds of the Station, and is affluent on one boundary to the very much larger Tana River which drains eastern Kenya. Within two miles of the Station, there are large hydro-electric installations on the Tana, and others are being considered, which will be of considerable fishery interest.

Both the Tana and the Ragati in the vicinity of the Station have falls of up to 15 ft. in their course, and above and below these falls there is in both rivers a good selection of indigenous fish such as cyprinids, eels, siluroids, cichlids and mormyrids. In order to study the biology of these indigenous river fish, the Ragati, a few hundred yards from the laboratory, has been spanned by a concrete weir supporting a horizontal grid trap of novel design, which traps all fish running both up and down (Fig. 1).

Last year, with only intermittent operation for nine months, the downstream grid of this trap yielded a catch of 366 lb. of fish, of which 264 lb. were eels, of two Indian Ocean species ; and at this trap an intensive marking programme of migratory fish is in progress, which is already yielding much valuable information on movements in relation to water conditions, spawning biology and growth. The biology of all these river fish is very imperfectly known. A small elver trap of traditional pattern has been erected at the Ragati Falls, and has already given results of interest[15].

River-water temperature and height are recorded continuously by instrumentation ; velocity, turbidity, and conductivity once daily. On the adjacent Tana River, there are a number of small indigenous basket trap fisheries, which have already been studied[3] ; the twice-yearly flood régime of the two rivers is a subject of particular study, since the large indigenous fisheries farther downstream are entirely dependent on these, and the commercial potential of the Tana, in particular, is large.

The climatic conditions at Sagana on the Station are recorded twice daily from Stevenson screen measurements, sunshine recorder, anemometer, and evaporation pan data.

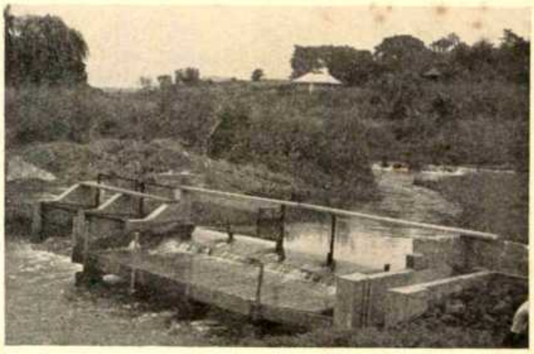


Fig. 1. Two-way fish trap on Ragati River. Upstream traps on left, horizontal grid downstream trap on right

The major part of the pond area is devoted to experimental cultural work, mainly on *Tilapia nigra*, an indigenous river cichlid ; this species has proved particularly suitable for the monosex technique of culture developed formerly at this Station[4]. Easier, and more rapid, applications of this method have already been developed[5], since it has been shown that growth potential even after maturation is very marked ; males can now be separated for fattening on the basis of breeding coloration only, and growth is very rapid even though they may already have bred.

Such sex-separation techniques, in addition to being an economic possibility, also offer a means of very precise population control in a pond, and hence are a most useful research tool in elucidating the factors which control basic growth, and hence final yield. Thus, monosex populations have already been used to determine the effect of depth and turbidity of water[6], sexual dimorphism in rate of growth[7], seasonal growth patterns[8], and effects of alterations of stocking density[9].

At the same time, attention is also being paid to different methods of cropping mixed breeding populations[10]. The value of all such experiments has been enhanced by tagging techniques[11] for recognition of individual and batches of fish, and the effect of such tagging determined[12].

At present, experiments are in progress on *Lebensraum* effects, further cropping methods, and a study of the scale structure changes found to be induced by monosex cultural procedures. Some twenty miles from Sagana, there is a large rice irrigation project, on which fish culture experiments are also in progress in co-operation with the Ministry of Agriculture, these being fertilization trials. To date, it would seem that ordinary farmyard manure and sulphate radicals (with or without nitrogen) increase final yields, though phosphates may have a depressing effect. No fertilization experiments are in progress at Sagana itself until the basic growth features of the ponds there have been finally determined, since any additives may change once and for all the basic composition of the pond.

Part of the Station is given over to the rearing and free distribution of fingerlings for elsewhere in the Colony. Other species under study are *T. mossambica*, *T. zillii*, a *Tilapia* from Zanzibar, and the new hybrid *T. zillii* × *T. nigra*, recently described[13].

Morphological, systematic and biological studies are also being made, such as that on the feeding mechanism of *T. nigra*[14]. River prawns, *Macrobrachium* spp., have recently become the subject of cultural study, since they could form a high-priced cash crop, but in general *T. nigra* still remains the main object of study, since in any such station confusion and mixing of fish can all too readily occur ; the strictest precautions are taken over this, as also over the control of predators such as birds.

The Station is staffed by one resident research officer, one fishery officer, two African laboratory assistants and ancillary staff. There is a great need for more intensive hydrological, chemical and botanical work in the rivers and ponds, which cannot be undertaken with present staff limitations, though the laboratory is now well equipped for additional techniques.

The Station works in the closest co-operation with the interterritorial organization at Jinja, with which mutual interchanges of staff have been of great value, and the work is complementary, but in no way overlapping. The Nuffield Trust has recently awarded a two-year grant to support a research worker for certain observations on *Tilapia* biology to be carried out at both stations, but to date of writing (March 1960) no suitable candidate has yet been forthcoming.

Limited guest house facilities and working space are available at Sagana for visiting workers, though it is not possible to assist any such visits financially. With both river and pond facilities available, however, Sagana offers research opportunities almost unique in the overseas territories, in climatic conditions which are by no means unpleasant.

[1] van Someren, V. D., *Nature*, **162**, 784 (1948).

[2] van Someren, V. D., "The Biology of Trout in Kenya Colony', (Gov. Printer, Nairobi, 1952).

[3] van Someren, V. D., *East Afr. Agric. J.*, **24** (4) (1959).

[4] Brown, J. M., and van Someren, V. D., *Nature*, **172**, 330 (1953).

[5] van Someren, V. D., and Whitehead, P. J., *East Afr. Agric. J.*, **25** (1) (1959).

[6] van Someren, V. D., and Whitehead, P. J., *East Afr. Agric. J.*, **25** (2) (1959).

[7] van Someren, V. D., and Whitehead, P. J., *East Afr. Agric. J.*, **25** (3) (1959).

[8] van Someren, V. D., and Whitehead, P. J., *East Afr. Agric. J.* (in the press).

[9] van Someren, V. D., and Whitehead, P. J., *East Afr. Agric. J.* (in the press).

[10] van Someren, V. D., and Whitehead, P. J., *East Afr. Agric. J.* (in the press).

[11] van Someren, V. D., and Whitehead, P. J., *Nature*, **183**, 1747 (1959).

[12] van Someren, V. D., and Whitehead, P. J., *East Afr. Agric. J.* (in the press).

[13] Whitehead, P. J., *Nature* (to be published).

[14] Whitehead, P. J., *Nature*, **184**, 1509 (1959).

[15] van Someren, V. D., and Whitehead, P. J., *Nature*, **183**, 950 (1959).

A SYNOPTIC STUDY OF INFRA-RED RADIATION OVER THE UNITED STATES

By Dr. JOHN L. GERGEN and Dr. WILLIAM F. HUCH

School of Physics, University of Minnesota

DURING the nights of May 26–30, 1959, twenty-five United States Weather Bureau stations co-operated in a synoptic study of infra-red radiation conditions across the United States. These twenty-five stations, each of which has the newer *AN/GMD*-1 radiosonde telemetry equipment, sent aloft Black Ball flights instead of the regularly scheduled wind soundings at 0600 G.M.T. The Black Ball[1] is an instrument which measures, at any height, the total radiation incident on a roughly spherical surface ; the quantity actually observed is the temperature, T_B, of a convection-shielded black absorber. This temperature is corrected for the effects of the thermal time constant and the residual convection to obtain the radiation temperature, T_r, which is a measure of the total radiation reaching the instrument.

The experiment was planned to take place on the nights of May 26, 27 and 28, 1959, and the radiation instruments and modified radiosondes were distributed to the participating stations before these dates. Some difficulty was encountered with faulty battery supplies for the radiosondes, however, and not all stations were able to launch flights on these scheduled dates. Each of the twenty-five participating stations reported results from at least one successful flight, however, and the experiment must be considered a complete success. The results include those for which a satellite experiment was previously proposed.

There are numerous ways of synthesizing the results obtained. Since the Black Ball measures the radiation temperature, T_r, at any level in the atmosphere, it measures at very high levels a temperature which is related to the total outgoing energy from the Earth and the atmosphere below. This is so because at sufficiently high levels the infra-red radiation propagated downward is completely negligible, due to the extreme tenuousness of the atmosphere still overhead. At a sufficiently high level, if the outgoing power per unit area, dP/dA, is expressed as a function of an equivalent temperature of upward propagated radiation, $T\uparrow$, then the radiation temperature at this level is given by :

$$dP/dA = \sigma T\uparrow^4 = 2\sigma T_r^4 \qquad (1)$$

so the power-loss per unit area by the Earth to space can be readily determined from the observed high-level radiation temperatures.

In practice, at temperate latitudes, the radiation temperature is observed to remain constant with increasing altitude above about 100 mb., or 15 km. From the results obtained at the stations the flights of which reached high altitudes it is possible to draw isopleths of constant power per unit area lost to space by the Earth and the atmosphere below, as a function of geography. Plots of this kind for the three nights of the experiment are shown in Figs. 1, 2 and 3. The power-loss to space varies from 15·6 to 26·6 MW /cm.² over regions which are small compared to the extent of the United States.

Several conclusions are immediately apparent from the observed results :

(1) Clouds have an overwhelming effect on the propagation of infra-red radiation through the atmosphere. The observed power-loss to space is not obviously dependent on the total atmospheric moisture or on the latitude, only weakly dependent on weather systems, and strongly dependent on cloud cover.

(2) The variation in power-loss to space over a relatively small geographical region on any one night is at least as large as the variation in the mean power-loss to space from equator to poles ; the same is true for any one location, comparing conditions from one night to the next.

(3) Since infra-red radiation is the only mechanism by which the Earth can lose to space the energy it gains from the solar illumination, the observed power-loss to space, which varies by a factor of 2 over

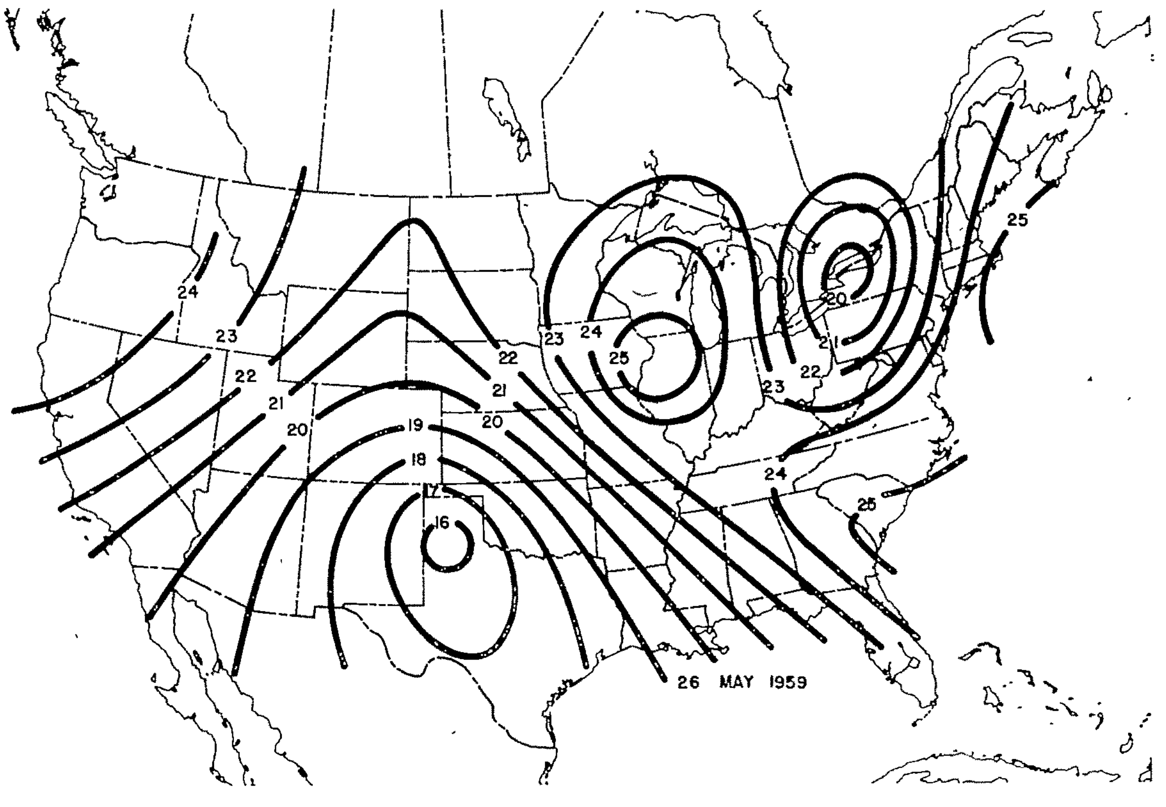


Fig. 1. Isopleths of constant power-loss to space per unit area (MW./cm.²) observed over the United States on May 26, 1959

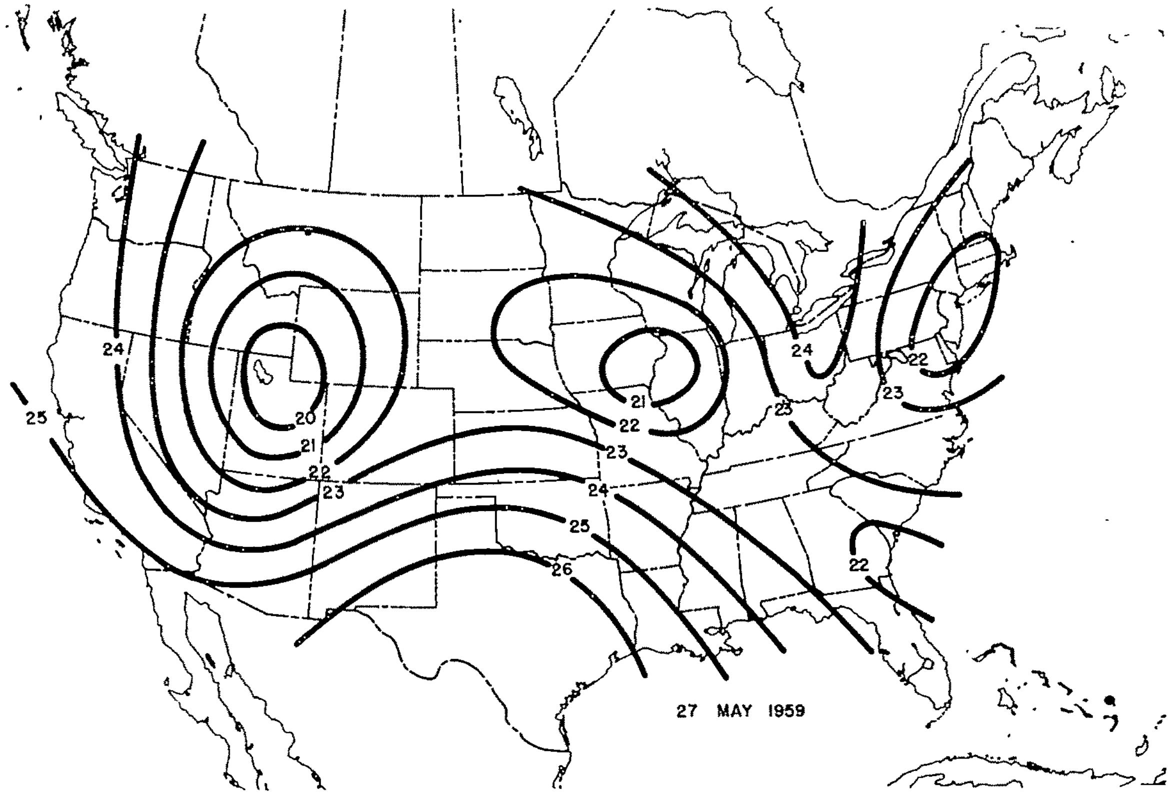


Fig. 2. Isopleths of constant power-loss to space per unit area (MW./cm.²) observed over the United States on May 27, 1959

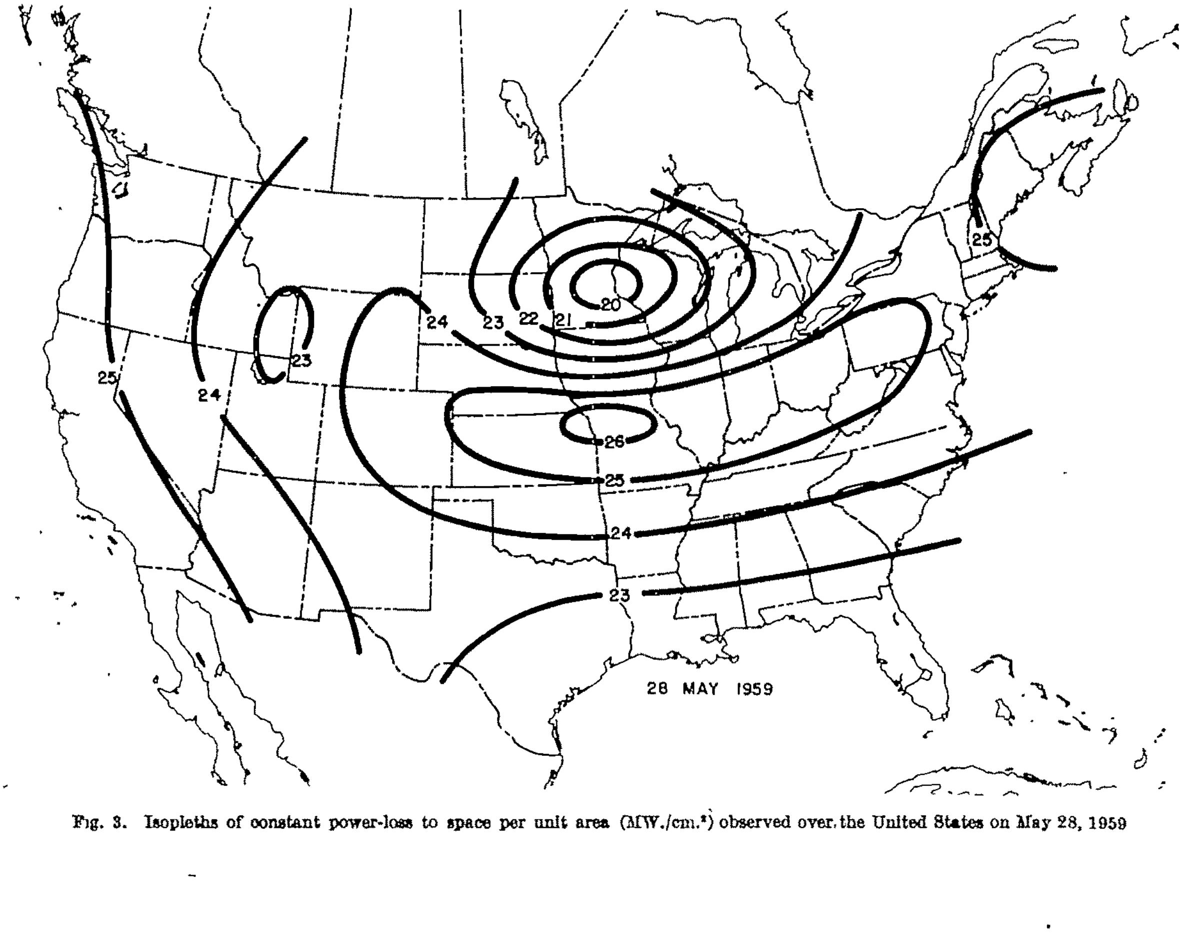


Fig. 3. Isopleths of constant power-loss to space per unit area (MW./cm.²) observed over the United States on May 28, 1959

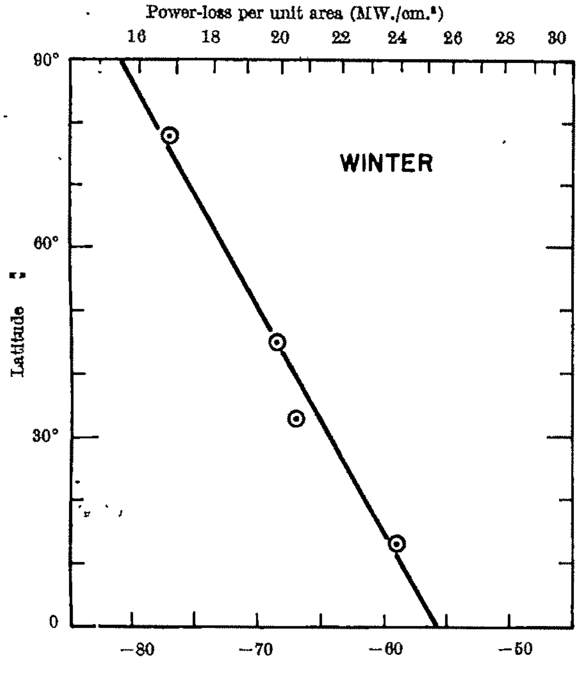


Fig. 4. Observed mean power-loss to space per unit area (MW./cm.^{2}) as a function of latitude, given in terms of an equivalent radiation temperature. Each point is an average of at least eight individual soundings which reached high altitude

very small distances, must significantly affect the formation and propagation of weather systems.

The radiation 'lows' which are observed are found to be due mainly (perhaps exclusively) to clouds existing at high levels, 300–150 mb. These clouds, in some cases, are associated with the weakest cloud patterns observed by the standard synoptic network; in most cases, it is impossible even to track the movement of these cloud patterns from the surface reports.

During the three days covering the experiment, a weak front and trough separated the drier air over the south-western United States from that in the eastern part of the country. The difference in total atmospheric moisture does not appear to affect the observed radiation pattern at all significantly.

The mean winter-time power-loss to space, expressed in terms of the observed high-level radiation temperatures, is shown as a function of latitude in Fig. 4. The points shown are from results obtained at Taguac, Guam (13° N.), Holloman Air Force Base, New Mexico (33° N.), and Minneapolis, Minnesota (45° N.), in January, and McMurdo Sound, Antarctica (77° S.), in July. Each point represents an average of at least eight soundings. This number has been found to give a good average because of the large fluctuations of the high-level radiation temperature from day to day at any one location. The mean power-loss to space from these results varies from 15·6 to 25·2 MW./cm.^{2} in going from the equator to a pole, a smaller variation than is observed on any one night across the United States. If one grants that the net radiation unbalance over latitude is responsible for the generation of weather systems and air motions, it must follow that the large radiation differences shown in Figs. 1, 2 and 3, occurring over small geographical regions, play an important part in controlling and modifying the weather systems existing there.

One further conclusion might immediately be drawn from the observations: the very nominal cost of flying the Black Ball as a standard synoptic instrument would be repaid many times over in detailed fundamental knowledge of the Earth's heat balance.

---

[1] Gergen, John L., *Rev. Sci. Instr.*, 27, 453 (1956).

NEW CLATHRATE COMPOUNDS OF THE INERT GASES

By J. G. WALLER

British Oxygen Research and Development, Ltd., London, S.W.19

A NUMBER of authors have claimed to have produced compounds of the inert gases. Thus, Crooke in 1906 postulated a reaction between molten zinc and helium gas[1]. Between 1927 and 1940 Damianovich published a large number of papers relating to compounds between inert gases and metals[2]. He claimed these compounds were formed when a glow discharge was struck between metal electrodes in an atmosphere of the inert gas at low pressure. Solid deposits were said to form around the electrodes, and these deposits were claimed to be compounds between the gas and the metal of the electrode. Boomer also claims to have formed a "tungsten helide" in the same way[3].

These processes for producing stable compounds of the inert gases have been re-examined. Discharges were passed between platinum or tungsten electrodes at about 5,000 V. in helium or argon, but no solid deposits containing appreciable amounts of the gases were obtained, although considerable sputtering of the metal of the electrodes occurred and some occlusion of gas could have taken place. Some experiments were conducted in which one electrode was a platinum gauze, with a third electrode just behind it. This third electrode was a coil of tungsten wire that could be heated. It was thought that inert-gas ions might be accelerated towards the gauze electrode, pass through it and form a compound on impact with the tungsten, either when hot or when cold. Again, no compounds were observed.

Other compounds have been claimed to exist between argon and boron trifluoride[4]. The evidence for their existence came from small differences in the freezing point of argon–boron trifluoride mixtures of different compositions. These differences in freezing point were small and were probably due to experimental errors. Later, other workers were unable to find any evidence for compound formation, under identical conditions, between boron trifluoride and argon, krypton or xenon, or between xenon and trimethylboron, sulphur dioxide, hydrogen sulphide, ether or methanol[5].

Various other chemical compounds have been claimed from time to time but none has been substantiated, and it may be concluded that the inert gases are truly inert. However, one class of compounds of the inert gases does exist, although they can scarcely be called chemical compounds since the electrons of the inert gas atoms are not involved in the binding forces which are responsible for their existence. These are the clathrate compounds.

The name 'clathrate' was coined by Powell to describe the compounds between quinol and inert gases in which the inert gas atoms fill cavities in the crystal lattice of the quinol[6]. They are therefore a solution of gas in the solid matrix. A review of much of the work on clathrate compounds has recently been published[7]. Such compounds are formed by argon, krypton and xenon as well as by other gases, when quinol is crystallized very slowly from a suitable solvent under an atmosphere of the gas at an elevated pressure. Stable solids are obtained that, on warming, evolve the gas. Recently, use has been made of these compounds as a means of handling a radioactive isotope of krypton (krypton-85)[8].

The hydrates of argon, krypton and xenon were prepared soon after the gases themselves had been isolated. The original work was published by Villard in 1896[9] and later confirmed by de Forcrand[10]. These workers showed that the inert gas hydrates conformed with hydrates of other gases in having a formula $X.5{\cdot}75H_2O$. More recent work by von Stackelberg has shown that the gas hydrates are, in fact, clathrate compounds[11–16]. Hydrates of krypton and xenon with heavy water have been prepared[17].

While the simple hydrates of the inert gases are known, little has been published on their double hydrates. This article describes some of these compounds.

Hydrates were made under elevated pressure in a stainless steel vessel or at atmospheric pressure in glass.

The high-pressure vessel was provided with a tube through which gas can be admitted under pressure and a side valve in the head of the vessel. By allowing gas to escape slowly from the side valve and maintaining the pressure in the vessel, gas was bubbled through the liquid in the vessel, thereby causing some agitation.

Argon at pressures up to 120 atm. was taken directly from a cylinder supply. For higher pressures it was fed into a 4,000 atm. compressor of the mercury piston type manufactured by Hart. Krypton and xenon were used at pressures up to 10 atm. from a cylinder supply and for higher pressures they were compressed in the Hart compressor.

Double hydrates were prepared using acetone, methylene dichloride, chloroform or carbon tetrachloride as the third component. After it had been shown that the compounds obtained were of the type described by von Stackelberg[13], having a formula $A.2B.17H_2O$ where A is the organic component and B the inert gas atom, liquid mixtures were used having the composition of 1 mole solvent to 17 moles water. Preparation of the acetone compounds was carried out by cooling in a bath at about − 30° C., while the other compounds were prepared in a cooling bath at between −5° and −10° C. To maintain a fine suspension of the halogenated methanes, about 0·01 per cent of sodium dodecylbenzene sulphonate was added to the water. The argon compounds were prepared at pressures between 200 and 400 atm., the krypton compounds at about 30 atm. and the xenon compounds at atmospheric pressure.

Table 1. TEMPERATURE AT WHICH DECOMPOSITION PRESSURE IS ONE ATMOSPHERE (° C.)

Inert gas	Organic liquid			
	Acetone	Methylene dichloride	Chloroform	Carbon tetrachloride
Argon	− 8·0	− 7·0	− 4·8	− 1·6
Krypton	− 5·0	+ 6·2	+ 9·0	+ 11·3
Xenon	+ 3·0	+ 8·6	+ 10·9	+ 13·7

The relative stabilities of the hydrates were determined by measuring the temperatures at which their dissociation pressures were one atmosphere (Table 1).

It will be seen from Table 1 that the stability increases from argon to krypton to xenon and for the third component in the sequence acetone (least stable), methylene dichloride, chloroform, carbon tetrachloride (most stable).

The xenon compounds were sufficiently stable to be formed simply by bubbling the gas through the appropriate solvent mixture cooled to 0° C. All the krypton compounds, except the acetone compound, could be obtained in the same way. However, the amount of gas taken up by the hydrates formed at atmospheric pressure was low and was usually less than 20 per cent of the theoretical amount. At higher pressures the gas content rose to about 100 per cent of the theoretical value.

In addition to the inert gas compounds, double hydrates of oxygen and of nitrogen with acetone and of nitrogen with carbon tetrachloride were prepared, but no reliable data on these compounds were obtained.

A number of other organic liquids were examined. Of these, *n*-butyl alcohol, methyl ethyl ketone, dimethylamine and ethylamine appeared to give double hydrates, none of them as stable even as the acetone compounds. Methyl, ethyl and propyl alcohols, glycol, glycerol, formaldehyde, acetic acid, ammonia, methylamine, hydrazine, hydroxylamine hydrochloride and chloral hydrate gave no evidence of double hydrate formation.

Attempts to make hydrates with benzene were also unsuccessful. This was a little surprising, since, according to the data given by von Stackelberg, the benzene molecule appears to fit the large cavities in the double hydrate lattice exactly[12]. Von Stackelberg mentions a double hydrate of benzene and hydrogen sulphide.

The crystallographic structure of some of the inert gas compounds was examined. The results showed the presence of a complex cubic hydrate, in agreement with the formula proposed by von Stackelberg, that is, one molecule of organic compound, two inert gas atoms and seventeen water molecules. The best pattern was obtained for the argon–acetone compound, which gave a cell dimension, a = 17·34 Å. This value is close to those for hydrates of type II reported by von Stackelberg[12]. All the other compounds showed patterns for both ice and hydrate in varying proportions. Generally, the cell dimensions were in the range 17·3–17·5 Å.

The double hydrates of the inert gases have not been reported before. Most of the work on double hydrates has been concerned with hydrogen sulphide as the gas. Carbon tetrachloride, chloroform and methylene dichloride have been used by earlier workers as double hydrate formers, but acetone has not been reported.

Von Stackelberg suggested criteria for the properties of organic compounds that are capable of hydrate formation[11]. In particular, they should not have strong van der Waals forces and, consequently, their boiling points should be less than 60° C.; furthermore, they should not exhibit strong hydrogen bonding and therefore should generally be insoluble in water. Acetone, of course, has a fairly low boiling point (56° C.) but it is soluble in water. Recently, von Stackelberg has described hydrates of water-soluble ethers, such as dimethyl ether and ethylene oxide[18]. He ascribed the solubility of these ethers in water to effects not associated with hydrogen bonding and therefore suggests that they fit in with his criteria for hydrate-forming molecules. However, Gordy's work on hydrogen bonding indicated that the ethers do exhibit some hydrogen bonding[19-21]. The proton-attracting power of acetone is, according to Gordy, about the same as that of dioxane, a cyclic ether, and less than that for diethyl ether. All show smaller proton-attracting power than the alcohols. It therefore seems that acetone can be classed with the ethers as an organic molecule that does not produce strong hydrogen bonds with water.

In conclusion, it may be said that a new series of double hydrates of the inert gases with acetone has been prepared. These compounds are of the same form as the double hydrates of chloroform or carbon tetrachloride with hydrogen sulphide. The inert gases also form double hydrates with carbon tetrachloride, chloroform and methylene dichloride.

I wish to acknowledge the assistance of Mr. D. Clark of the Royal Aircraft Establishment, Farnborough, Hants, in carrying out the crystallographic identification of the double hydrates.

Thanks are due to the directors of British Oxygen Research and Development, Ltd., for permission to publish this work.

[1] Crooke, W. T., *Proc. Roy. Soc.*, A, 77, 148 (1906).

[2] Damianovich, H., *et al.*, *Anales asoc. quim. argentina*, 15, 10 (1927) (*Chem. Abst.*, 21, 3290); *C.R. Acad. Sci., Paris*, 188, 790, 991 (1929); *Bull. Soc. Chim.* (5), 5, 1085 (1938); Proc. Eighth Amer. Sci. Congr. (Phys. and Chem. Sci.), 7, 137 (1940). (This is a short selection of more than thirty papers by this author and his co-workers.)

[3] Boomer, E. H., *Nature*, 115, 16 (1925); *Proc. Roy. Soc.*, A, 109, 198 (1925).

[4] Booth, H. S., and Willson, K. S., *J. Amer. Chem. Soc.*, 57, 2273 (1935).

[5] Wiberg, E., and Karbe, K., *Z. anorg. Chem.*, 256, 307 (1948).

[6] Powell, H. M., *J. Chem. Soc.*, 298, 300, 468 (1950).

[7] Mandelcorn, L., *Chem. Rev.*, 59, 827 (1959).

[8] Anon., *Sci. Amer.*, 68 (Aug. 1959).

[9] Villard, P., *C.R. Acad. Sci., Paris*, 123, 377 (1896).

[10] de Forcrand, R., *C.R. Acad. Sci., Paris*, 135, 959 (1902); 176, 355 (1923); 181, 15 (1925).

[11] von Stackelberg, M., *Naturwiss.*, 36, 327, 359 (1949).

[12] von Stackelberg, M., and Muller, H. R., *Z. Elektrochem.*, 58, 25 (1954).

[13] von Stackelberg, M., and Jahns, W., *Z. Elektrochem.*, 58, 40 (1954).

[14] von Stackelberg, M., and Frühbuss, H., *Z. Elektrochem.*, 58, 99 (1954).

[15] von Stackelberg, M., *Z. Elektrochem.*, 58, 104 (1954).

[16] von Stackelberg, M., and Jahns, W., *Z. Elektrochem.*, 58, 162 (1954).

[17] Godchot, M., Cauquil, G., and Calas, R., *C.R. Acad. Sci., Paris*, 202, 759 (1936).

[18] von Stackelberg, M., and Meuthen, B., *Z. Elektrochem.*, 62, 130 (1958).

[19] Gordy, W., and Stanford, S. C., *J. Chem. Phys.*, 8, 170 (1940).

[20] Gordy, W., and Stanford, S. C., *J. Chem. Phys.*, 9, 204 (1941).

[21] Gordy, W., *J. Chem. Phys.*, 9, 215 (1941).

INTRASPECIFIC DIFFERENTIATION: BIOLOGICAL AND SOCIAL ASPECTS

By Dr. MAX PETTERSSON

Brunel College of Technology, London, W.3

SIR JAMES GRAY has recently reminded us that it is quite 'proper' to seek rational pathways through palæontology to archæology and history; through sociological as well as biological evolution[1]; and it seems useful, in this connexion, to review the progressive differentiation among individuals of the same species.

Thus (1) slight ontogenetic differentiation will have occurred very early, between older and younger individuals. (2) Recombination, etc., gives genotypic differentiation among individuals of the same age. (3) Incipient speciation is also intraspecific; but not, of course, the follow-through of full speciation and adaptive radiation. (4) The individual of the diploid phase became different from that of the haploid; and it is fascinating that in several independent cases it was usually the diploid which then forged ahead, presumably due to the greater variability of its larger gene complement. (Within the multicellular individual, the differentiation among cells is well known; and most motile animals of more than 1 mm.[2]—or more than one million cells—are now internally administered by a nervous system including some kind of 'brain'.) (5) Perhaps several times independently, anisogamy and oogamy arose, being a differentiation in function and structure among 'individuals' of the haploid phase.

Our own ancestors had already accumulated all the above forms of differentiation by 500 million years ago. Possibly by then, or not long after, they also became (6) diœcious, as opposed to hermaphrodite, with the haploid dimorphism thrusting back round the life-cycle to affect the diploid stage as well. (The 'incompatibility' of many modern plants is a kindred extension of No. 5.) (7) Either before or after diœcy, ontogenetic differentiation often becomes much pronounced: as in cestode, insect, amphibian and mammal.

The more successful among the larger land animals and plants of the past 100 million years—the mammals, birds and seed plants—have better developed 'care of young'. So have some Hymenoptera; and *Andrena*, *Osmia* and *Megachile*, for example, as well as *Halictus*, *Bombus* and *Apis*. One kind or other of this benign activity, on the part of the diploid parent, thrusts forward round the life-cycle to encompass both the haploid phase and the younger stages of the next diploid individual as well. With dioecy, this commonly involves (8) a pronounced part-time differentiation of function between adult female and male. While exceptions are known, it is predominantly the egg-bearing adult which develops these benign parental activities which seem to be at the root of all fully developed social life[1]. It is nowadays clear that young birds and mammals learn some of their behaviour after birth, as cultural tradition. Thus in mammals, in any event, it is not uncommon for (9) the mother to be further differentiated functionally as providing the rudiments of the young's informal education and moral training[2].

Within the past million years, our ancestors have experienced several further types of differentiation as among the individuals of the same species, though two of these types arose in the Hymenoptera long before. Perhaps long after the first toolmaking, man experienced for the first time (10) a full-time differentiation of function between adult males and females. In surviving societies in the food-gathering stage, there is commonly a pronounced differentiation of this kind. For example, the larger game animals are hunted by men only; and certain domestic skills are practised by women only. This occupational differentiation between men and women may have been standard custom throughout post-glacial times, and for long before. It also occurs in some hymenoptera[3]. Some of these have domesticated certain animals and plants for food. *Homo sapiens* did, too, much later; but the effect of this on the social life of man[4] has been more profound than on any hymenopteran.

Some wasps, bees and ants achieved societies large enough to evoke (11) full-time occupational differentiation between individuals of the same sex. Indeed such intrasexual differentiation occurs in societies of *Halictus malachurus*, where the number of adult females is as low as about a dozen, though total individuals are greater. But in man, such full-time intrasexual specialization is not attested until much larger societies developed. Man achieved communities large enough for this change only after the inception of domestication, of agriculture. Thus in the ancient 'cities', full-time priests, kings and scribes arose as administrators—compare nerve cells arising in multicellular organisms—while other full-time male specialists who became differentiated included smiths, potters and merchants. The original threshold value of settlement size, for this differentiation to become conspicuous, seems to have been about 10 hectares, or 10^5 square metres, as during the Fourth Millenium B.C. in Halafian Iraq and Amratian Egypt[5]. The population of such settlements was something like $10^{3.5}$. Much later, and apparently by independent and parallel social evolution, the same occupational differentiation among members of one sex took place in the New World too. It occurred in Peru in the First Millenium B.C., perhaps earlier than the Moche culture[6]. In man, there now soon arose (12) marked economic differentiation within one region. Thus in Third Millenium theocratic Egypt, the ratio of net equivalent income for sovereign and labourer was apparently sometimes about $10^5 : 1$; while it is only a little greater than $10^3 : 1$ in the United Kingdom to-day. Similarly, there arose (13) an intensified differentiation between richer and poorer regions. Compare Sumer and Greece in the Third Millenium B.C.; Greece and Britain in the First Millenium B.C.; and Britain and India since 1760 [7].

With our increasing mastery of the environment, in recent centuries, (14) the number of different specialist occupations has again increased tremendously. But especially since 1870, two further forms of differentiation among human individuals may be discerned. While the child is still mainly left to the benign attentions of its mother, and father, for several years after weaning, it is then given ten years formal education by parent-substitutes. This is a further thrusting forward of parent-like activity, round the life-cycle. It proceeds at least to the age of 15 (United Kingdom); indeed to beyond the time when the scholar has become a sexually mature individual. Thus (15) in England and Wales to-day, nearly 2 per cent of gainfully employed persons have become differentiated in this manner, having become dedicated to the profession of education. As a consequence of this development of education, a further kind of differentiation can become much more intensified, (16) a social differentiation based on real differences in ability; which could greatly intensify the existing occupational and economic differentiation.

Most biological differentiations in man (Nos 1, 2 and 4–8, above) are fixed or very firmly rooted. But when considering the development of society in the next few centuries, the sociological differentiations (Nos. 9–16), besides No. 3, are clearly to some extent capable of adjustment. The sociologist, after much more research, will need to consider which, among various attainable conditions, promotes greater social health besides mere survival. One cannot with certainty anticipate such findings. But it may be noted that in recent centuries some sociological de-differentiation[8] has in fact occurred. Thus (3), the incipient speciation of *H. sapiens*, due to reproductive isolation of populations in different regions, has been arrested and reversed; also (10) men and women are now very much less occupationally segregated; (11*a*) persons of different occupations now have much early education in common; indeed (11*b*) modern science itself was developed by persons who combined the abilities of craftsman and scribe; (12*a*) in many countries the institutions of slavery and feudal serfdom have disappeared, that is to say, the economic differentiation between 'free' and 'un-free' has lapsed; and (12*b*) the economic ratio between richest and poorest seems, in some advanced countries, now actually sometimes less than in ancient times.

Zoologically, man is often regarded as a relatively unspecialized animal—without horns, hooves or large canine teeth—and this is regarded as a factor contributing to his success. Some species of animal have become too specialized to survive environmental change, or to evolve further. Does the condition of less rigid or extreme differentiation among individuals in society correspond, in this respect, to being less specialized?

---

[1] Gray, J, *Advanc. Sci*, 16, 3 (1959).

[2] Huxley, J S., "Evolutionary Ethics" (Oxford, 1943). Montagu, M. F A., "The Direction of Human Development" (London, 1957).

[3] Imms, A. D., "Insect Natural History" (London, 1947).

[4] Pettersson, M., *Nature*, 184, 481 (1959).

[5] Childe, V. G, "Social Evolution" (London, 1951). "What Happened in History" (Harmondsworth, 1954)

[6] Mason, J. A., "The Ancient Civilizations of Peru" (Harmondsworth, 1957).

[7] Blackett, P. M S., *Advanc. Sci.*, 14, 3 (1957). Wilson, H, "The World War on Poverty" (London, 1953).

[8] *Postscript*.—Compare the 'convergence' of de Chardin, P. T, "The Phenomenon of Man" (London, 1959).

OBITUARIES

Sir David Pye, C.B., F.R.S.

The death of Sir David Pye, on February 22, at the age of seventy-three, at his home in Surrey, caused a deep sense of personal loss to his many friends and colleagues in university and government circles. He wore his eminence in science and engineering with a modesty and tolerance which engaged the warm affection of those who had the privilege of working with him. He was a scientist engineer who devoted much of his working life to the thermodynamics of the internal combustion engine and its design and construction. His wide knowledge and experience found their expression in "The Internal Combustion Engine", the standard English text-book and work of reference on the subject.

His heart was in university life. Educated at Tonbridge School and Trinity College, Cambridge, he began his career in 1909 as a lecturer in engineering at Oxford, and Fellow of New College, and ended it as Provost of University College, London, in 1951. He faced adverse circumstances and overcame formidable difficulties in both universities.

At Oxford, in the first decade of the century, engineering was fighting for its existence. Pye illuminated the scene in the course of his presidential address in 1952 to the Institution of Mechanical Engineers: ". . . There was one college where, for four years no student ever dared to risk the wrath of the Master, that was known to be impending for anyone who might be so rash as to suggest that he wished to take a degree in engineering science. Then, in 1913, we were astonished to receive a registration from the college in question. Vain jubilation! The wrath from heaven in the shape of the Master of the college, magnificent in full academic robes, was next morning at the doors of the engineering laboratory, demanding that his erring lamb should return to the classical fold. We never saw our potential student again".

One can almost see the quizzical look on Pye's face. He could not have been altogether surprised. Anger never came easily to him, but he must have resolved then and there to hang on. Throughout his life his invariable courtesy and reasonableness concealed a strong tenacity of purpose. Oxford engineers have good reason to be grateful to him.

The difficulties he faced at University College (the first institution in Great Britain to appoint a professor in engineering) were of an altogether different kind. He became Provost in 1943 of a bombed and dispersed College. It existed more in spirit than in fact, and when the War ended, the problem of satisfying the multitude of new and returning students called for a miracle. There was no miracle. There was only the diligent, steady, painstaking day-to-day effort of David Pye, tolerant as ever with those who wanted more than was humanly possible, and stimulating to those who were ready to share the real work. Before his period of office came to an end, the College had more than re-established itself as a great centre of learning and research. His anxieties were at times overwhelming, but his labours must, in the end, have given him a deep satisfaction.

Pye left Oxford in 1914 at the outbreak of war to become an experimental officer in the Royal Flying Corps. The then professor of engineering at Cambridge, Bertram Hopkinson, soon picked him out, and on demobilization in 1919 he went to Cambridge as Fellow of Trinity College and lecturer in engineering. There followed a most fruitful six years of teaching and research on volatile fuels pursued, largely during vacations, in collaboration with the late Sir Henry Tizard and Sir Harry Ricardo at his works at Shoreham.

His career in the Scientific Civil Service began in 1925 as deputy director of scientific research in the Air Ministry at the invitation of Mr. H. E. Wimperis, the first director. Wimperis and Pye laid the foundations of a vigorous and lively research department which was to prove its worth in the critical years ahead. The shadow of war was lengthening when Pye succeeded to the directorship in 1937, and again he faced a period of difficulty and anxiety. Air warfare and air defence loomed large in strategic importance, embracing many fields of science and engineering. New weapons, devices and equipment found their way into the Royal Air Force, and when Pye retired in 1943 he had carried the burden of the day, and what he set out to do was largely accomplished.

Pye disliked damping enthusiasms in others. His imagination gave him a real flair for uncovering other peoples' talents, and much of his life was spent in contriving circumstances favourable to their development. His interests and activities were wide, ranging from enthusiasm for mountaineering and rock climbing, to the love of music and musicians. Many young professionals and amateurs owe much to his warm encouragement.

He married in 1926 the daughter of C. Moore Kennedy, Virginia Frances, who nursed and comforted him throughout the long illness at the end of his life. Our sympathies go out to her, and to her two sons and daughter. BEN LOCKSPEISER

Prof. B. Gutenberg

With the death of Beno Gutenberg on January 25, seismology loses an outstanding figure. Throughout an academic career of nearly half a century he maintained an astonishingly large output of high-grade papers covering the whole range of seismology, especially in connexion with the propagation of seismic waves through the interior of the Earth. Indeed, it was truly remarked by Prof. Perry Byerly on the occasion of the presentation to Gutenberg of the Bowie Medal of the American Geophysical Union: "It is rare that anyone writes a paper in seismology without referring to him". Of his many achievements perhaps his most celebrated was the calculation in 1912 of the radius of the so-called liquid core of the Earth, usually referred to as the Oldham–Gutenberg core, the existence of which had been inferred by R. D. Oldham in 1906; considering the roughness of the existing data and the tentative methods then available this stands out as a veritable *tour de force*, and calculations by Jeffreys with a large body of precise data, embodying reflexions from the core that were not known when Gutenberg began hi researches, have shown that only a trifling correction is needed to Gutenberg's early result. It is somewhat invidious to attempt to single out any one topic from the vast array of subjects on which he worked in later years, but mention should be made of the important impact produced on geological and geophysical science by the long series of studies, made jointly with C. F. Richter, of the magnitude and distribution of earthquakes, a work that has given an enormous impetus to the study of the seismicity of the Earth.

Beno Gutenberg was born in Darmstadt on June 4, 1889. His training at the University of Gottingen afforded him the best possible ground-work at that time in the young science of seismology. Already well equipped with a wide and deep pre-university education, he attended mathematical lectures by Hilbert, Klein, Minkowski, Landau, Born, Wiechert and Weyl. In geophysics he worked on microseisms under Wiechert, who indeed covered in his lectures a wide range of geophysical studies. Jointly with Geiger, Gutenberg developed the Zoppritz method of using the amplitudes of seismic waves to study the internal structure of the Earth, and received his Ph.D. degree in 1911 at the age of twenty-two. After a further year of advanced study, during which he completed his paper on the Earth's core, and a year in the Army, Gutenberg was appointed assistant at the International Seismological Central Station at Strasbourg, which at that time was in Germany. In 1924 he became director of the Feldberg (Taunus) Seismic Observatory of the University of Frankfurt, at which University he later became a professor. During these years, in addition to the heavy load of observation, writing and teaching, he directed the family business inherited from his father.

In 1931 he was appointed professor of geophysics and meteorology in the California Institute of Technology, Pasadena; here he played a notable part in the development of the Seismological Laboratory, of which he was director from 1947 until his retirement in 1957.

In later years honours fell thick upon him, both from European and from American academies. During 1951–54 he was president of the International Association of Seismology and Physics of the Earth's Interior.

Gutenberg was a kindly man, ever ready to help a fellow scientist and to indulge in a scientific *tête-à-tête*, and his accurate and retentive memory made him a pleasant and interesting companion. Visitors to Pasadena received a warm and hospitable welcome from Prof. and Mrs. Gutenberg; theirs was indeed a happy and cultured home. Gutenberg had a large collection of records of classical music, and those visitors who shared his taste appreciated the privilege of the musical intimacy that he so freely extended. To the last his powers of original work remained unimpaired; seismologists will mourn the loss not only of a great man but also of a valued friend.

R. STONELEY

Dr. Otto Schindler

DR. OTTO SCHINDLER, who died suddenly on September 4 at Poitiers, while on a collecting expedition, had come to occupy a leading position among the small band of European ichthyologists.

He was born on December 1, 1906, and spent his childhood in Vienna and the Sudetenland. During 1925–30 he studied in Vienna under Versluys and gained his doctorate in 1930 with a thesis on fishery biology. For a short time he worked in the Vienna Museum; but the greater part of his mature work was done at the Zoologische Staatssammlung at Munich, where he attained the rank of *Oberkonservator*.

At Vienna it fell to his lot to describe two species of small fishes collected by Dr. V. Pietschmann over Hawaiian reefs. Although no more than a couple of centimetres long and showing many larval characters, these fishes included ripe males and females. Dr. Schindler directed attention to their pædogenetic characters, but placed them in the genus *Hemirhamphus*. When later Giltay found one in New Guinea waters he formed other views on their relationships and created a genus *Schindleria* and family Schindleriidae for them. More recently, Gosline (1959) made of them a distinct suborder, relating them tentatively, as Giltay did, to the blennies. Schindler himself was stimulated by them to make a comparative investigation of the kidneys of larval marine fishes, for which he paid a special visit to the Plymouth Marine Laboratory to collect material.

Schindler's other fields of interest were the ecology of the freshwater fishes of the Austrian and Bavarian lakes and the fish-fauna of South America. He took part in two expeditions to the latter continent and studied the collections of the early expeditions in Vienna and London. His field book of German freshwater fishes, "Unserer Süsswasserfische" (1953 and 1959), was translated into English and edited in 1957 by Dr. P. A. Orkin.

As a result of Dr. Schindler's initiative and organization the German ichthyologists produced a quarterly "Ichthyologischer Schriftennachweis", a classified list of titles, by which they helped each other to keep abreast of current ichthyological publications. Without his leadership this and much else in German ichthyology come to an end. All who knew him miss a valued colleague and friend. Frau Dr. Schindler, a scholar in another field, is left to mourn him with their daughter and two sons, the eldest just of university age.

E. TREWAVAS

Dr. L. O. Kunkel

LOUIS OTTO KUNKEL, faculty member of the Rockefeller Institute during 1931–49, was actively conducting scientific research in the field of plant pathology at the Institute up to the time of his death on his farm at Newtown, Pa., on March 20.

Dr. Kunkel established the Division of Plant Pathology at the former Princeton, New Jersey, branch of the Rockefeller Institute in 1931 and influenced significantly the growth of knowledge concerning the relationship of viruses to plant diseases. Bringing to his research theoretical knowledge and practical experience in the United States and Hawaii, he conducted research which shed new light on the nature of the virus and also led to new understanding of disease in peaches and other fruits, cranberries, maize and carrots.

Dr. Kunkel helped to foster the work of his associate, Dr. Wendell M. Stanley, who, in conjunction with Dr. John H. Northrop, shared the Nobel Prize in chemistry in 1946 for crystallizing the tobacco mosaic virus. Dr. Kunkel, in administering his laboratory, gave his junior associates a free hand in investigating the cause, transmission, pathology, treatment and prevention of a number of plant virus diseases of great economic importance and theoretical interest.

It was shown for the first time in his laboratory that several different yellows-type diseases (such as the virus disease of asters known as 'yellows') could be cured by heat-treating the plants in which they occur naturally or to which they may be transferred. Various virus diseases of the peach were cured in this manner as well as some virus diseases in cranberry, periwinkle, and the potato.

Dr. Kunkel and his associates discovered the transmission ability of leafhoppers in spreading virus disease, the ability to kill such infective activity by heat treatment, and the restoration of the infective ability to the insect. He charted out carefully the infective ability of various virus strains of such diseases as the tobacco mosaic virus or yellows-type, and demonstrated for the first time how a leafhopper infective for one strain was unable to pick up and transmit the other. He showed how a parasitic plant, the dodder, can transmit virus diseases from woody plants to herbaceous plants in which they are more easily studied. He also demonstrated that peach yellows, one of the oldest and best-known plant diseases, is transmitted by a leafhopper of a certain species. He demonstrated the same kind of transmitting factor for corn stunt, a yellows-type virus disease of maize.

Born in Mexico, Missouri, on May 7, 1884, Dr. Kunkel received the bachelor's and master's degrees from the University of Missouri, and the Ph.D. degree from Columbia University in 1914. He held a travelling fellowship in Europe, served as a pathologist in the Bureau of Plant Industry, U.S. Department of Agriculture, and started to study the virus diseases of plants.

Working with the Hawaiian Sugar Planters Association, he served as associate pathologist to study the problems of mosaic disease of sugar cane. He then became a staff member of the Boyce Thompson Institute in Yonkers, New York, in 1923 and gathered around him a group of young men trained in several fields of scientific investigation. At the Boyce Thompson Institute, Dr. Kunkel made important contributions to our knowledge of the mosaic diseases of tobacco, sugar cane and Indian corn as well as asters yellows.

He was a member of several scientific societies including the National Academy of Sciences, the Botanical Society of America and the American Philosophical Society.

NEWS and VIEWS

New Foreign Members of the Royal Society

THE following have been elected foreign members of the Royal Society: Prof. G. W. Beadle, chairman of the Division of Biology, California Institute of Technology, Pasadena, California, distinguished for his outstanding contributions to genetics; Prof. Ragnar A. Granit, professor of neurophysiology, Kungl. Karolinska Mediko-Kirurgiska Institutet, Stockholm, distinguished for his researches on the physiology of vision and neurophysiology; Prof. G. B. Kistiakowsky, professor of chemistry, Harvard University, Cambridge, Massachusetts, distinguished for his work in chemical kinetics of gaseous reactions, photochemistry, thermochemistry, and structure of polyatomic molecules; Academician L. D. Landau, professor of theoretical physics, S. I. Vavilov Institute of Physical Problems, Moscow, U.S.S.R., distinguished for his contributions to theoretical physics.

The Zoological Society of London: Nuffield Institute of Comparative Medicine

THE Nuffield Foundation has made a grant of £100,000 to the Zoological Society of London to found an Institute of Comparative Medicine, and to provide two senior research fellowships. In expressing its deep gratitude, the Council of the Society has asked that the name of Lord Nuffield be associated with the name of the Institute. The Society already has a modern animal hospital, and the new Institute will provide a much-needed opportunity to increase knowledge of disease in animals, and so to maintain the health of the Society's collections at an even higher degree of excellence than at present. Much unique material from the Society's collections and elsewhere is available for study, and full use can now be made of opportunities for research that have not been fully exploited in the past owing to the lack of the facilities and personnel. A Committee, including Sir Roy Cameron, Dr. E. Cotchin, Mr. R. Fiennes, Dr. R. E. Glover, Prof. A. Haddow, Prof. R. Hare, Dr. L. Harrison Matthews, Mr. J. N. Ritchie, Dr. J. G. Smith, Prof. G. Paling Wright and Sir Solly Zuckerman, has been appointed to advise the Council on the organization of the new Institute, the terms of reference of which are to study disease in all its comparative forms.

Mr. Richard Llewelyn Davies, director of the Nuffield Foundation Division for Architectural Studies, and professor elect of architecture in the University of London, will design the new building in accordance with the over-all plan for the Gardens that has been devised by Sir Hugh Casson in collaboration with Mr. F. A. Stengelhofen, the Society's resident architect. In planning the Institute, it is hoped that effect can be given to conclusions drawn from an exhaustive study of the laboratory designs for which the Nuffield Foundation has been responsible over the past few years.

The new Institute, which it is hoped will be in operation in about two years time, is to be built as part of a new block immediately west of the main offices. It will form the central part of the block, the east wing of which will provide a new meeting room for the Society. The western wing will be added at a later date and will house the Education Centre. It is proposed that the Institute itself will have a frontage of about 85 ft. and a depth of 50–60 ft., and will have a basement, ground floor, and two upper floors. The foundations will be constructed so that an additional floor can be added at a later date if required. The floor area, including the basement, will be about 18,200 sq. ft. Twelve laboratory units each of 300 ft. are planned, with offices, technicians' rooms, photographic rooms, workshops and stores. In addition there will be weighing and sterilizing rooms, a media kitchen, chromatography, balance and other specialized instrument rooms, hot and cold rooms, animal accommodation, seminar and common rooms.

Agricultural Research Council: Weed Research Organization

THE Agricultural Research Council is setting up a new Weed Research Organization which will assume some of the present functions of the Council's Unit of Experimental Agronomy at the University of Oxford. The new Organization has been created for the purpose of extending the applied research which lies between the basic scientific investigations being carried out at the Unit and the introduction of new methods of weed control in agriculture and horticulture. To provide the facilities required to enable the Organization to carry out this work, the Council has acquired a farm near Oxford, where a laboratory and other buildings are to be provided. The director of the new Organization will be Dr. E. K. Woodford, who is at present assistant director, under Prof. G. E. Blackman, of the Council's Unit of Experimental Agronomy. The Organization will maintain close liaison with the Unit, which will continue its main purpose of fundamental research concerning the factors which determine the selective action of compounds toxic to plants.

Nuffield Foundation: Unit for the History of Scientific Ideas

THE Nuffield Foundation has formed a Unit for the History of Scientific Ideas which will produce educational films and books under the direction of Prof. Stephen Toulmin, formerly professor of philosophy in the University of Leeds. A sum of £60,000 has been allocated for the Unit. The Foundation believes that a better public understanding of science would be assisted if discussion of the history of scientific ideas had a larger part in the educational curriculum and in intellectual life generally. A place is being made for the subject at some schools and universities; but there is not enough educational material available at levels suitable for sixth forms and undergraduates. The first aim of the Unit will be to produce a basic collection of teaching films and text-books for use in sixth forms and introductory university courses in the history and philosophy of science.

Before the Unit was conceived, the Nuffield Foundation supported the production by Prof. Toulmin and Miss Goodfield of a colour film "Earth and Sky", which has been well received by educationists. The first two films to be made by the Unit are likely to be on the theory of matter and evolution, and the Hutchinson Group are to publish a series of books under the general title "The Ancestry of Science" covering the same ground as the films. A series of monographs at a more advanced level is also to be published, and some books with colour illustrations for secondary modern schools are also envisaged.

The Textile Institute

IN his presidential address to the Textile Institute at its fiftieth annual general meeting at Leicester on April 22, the Earl of Derby stressed the value of the Institute to the textile industry. This was shown by the way in which the Institute's activities had flourished and its membership been maintained in a period of reorganization when many mills had closed, and it was encouraging to note the interest employers' organizations were now showing in technological education. Management, he said, must be prepared to spend both time and money in making certain that the right number of young men of the proper outlook are encouraged to enter the industry, and trained when in it, or that they would be ready to guide the industry in a future when other countries have developed technical resources equal to those of Britain. This could not be achieved cheaply: the industry must be prepared to invest in men as well as in machinery and it was a matter of vital concern to the industry that a professional man should keep his knowledge up to date and contribute to the development of his technology by playing his full part as a member of the Textile Institute. Lord Derby referred particularly to the technological work undertaken by the Institute, for example, in the preparation of standard methods of test for publication by the British Standards Institution, in the Institute's own publications such as "Terms and Definitions", its *Transactions* and its *Abstracts*. Appealing for more generous support from the industry, he suggested that the income of the Institute could usefully be doubled.

The Wandering British Scientist

IN a written answer to a question in the House of Commons on March 28 as to what steps were being taken to stop the gradual loss of scientific personnel from the United Kingdom to the United States, particularly in view of the number of scientists who had left the Jodrell Bank radiotelescope project, the Minister of Education, as representing the Minister for Science, said that the general problem of emigration of scientific personnel had been under consideration for some years by the Advisory Council on Scientific Policy. Since 1958 steps taken by the Civil Service Commission and the Atomic Energy Authority to recruit British scientists in America had met with some success.

Payment of Scientific Civil Services

State Service of April 1960 contains the annual report for 1959 of the Institution of Civil Servants, issued in readiness for the annual meeting of the Institution at Eastbourne during May 23–25. The year was marked by a 3·5 per cent pay supplement on salaries up to £2,000, the Coleraine Committee's recommendations for the higher Civil Service and their acceptance by the Government, and a 10 per cent increase in night subsistence allowance with the commencement of a review of all subsistence arrangements. The report regrets the apparent downward trend of the status of professional scientific and technical officers in the Atomic Energy Authority, also some steps which might indicate an intention to minimize the role of the Department of Scientific and Industrial Research in scientific research. The Government's attitude to salaries in general is criticized, as is the continued refusal to make any move towards counting unestablished service in full for superannuation purposes. The membership of the Institution on December 31, 1959, is given as 51,632, and the issue notes that the present general secretary will be retiring after the 1961 Conference. Reference is also made to the possibility that technical Civil Servants may take a day off simultaneously in view of their growing impatience at handling pay requests.

Apprenticeship Training in Britain

IN reply to a question in the House of Commons on April 11, the Minister of Labour, Mr. E. Heath, said he is proposing to set up a small number of classes in Government training centres to provide first-year apprenticeship training. This training would only be given to boys accepted as apprentices by firms, and preference would be given to boys from firms which had hitherto found it impracticable to undertake apprentice training or to increase their present number of apprentices. No charge would be made for the training provided, but employers participating in the scheme would be required to undertake to pay the wages of apprentices during the year and to continue the boys' training afterwards under the normal industrial arrangements. The usual provision for day release would apply during the year. The scheme, he said, has been approved as a whole by the British Employers' Confederation and the Trades Union Congress, and the establishment of classes in engineering has been agreed by employers and trade unions in that industry. Mr. Heath said he proposes to extend the scheme to other trades and he is already in touch with the building industry.

The first training places will be available early this summer at eight Government training centres, and he expects to set up classes at other centres later this year, making a total of about 300 training places. The scheme will not in itself make a large numerical contribution to the expansion of training for skilled occupations during the 'bulge' years and is intended primarily to demonstrate a pattern of training which should appeal particularly to the small firms with only limited opportunities for undertaking training themselves. In reply to further questions, the Minister confirmed that the course would be a full-time one for the whole year, except for the normal arrangements for day release. A leaflet has been prepared for distribution to all firms concerned within the range of the Government training centres where training is to be given. It is not a pre-apprenticeship scheme and is governed by normal industrial arrangements. As to expansion, Mr. Heath said that the response from the industries involved must be considered. The first centres are at Aintree, Birmingham, Bristol, Cardiff, Millington (Glasgow), Leeds, Letchworth and Long Eaton. A similar statement was made in the House of Lords on the same day.

Scientific Information News

WITH the second volume, the title of *Science Information News* issued by the U.S. National Science Foundation is changed to *Scientific Information Notes*, which is regarded as more descriptive of its contents. The purpose of the periodical remains unchanged, and No. 1, Vol. 2 (February–March 1960), includes a note on the work to be undertaken by the Association of Special Libraries and Information Bureaux in Britain on the comparative efficiency of four indexing systems with the aid of a grant from the National Science Foundation. The Foundation is also making a survey of the publication practices of American industrial corporations, including some 200 of the largest companies undertaking fundamental research, and the survey data will be processed and analysed by the Foundation's Office of Special Studies.

Press Publicity for Scientific and Technical Conferences

A CONCISE, well-written "Guide to Press Arrangements for Scientific, Medical and Technical Conferences" has been prepared by the Association of British Science Writers, and is being distributed by the British Association for the Advancement of Science, 18 Adam Street, Adelphi, London, W.C.2. (Pp. 31, 2*s*.) Edited by Ronald Bedford, the pamphlet deals successively with the impact of the Press on the public and on business; general points such as what journalists expect, the functions of the press officer and the various types of conference; the varied types of press representatives who may be present, such as the news agency reporters, journalists from the national and the evening newspapers, radio and television reporters, and the representatives of technical journals, the local press, the foreign press and free-lance journalists. A section outlining the organization required follows, which centres on such details as the equipment of press rooms and the arrangement of press conferences and briefings. There is a section on press summaries and finally some suggestions are collected for the guidance of the press officer.

Manchester Public Libraries

THE one hundred and seventh annual report of the Manchester Public Libraries Committee, covering the year ended March 31, 1959, records a continuing increased demand: issues from the lending libraries rose to 5,675,301 volumes, from the reference libraries to 1,226,183 volumes, and the total book stock is now 1,152,827 volumes (pp. 28 + 4 plates. Manchester: Manchester Public Libraries, 1960). Considerable work was carried out on the Great Hall, the Technical Library, the Commercial Library and the Central Lending Library but the increased seating in the reference library did little to diminish overcrowding. Seating in the Technical Library was more than doubled and the number of volumes on the open shelves was increased from less than 8,000 to more than 25,000, while a lending section was added. There was a pronounced increase in information work and inquiries, and 459 books were supplied to other libraries, mainly in the north-west of England, and 128 books were obtained from outside sources.

Scientific Techniques in the Conservation of Paintings

IN his recent lecture to the Royal Society of Arts entitled "Scientific Methods in the Care of Works of Art", Mr. F. I. G. Rawlins, recently scientific adviser to the Trustees of the National Gallery, reviewed the advances that have been made in the application of scientific techniques in the conservation of paintings during the past twenty-five years. The basic problems, from the point of view of the scientist, are largely those of chemical physics, because the materials of painting are essentially of a colloidal nature, and the process of cleaning which involves the diffusion of solvents through films is itself a lesson in chemical physics. The physical techniques discussed were soft X-rays (that is to say, at about 10 kV.) which give improved results when thin paint-films are being examined, and infra-red photography, which may often reveal an image of what lies under discoloured varnish. On the chemical side, reference was made to improved methods for the preparation of paint cross-sections, and development in the National Gallery of a special reversed-phase system of chromatography as a method of analysis for paint media. The importance of fundamental research was emphasized. As illustrations of this kind of work, reference was made to experiments being carried out to develop picture varnishes having a longer life than the traditional varnish based on natural resins, and also the precise action of solvents on paints and varnishes which is in principle fundamental to a proper understanding of the processes involved in the cleaning of pictures and other painted objects. Mr. Rawlins also pointed out that international co-operation in this field has substantially improved, as is exemplified by the increasing influence and activity of the International Council of Museums, the foundation (in 1950) of the International Institute for the Conservation of Historic and Artistic Works, and the recent formation of the New International Centre in Rome.

Fluoridation of Drinking Water

THE attitude of different countries to fluoridation of water as a means of preventing dental caries has been described by Gerald H. Leatherman and J. A. Ellis, secretary-general and his assistant, respectively, of the Fédération Dentaire Internationale (*Health Educ. J.*, 17, No. 3; 1959). The majority of health authorities throughout the world are in favour of fluoridation. They include: Austria, although a few State authorities are undecided; Canada; Great Britain, where the Government has gone on record through the Minister of Health approving fluoridation as a proved method of prevention; Greece; the East German Democratic Republic; Hong Kong; Republic of Ireland; New Zealand, where the Department of Health is campaigning for fluoridation and the Minister of Health has publicly stated his support of fluoridation, although the Government has made no pronouncement either for or against the measure; Norway; Spain; the United States; and Yugoslavia (Republic of Slovenia), where the political, as well as health authorities, are financially supporting fluoridation and propagating it.

In the main, the following countries support fluoridation: Australia, Belgium, Czechoslovakia, Northern Ireland, Italy, Switzerland, and the Union of South Africa. The following countries are undecided: Denmark, Egypt, Finland, France, Japan, Hungary, Netherlands, Sweden. Opposed to fluoridation are the German Federal Republic, where the health authorities consider the addition of fluorine as dangerous, as fluorine is only harmless in small quantities and there exists a possibility of overdosage as a result of human incompetence; Indonesia, where there are no experts to supervise fluoridation of drinking water and insufficient personnel to practise fluoridation by the topical application method, while only a few big cities have a central water supply; in Latin America as a whole, there appears to be an absence of initiative on the part of many health authorities, as well as the absence of any movement to stimulate the interest of the municipalities.

Biological Standardization of Drugs

THE Research Defence Society, 11 Chandos Street, Cavendish Square, London, W.1, has issued a new pamphlet (No. 10, April 1960, pp. 6) entitled "The Use of Laboratory Animals in the Standardization of Drugs". This explains, by means of straightforward questions and answers, what is meant by standardization of drugs, why it is necessary, why animals must sometimes be used, and what legal control is imposed in tests of this kind.

Exhibit of Invertebrate Evolution

A STRIKING exhibit entitled "These are Invertebrates" was opened at the Australian Museum in July 1959. It is 32 ft. long and 9 ft. high, and shows the main groups of invertebrate animals and their relationships to each other traced by a system of fluorescent plastic lines and lights which flash in sequence, some eight hundred light globes and ultra-violet light being used. Labels outline the characteristics of each major group and the scientific and popular names of the individual species are shown. A panel informs the visitor how to use the exhibit. Of the total of 215 species displayed, fifty-five are paintings and forty-three are models.

Photoperiodic Response of Some Tropical Plants

IT was formerly thought that the small variation in day-length in the tropics could have no appreciable photoperiodic effect on native plants. This has now been refuted by Indian work on rice and other plants. E. Njoku of the Department of Botany, University College, Ibadan, Nigeria, has tested whether certain plants are sensitive to photoperiod when grown at Ibadan (latitude 7° 26′ N.) with a day-length varying from 11 hr. 41 min. in December to 12 hr. 33 min. in June (Njoku, E., "The Photoperiodic Response of Some Nigerian Plants", *J. West African Sci. Assoc.*, 4, No. 2, 99; August 1958). The plants used fell into two main groups, day-neutral and short-day plants. No long-day plants were found. The results suggested that some plants had a critical day-length of less than 12 hr. Others flowered in 12 hr. but not 14-hr. days, indicating a critical day-length between 12 and 14 hr. A critical photoperiod of 12 hr. or less would make it possible for day-length to control flowering at the latitude of Ibadan.

Using day-lengths of 11½–12½ hr., that is, the extremes of day-length at Ibadan, it was shown that late okra (*Hibiscus esculentus*) and *Sphenostylis stenocarpa* showed a critical day-length of less than 12½ hr., and hence did not flower in the long 'summer' days at this latitude. Early okra and *Phaseolus lunatus*, on the other hand, flowered in both 11½-hr. and 12½-hr. days as well as in the natural day-length, but their response was quantitative in nature, the time to flowering being longer in the longer days. In order to test the effect of natural changes in day-length, successive monthly plantings were made in the field throughout the year. The results support the conclusions drawn from the experiments in which day-length was artificially controlled. Hence the photoperiodic response is of practical significance in the latitude of Ibadan. Plants of both groups grown under field conditions showed a marked shortening or lengthening of the vegetative period as the natural photoperiod decreased or increased. A difference of 15 min. may mean flowering or only vegetative growth.

Geology in the U.S.S.R.

AN announcement of forthcoming publications issued by the Academy of Sciences of the U.S.S.R. lists 120 books on geology to be published in 1960, excluding periodicals, popular works, and reprints. Much the same order of output appeared last year from the State Publishing House for Geological Literature ("Gosgeoltekhizdat"); and taking into account the production of other agencies, it seems likely that the geological monographs and text-books published within the U.S.S.R. now number close on five hundred volumes annually. Since much of this literature is little known in the West, a special interest attaches to a paper by Prof. S. I. Tomkeieff on "The Progress of Geology in the U.S.S.R." (*Liverpool and Manchester Geological Journal*, 2, 474; 1960).

This gives the first reasonably full account in English of the extensive geological work which has been conducted in the U.S.S.R., describing the organization of teaching and research and giving brief notes on progress in the various branches of the science. Although the scope of his short paper is immense, Prof. Tomkeieff brings to it a lifetime study of Russian literature, with the result that he opens new avenues to all geologists who are prepared to surmount the language barrier.

Magnetic Annealing

THE phenomenon of magnetic annealing, that is to say, the production of directional properties in a homogeneous alloy by allowing it to cool from a high temperature in the presence of a strong magnetic field, is well known from the early experiments of Bozorth and Dillinger on soft magnetic materials and those of Oliver and Shedden on hard ones. But the reasons for the establishment of such magnetic anisotropy have always been somewhat obscure. According to an announcement issued by the Bell Laboratories, recent experiments have thrown some light on the problem in the case of permalloy, which is in great demand in the form of fine tapes in electronic memory devices, where their switching times under suitable conditions are very short. The new experiments indicate that the magnetic annealing is not effective unless about 14–20 parts of oxygen per 10^6 are present in the permalloy, and there is little beneficial change in increasing the oxygen content beyond these limits. While the mechanism by which the oxygen acts is not clearly understood, it is suggested by Heidenreich, Burbank and Nesbitt that atoms are deposited on a crystal stacking plane at high temperatures, and so result in a displacement or dislocation of the next plane of atoms in the alloy. Whether this suggestion is correct or not, it certainly appears that close control of oxygen content is necessary.

A Commercial Thermoelectric Cold Box

IT is well known that many firms in Great Britain, the U.S.S.R. and the United States of America are working on the development of a practical form of thermoelectric refrigeration; also that the General Electric Co., Ltd., at their research laboratories at Wembley, have carried out extensive investigations on the fundamental properties of bismuth telluride and other semiconductor compounds. It is therefore not surprising to learn in a recent announcement that the Company has now produced what is claimed to be the world's first prototype model of a commercial design of thermoelectric cold box. The box is about 1 ft.^{3} in size and has a drop-down door. The Peltier effect is used for the production of cold, the cooling power of about 0·25 W. taking place at one junction of the thermocouple through which a direct current of 5–10 amp. is passed. The drop in temperature in the enclosure is 20–30 deg. The practical stage of development has been reached by the production of efficient semiconductor thermocouples and a form of construction which provides adequate thermal insulation between the hot and cold sides of the couple. The advantages of the system are lightness, the absence of moving or wearing parts, silent operation and the avoidance of chemical refrigerants. It can operate from a low-voltage battery d.c. supply, such as a motor-car battery, and the prototype cold box fits easily into the boot of a car.

The Wellcome Trust: Grants for Medical Research

THE Wellcome Trustees have announced that among the grants made during the half year ended February 29 were: £120,000 to King's College, University of London (Prof. J. T. Randall), towards the purchase of the lease of premises to house a Department of Biophysics; £70,000 to the University of Toronto (Prof. C. H. Best), to build and equip basically additional research accommodation in the Charles H. Best Institute; £15,000 to the Johns Hopkins Hospital, Baltimore (Prof. A. McGehee Harvey), to adapt premises in the Department of Medicine as a research laboratory for studies of the heart and blood vessels in man, especially by the method of X-ray cinematography; £30,000 to University College, London (Prof. P. B. Medawar), to build and furnish a research unit in cellular immunity as an annexe to the Department of Zoology; £8,000 to the University College of the West Indies, Jamaica (Prof. J. Waterlow), to purchase a mass spectrometer for use in the Medical Research Council's Tropical Metabolism Research Unit; and £2,500 per annum for up to five years, to Prof. A. St. G. Huggett, St. Mary's Hospital Medical School, London, to provide technical assistance and research expenses for work on the physiology of pre-natal growth.

Senior Research Fellowships of the U.S. Public Health Service

THE U.S. Public Health Service has announced that it will award twenty-one five-year senior research fellowships to scientists in eighteen universities and schools of medicine in thirteen States. Cost of the awards for the first year will amount to 260,562 dollars. No maximum stipend is set by the Public Health Service for these fellowships. Instead, each institution requests an amount for the stipend in accordance with its policy. The institution also receives 2,000 dollars a year towards research and travel expenses connected with the project. This is the fourth year of a five-year Federal programme to increase man-power for research in the pre-clinical sciences. The programme is administered by the Division of General Medical Sciences of the National Institutes of Health. The awards are designed principally for the partial support of promising young scientists sponsored by preclinical departments in the period between the completion of their postdoctoral research training and their eligibility for permanent academic appointments. In special circumstances, senior scientists may be awarded these fellowships to supply needed strength in preclinical science departments of schools of medicine, dentistry and public health.

First International Congress on Automatic Control

As the British member body of the International Federation of Automatic Control, the British Conference on Automation and Computation has, during the past year, selected 28 papers to form the British contribution on the subject of automatic control for presentation at the first International Congress on Automatic Control in Moscow during June 27–July 7. The arrangements for this Congress are being undertaken for the Federation by the U.S.S.R. National Committee for Automatic Control. The total number of papers to be presented is 282, and 20 countries are represented. The leader of the British delegation is Mr. John F. Coales of the

University of Cambridge. Further information can be obtained from the Honorary Secretary, Group *A*, the British Conference on Automation and Computation, c/o The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

Autonomics Division, National Physical Laboratory

THE name of the Control Mechanisms and Electronics Division of the National Physical Laboratory is to be changed to the Autonomics Division. The Division is already well known in the field of automatic control and in pioneering digital computers. Such machines are deterministic in that their behaviour can be predicted from their design and their environment, and they can be designed only after a detailed mathematical analysis of the factors involved. By working closely with biologists in studying the methods which living physical systems use to achieve control, the newly named Division hopes to discover underlying principles on which machines that can improve their own performance can be built.

The Royal Institution

AT the annual meeting of members of the Royal Institution held on May 2 the following officers were elected: *President*, Lord Brabazon of Tara; *Treasurer*, Mr. W. E. Schall; *Secretary*, Sir Harold Spencer Jones; *Managers*, Dr. T. E. Allibone, Dr. H. D. Anthony, Mr. E. R. Davies, Dr. A. G. Gaydon, Dr. H. Heywood, Brigadier H. E. Hopthrow, Mr. L. B. W. Jolley, Mr. P. H. Schwarzschild, Wing-Commander H. F. Tiarks and Prof. W. D. Wright; *Visitors*, Mr. A. D. R. Caroe, Mr. A. H. Ewen, Mr. G. J. Gollin, Mr. S. Rees Jones, Mr. W. C. Lister, Miss C. M. McDowell, Mrs. J. E. Milton, Mr. F. Allen Mitchell, Dr. A. A. Moss and Miss D. Sidebottom.

Royal Meteorological Society: Awards for 1959

THE following awards were announced at the annual general meeting of the Royal Meteorological Society: *Buchan Prize for* 1955–59, Dr. R. J. Murgatroyd; *Hugh Robert Mill Medal and Prize for* 1959, Dr. B. J. Mason; *Darton Prizes*, (*a*) *Home Awards*, first prize to Dr. C. J. Adkins and second prize to Dr. J. A. Funk; (*b*) *Canadian Awards*, first prize jointly to Mr. R. H. Douglas and Dr. W. Hitschfeld, and second prize to Mr. D. K. A. Gillies.

University News: Cambridge

THE Fellowship Electors have made the following appointments to Churchill College: Official fellowships: Dr. F. H. Hahn, fellow from October 1 and College lecturer in economics from October 1, 1961; Dr. D. J. Thouless, fellow and College lecturer in mathematics from October 1, 1961. Extraordinary fellowship: Dr. F. H. C. Crick, from October 1. Overseas fellowship: Prof. S. B. Treiman, associate professor of physics, Princeton University, from October 1.

London

THE following appointments tenable at Westfield College have been announced: Dr. E. H. Bellamy, senior lecturer in the University of Glasgow, to the University chair of physics; Dr. E. H. Sondheimer, reader in applied mathematics at Queen Mary College, to the University chair of mathematics; Dr. G. E. Fogg, reader in botany at University College, London, to the University chair of botany.

Announcements

THE Holweck Medal and Prize, given jointly by the Société Française de Physique and the Physical Society, has been awarded to J. Brossel, in recognition of his distinguished work on spectroscopy The presentation will be made on May 11 in the Clarendon Laboratory, Oxford, after which M Brossel will deliver an address (in English) on "Optical Detection of Nuclear Magnetic Resonance".

DR. M. TORDOFF, associate editor of the *Journal of the Textile Institute*, is to become editor of the *Journal of the Society of Dyers and Colourists*. He takes up his new appointment in August.

APPLICATIONS are invited from members of the British Mycological Society and heads of departments for grants from the Cheesman and Pethybridge funds to enable students of mycology to attend the Spring or Autumn Foray, or the Plant Pathology Field Meeting. Grants will be made only to students who would otherwise be unable to attend these meetings on financial grounds. Applications should reach the secretary, Dr. J. G. Manners, Botany Department, The University, Southampton, not later than May 10.

THE Department of Chemical Technology of the Bradford Institute of Technology is organizing a symposium on Co-ordination Compounds: their Chemistry and Applications during May 20–21 Further information can be obtained from Mr. G. J. Weston, Institute of Technology, Bradford.

AN international colloquium on Sub-aquatic Medicine is to be held by the "Club Alpin Sous-Marin" at Cannes during June 15–19. Further information can be obtained from Dr. J. Ferrari, "Club Alpin Sous-Marin", 10 Place Commandant-Lamy, Cannes (A.-M.).

L'ASSOCIATION des Ingénieurs Electriciens sortis de l'Institut Electrotechnique Montefiore is to organize an international information day about nuclear energy in Liège on June 9. Further information can be obtained from Mr. A. Biron, the secretary of the Association, at 31 rue Saint-Gilles, Liège, Belgium.

THE twenty-fourth congress of the International Association for the Protection of Industrial Property will be held in London during May 30–June 4, under the presidency of Sir John Hanbury-Williams, chairman of Courtaulds, Ltd. Further information can be obtained from the secretary of the Organizing Committee, H. C. Miller, 16 St. Martin's Le Grand, London, E.C.1.

A JOINT meeting of the Biochemical Society and the Société de Chimie Biologique in the Faculté de Pharmacie, Avenue de l'Observatoire, Paris 6e, during May 27–28, has been arranged. Further information can be obtained from Dr. W. J. Whelan, Lister Institute of Preventive Medicine, Chelsea Bridge Road, Chelsea, London, S.W.1.

W. H. FREEMAN AND CO., LTD., Hyde House, West Central Street, London, W.C.1, state that they are now the English publishers of Gilluly, Waters and Woodford "Principles of Geology" and of Sawyer "A Concrete Approach to Abstract Algebra", noted in *Nature* of April 2, pp. 57 and 69; the English prices are now 42*s*. and 7*s*. 6*d*., respectively.

POLYMERIC PROGRESS

FIVE hundred people attended a conference on Polymeric Progress held by the Plastics Institute during March 30–31. This figure was limited by the capacity of the William Beveridge Hall of the University of London, and many applications had to be refused. A speaker at the conference dinner pointed out the double meaning of the title, with its appropriate recognition that progress in polymer science and technology is so many-sided that it can be appropriately described as polymeric.

Following an introductory address by J. R. Whinfield, the conference took the form of eight papers, each of approximately forty-five minutes, followed by thirty minutes for questions and discussion. The diverse interests of members of the audience inhibited any detailed discussion and the question periods were for the most part used in clarifying and amplifying the papers. Each of these was an individual contribution, but for the purpose of this report they may be conveniently grouped.

The most dramatic of recent advances are concerned with the development of new methods of polymerization offering a high degree of control over the structure of a polymer. The effect of this on the physical properties of the polymer can be seen by reference to a few examples: (1) Polyethylene has become a well-known material in many household goods, characterized by toughness and flexibility, with a melting point of about 108° C.; the newer techniques give a much more rigid product, melting at 130° C. (2) Polymethyl methacrylate is familiar as the glass 'Perspex'; two new crystallizable forms have now been produced. (3) Naturally occurring polyisoprenes have long been known—natural rubber and gutta percha; essentially identical products have now been made synthetically, together with other crystallizable products.

The nature and the mechanisms of these new processes were the subject of a paper by G. Gee, in which several levels of structural control were recognized. The terms isotactic, syndiotactic and atactic, originally proposed by G. Natta, have now been widely adopted to indicate the sequence of stereochemical configuration along a polyvinyl chain $-(CH_2-CHX)_n^-$. If the configuration of all the tertiary carbons are identical the polymer is isotactic; if configurations alternate regularly the polymer is syndiotactic; in an atactic polymer configurations are random. The configuration of each carbon is established as the unit is attached to the chain and it is clear that in general the two configurations will differ in probability: it is by control of these probabilities that the new procedures determine the product.

The simplest method of control uses low-temperature catalysts to favour the lower-energy configuration—generally syndiotactic. As the polymerization temperature is lowered, the degree of stereochemical regularity increases continuously and ultimately becomes sufficiently great for the polymer to crystallize. It has been suggested that polymer conformation in solution may sometimes be important: once a regular sequence is established (by chance) the polymer may tend to take up a regular conformation (for example, a helix) in which the same mode of addition is favoured.

The most remarkable of the new catalysts are metal alkyls or products derived from them. Especially noteworthy are the lithium alkyls and the Ziegler catalysts (typified by a combination of titanium trichloride and an aluminium alkyl). The three features which here seem important are highly polar metal–carbon bonds, metal atoms such as aluminium with a strong co-ordination tendency, and solid ionic surfaces. Almost all the most remarkable achievements in stereospecific polymerization so far reported have involved the use of heterogeneous catalysts. A particularly interesting system is found in the polymerization of propylene oxide by metal alkoxide catalysts, where the production of crystalline polymer is stimulated by partial hydrolysis of the alkoxide, giving condensed chain structures which reach their optimum efficiency just as they are on the verge of precipitation from solution.

The use of Ziegler catalysts was considered in more detail in the paper by G. Bier, who reported that the properties of nominally similar catalysts are highly dependent on the method of preparation. It is generally agreed that polymerization on these catalysts involves interpolation of successive molecules of monomer between metal (M) and polymer chain (P), which may be written formally:

$$M \ldots P + CH_2 : CHX \rightarrow M \ldots CH_2.CHX.P$$

Various processes can lead to removal of the polymer which then ceases to grow and is replaced by a new chain, for example,

$$M \ldots CH_2.CHX.P \rightarrow M \ldots H + CH_2 : CX.P$$

Bier presented evidence of the preparation of catalysts in which such processes can be reduced to negligible proportions. In these circumstances it becomes possible to synthesize block copolymers $(CH_2CHX)_{n_1}(CH_2CHY)_{n_2}(CH_2CHX)_{n_3} \ldots$ by supplying two (or more) monomers successively to the catalyst. Copolymers of ethylene and propylene containing 10–20 blocks per chain have been made in this way and show physical properties generally quite different from those of either mixtures of the two polymers or random copolymers. A striking feature of these block copolymers is that all appear to be crystalline, though the crystal structure is unknown.

In the paper on "Acetal Polymers", W. H. Linton described another development in which a familiar monomer has been polymerized in new ways to produce a polymer the properties of which are such as to make it, from the engineer's point of view, a new material. The polymerization of formaldehyde is mentioned in elementary text-books, but stable high polymers have only recently been produced, and marketed as 'Delrin'. Linton described this material as an essentially linear polyoxymethylene with a density of 1·425 at room temperature and a crystal melting point of 180° C. It was stated to be usable continuously at 60–70° C. or intermittently at 100° C. Compared with older formaldehyde polymers, its high stability appears to be due in part to chemical treatment to remove terminal hydroxyl groups, and partly to the high degree of crystallinity consequent upon its very regular structure.

Another group of new-old materials was described by H. Schnell, in his paper on polycarbonates. Intensive earlier work on polyesters had failed to produce any polycarbonates of satisfactory stability and useful physical properties. Two factors which combined to open up this new field were the production of 'bisphenol *A*' $HO.C_6H_4.CMe_2.C_6H_4OH$ and its conversion to a polycarbonate by reaction with phosgene. It proved possible in this way to obtain polymers of high molecular weight which were crystalline and melted above 200° C. Subsequent work has led to the synthesis of many polymers of the general structure $—(OC_6H_4.X.C_6H_4O.CO)_n—$, where X may be $—CR_2—$, $—O—$, $—S—$, $—SO—$, $—SO_2—$. These are broadly similar in physical properties, an attractive feature being high impact strength. The polymers are all crystalline, generally melting above 200° C.; but a high degree of transparency shows that the crystallites must be small. Moreover, the fact that many of these materials are soluble in organic liquids at room temperature is surprising having regard to their high melting points.

The relation of melting point to chemical structure was discussed by H. C. Raine in his paper on polyolefins. Following the pioneer work of G. Natta, a range of 1-olefins have now been polymerized to crystalline polymers which are generally described as 'isotactic'. Raine emphasized that the ability of a polymer to crystallize is not a sufficient proof of 100 per cent stereochemical purity. In illustration he presented data on a large series of polypropylenes having melting points ranging from 110–180° C., correlated roughly but not exactly with the estimated percentage of crystallinity. For any discussion of the effect of monomer structure, one should clearly use the highest melting point which has been attained; but there remains some doubt as to whether data available at the present time are all reliable. Following the work of C. W. Bunn, Raine sought to interpret the data in terms of three factors: cohesive energy per unit length of chain, intrinsic chain stiffness and spatial symmetry.

Of these new polyolefins, only polypropylene has yet been developed commercially, but it may well prove that some others may have useful combinations of properties: the high melting points of polyolefins with bulky side groups are particularly noteworthy. The presence of these side groups in an isotactic polymer makes a planar zig-zag conformation of the chain sterically impossible. Crystal structure determinations on a series of polyolefins have shown helical structures to be characteristic. With this in mind, it might well have been expected that if vinyl cyclopropane could be polymerized isotactically, the polymer would show a similar structure. In his account of recent work by the polymer group at Brooklyn Polytechnic, M. Goodman reported that this does not appear to be the case. Vinyl *cyclo*propane has recently been synthesized, and polymerized with a Ziegler catalyst. Preliminary X-ray studies suggest that the crystal structure is a planar zig-zag.

The problem of polypeptide conformation in solution is dominated by the possibilities of hydrogen bonding. Goodman described work in progress on the synthesis and study of a series of short-chain polypeptides (2–12 peptide links). Optical rotation and rotary dispersion are being used as tools to study the competition between intermolecular association and formation of an α helix. In the latter, intramolecular hydrogen bonding occurs between links 1–5–9–13, 2–6–10–14, etc. End effects are naturally important in these short chains, and the interpretation of the results is not yet entirely clear.

Two papers remain to be mentioned: by H. M. Stanley, on "The Impact of Petrochemical Development on the Plastic Industry"; and by N. J. L. Megson on "High-temperature Resistant Materials". These approached the question of new polymers from opposite ends. The industrial development of a polymer is naturally highly dependent on economic consideration, and in these the cost and availability of monomers looms large. The remarkable progress of the petrochemical industry is well known, both in cheapening established products by opening up more direct and economical routes, and in making available on an industrial scale products formerly laboratory curiosities. In his survey of current trends, Stanley gave good grounds for the belief that if a polymer can be shown to be sufficiently worth while, the petrochemical industry will find a feasible route to the necessary monomer.

Megson's paper pointed the need for the development of polymers with new properties. The kinetic heating of high-velocity aircraft and rockets is already creating a demand for materials, both metallic and non-metallic, capable of performing more satisfactorily at higher temperatures than those hitherto encountered, and it is clear that the problems will become progressively worse as speeds rise. There are really two groups of problems, concerned respectively with thermal, oxidative and hydrolytic stability under very severe conditions; and with the physical properties of materials which encounter an exceptionally wide temperature range. Megson stressed the shortcomings of all known polymeric materials, but was naturally less able to suggest remedies. The overall problem is certainly too complex for any simple solution, and progress can only be foreseen over a broad and straggling front. General studies of new types of polymer will certainly have the high-temperature problem in view as an objective. At the same time, specific applications will require individual study to determine the best compromise between design and material. This is one of the areas where one may hope to find advances when the Plastics Institute holds its next conference on polymeric progress.

G. GEE

THE SCIENCE ASSOCIATION OF NIGERIA

THE second annual conference of the Science Association of Nigeria was held in Zaria, Northern Nigeria, during December 15–18. This Association, affiliated to the wider organization of the West African Science Association, has only been in existence for one year. Its membership is recruited from all branches of the teaching profession, from government scientists and from industrial organizations.

The immense developments in Nigeria since the Second World War have given rise to a large increase in the numbers of scientific workers, both African and European. Yet the overall numbers are still grossly inadequate for the country's need in an age of technological expansion. The Association was brought into being for the dual purpose of providing a forum for scientists working in the country and of informing the general public of the role which scientific work is playing in their lives. Already the Association has achieved considerable success. The quality of the papers and the discussions at the present meeting was extremely high, and it gave a picture of a general standard of work and achievement which would have been unthinkable not many years ago.

The most obvious immediate technological needs of Nigeria are in the agricultural and allied fields. It is not surprising, therefore, that a great deal of emphasis was laid on agricultural developments and of the relation of these developments to nutrition. But other subjects were not neglected. The vexed question of the biological effects of radiation—a real issue in Nigeria since the first mention of Sahara atom bomb tests—was dealt with in a most scholarly and authoritative manner. There were brief incursions into the realms of physiology and even of philosophy.

The importance of the meeting, though, really lay in that it brought together workers from many parts of Nigeria and from many fields of work. Physical and intellectual isolation are an ever-present danger in such a vast under-developed territory, and the real necessity is an interchange of ideas and points of view.

This meeting underlined a phenomenon of great significance certainly in Africa, probably also in other territories, namely, a re-orientation in the pattern of research. Before the War the tropics at the best were field stations visited by scientists from Europe, who collected their material for examination in properly equipped laboratories in Europe. To-day, Nigeria not merely has the laboratories—insufficient in number, perhaps, but still there—but also the scientific personnel to carry out the work. The opportunities here are immense, and the challenge is something which Europe cannot match. There is, after all, a fundamental absurdity, justified at the time they were created, in institutions of tropical research situated in England or indeed anywhere outside the tropics. This alone is a big development. Most of the original work carried out in Nigeria is, perforce, in applied subjects such as agriculture and medicine. Nevertheless, the third step towards scientific maturity has already been taken, for there is now a great deal of 'pure' research being carried out, particularly at the University College, Ibadan.

Science and technology in Nigeria are still young, but one feels that the plant is viable, that scientific activity will continue to grow, and that the nation as a whole will increasingly come to accept the new technologies as her best guarantee of future prosperity.

B. Hopkins

THE SMITHSONIAN INSTITUTION

THE annual report of the Smithsonian Institution for the year ended June 30, 1959, includes the Secretary's report, reports of branches of the Institution, the library and publications, and the financial report of the Executive Committee of the Board of Regents (Pp. x+243+10 plates. Smithsonian Publication No. 4389.) Washington, D.C.: Government Printing Office, 1959). Real progress continued to be made in transforming the museum displays into modern effective teaching exhibits and with 951,608 visitors at the National Gallery of Art, an estimated 4,055,673 at the National Zoological Park, the total number of visitors was 11,358,633. Some 260,000 specific inquiries were handled and 1,144,445 specimens were added to the National Museum, including four collections of Micronesian ethnological material, the entire herbarium of Goucher College, consisting of about 6,100 specimens, the legendary Hope diamond, a superb collection of Chinese jade carvings, more than 7,300 specimens of Carboniferous plants, the Monrós collection of more than 54,000 chrysomelid beetles, and many molluscs and marine invertebrates collected by the Bredin–Smithsonian Caribbean expedition; a collection of early handmade locks, bolts and decorative hardware, and dental instruments, furniture and equipment relating to the history of dentistry. Efforts to acquire early scientific apparatus used in colleges continued, and a group of scientific instruments used by Ira Remsen at Johns Hopkins University was acquired. Field work was conducted by members of the Museum staff in Central America, South America, the Caribbean and many parts of the United States.

Systematic researches by the Bureau of American Ethnology ranged from the River Basin Surveys, Arctic and Eskimo studies, the Seminole and Seneca Indians to archæological work at Russell Cave, Alabama, and progress is reported with the bibliography of the Arctic. The survey parties have now located 4,909 archæological sites in the River Basin Surveys and, of these, 1,017 have been recommended for excavation or limited testing. Work at the Astrophysical Observatory included solar physics, the development of two methods for determining the structure of non-grey stellar atmospheres, a study of atmospheric structure and its correlation with solar activity, studies of the secular acceleration of artificial satellites, meteoritic studies and the design of a telescope for use in space. The satellite-tracking programme continued and the Division of Radiation and Organisms continued its studies on the biochemical changes that occur during the development of the chloroplasts of higher plants. In a study of the lag phase of chlorophyll synthesis it has been shown that X-irradiation of 5–10 kr. can increase the lag phase in etiolated bean leaves, and radiant energy in the region 710–820 $m\mu$ significantly increases the frequency of chromosomal aberrations when used as a supplement to X-irradiation. Accessions totalling 341 specimens in 56 separate accessions to the Natural Air Museums included an early example of a German one-man helicopter, a *DM*-1 delta-winged glider of the Second World War, and many documents pertaining to pioneer rocketry research.

Accessions of 1,286 animals brought the total count at the National Zoological Park to 2,384; about 400 people visited the Canal-Zone Biological Area, including 54 scientists, students and observers using the station's facilities for special researches.

particularly in plant and insect studies, observation of wildlife and photography. The International Exchange Service received 1,129,476 packages, weighing 767,399 lb. of government, scientific and literary publications, and distributed 63 full and 43 partial sets of United States official publications; 85 copies of the Federal Register and 95 copies of the Congressional Record were also dispatched under the Interparliamentary Exchange of the Official Journal. The library received 52,669 publications during the year, bringing its holdings to 982,596 volumes, including 586,722 in the Smithsonian Deposit at the Library of Congress, and arranged 159 new exchanges. Eighty-one publications were issued during the year.

A CENTRAL INSTITUTE FOR SCIENTIFIC CINEMATOGRAPHY

TO find out what services a Central Institute for Scientific Cinematography could render to research and teaching in Great Britain, an inquiry has been carried out by the British Universities Film Council among a representative group of university teachers*.

A questionnaire relating to research was designed with the view of ascertaining, *inter alia*, whether by some method of sharing apparatus, existing facilities could be better used. The views of the research workers were as follows.

Research projects are undertaken with available resources in mind and unless cinematographic equipment already exists, or a grant to buy it is a possibility, cinematographic methods will not be used. Those departments with such equipment are using it most of the time and it is likely only to be available to visiting workers for short times; however, in the majority of instances visiting workers would be welcome, particularly to learn the methods in use. Many who use ciné equipment, and many more who do not do so at the moment, would welcome information concerning equipment available and the ways in which it can be applied to specific problems. This could be one of the functions of a Central Institute.

Another questionnaire was designed to determine how a Central Institute could assist teachers. The general reaction was that film at university level is properly used in showing the student moving phenomena which he cannot, for any reason, see at first hand; film should not be used to show observations or experiments which the student should make himself. Many films available, although they fulfil this criterion, are unsatisfactory for university work because they include theoretical material best dealt with in other ways.

University teachers want short films to illustrate particular points which can be best illustrated by cinematographic methods. This need involves an automatic 'push button' projector which has yet to be perfected and a source of supply of the illustrations.

Until such time as apparatus and illustrations are forthcoming, films will have to be used as at present. Many teachers are not aware of the films available on their subjects; the multiplicity of catalogues and sources of supply, each of which has few, if any, items of university standard adds to this confusion. A more centralized source of information is essential.

While the foundation of a Central Institute which had sections for the making of research films, the loan of equipment and secondment of specialized staff, an advisory service on research problems, the making of teaching films and a comprehensive information service on teaching films would appear one solution to these problems, it would seem that some of the current difficulties might also be solved in other ways. If there were greater recognition of the fact that, in many sciences, cinematographic methods have established themselves as a means of recording events for subsequent analysis, apparatus would be provided on a more liberal scale. Such apparatus requires skilled use, and short courses for training of technicians should be provided, perhaps in colleges of technology in various parts of Britain. If the research problems were tackled along these lines, it might be easier to obtain co-operation with other bodies interested in cinematographic methods in research and avoid the isolation which might result if a central institute for university research alone were set up.

The use of an existing organization for a comprehensive service of information of teaching film might well be considered. This would involve the organization in question receiving an earmarked grant from a government source, the grant being used for the collection, collation and dissemination of information on films available for instruction at university level.

Interest in the use of advanced cinematographic techniques is not confined to university departments; other bodies such as the Research Councils, various Ministries and industry are also concerned. If it proposed to set up an Institute which served all these interests, the universities would make full use of the facilities provided. It may be envisaged that universities would, in particular, be users of an advisory service on the application of cinematographic methods and on technical problems, any short instructional courses on methods whether for scientists or their technicians, and an information service on existing film which could be used for further research or for teaching purposes. University departments might be users of a service for the loan of specialized apparatus although they would wish to be free to apply for grants for the provision of apparatus for their exclusive use as previously. Here there may be a difference between the needs of pure and applied science departments; the latter frequently undertake research of an *ad hoc* nature for which the availability of apparatus on loan might have distinct advantages in that it would encourage a high technical standard in the research film made; much film produced in research in Britain, although adequate for the immediate purpose of the worker, is seen to be of poor quality when shown at scientific meetings, and is also inadequate teaching material.

---

* The Use of Film in Teaching and Research in British Universities 1959. (A Report of an Investigation carried out in selected University Departments by a Sub-committee: G. E. H. Foxon, G. H. Bell and C. J. Duncan.) Pp. 24. (Newcastle upon Tyne: C. J. Duncan, Hon. Secretary, The Medical School, King's College, 1960.)

WEIGHT STANDARDS FOR MEN AND WOMEN

IN view of the importance of body-weight to health and longevity, the findings of the Build and Blood Pressure Study, 1959, conducted by the Society of Actuaries of the United States, are of major significance (Metropolitan Life Insurance Co. Statistical Bulletin, Vol. 40 (November–December 1959): New Weight Standards for Men and Women. Fathers are Younger. How Fatal Accidents Occur in the Home. Geographic Variations in Mortality by Cause. Pp. 12. New York: Metropolitan Life Insurance Company, 1959). The study not only contributes new data on average heights and weights according to age but also provides information from which new standards of desirable weight have been developed by the Statistical Bureau of the Metropolitan Life Insurance Co.

The new tables of average weights differ from those which were based on two similar studies of insured persons covering the periods 1885–1900 and 1909–27. For women the new average weights are consistently less than they were in the earlier studies, while for men they tend to be higher than before. Thus, at age 25 the average weight for women is generally 5 to 6 pounds less than that shown in the last study; at the age 35 it is from 2 to 4 pounds less, and at age 45 generally 2 to 3 pounds less. The decrease in average weights of women reflects chiefly their efforts to keep slim and, to some extent, the lighter weight of their clothes. Among men, the increase in average weight, compared with earlier studies, varies appreciably with height. The increase is greatest for short men, amounting to 5 pounds or more at most ages. For men of average height the increase is from 2 to 4 pounds, and for tall men from 1 to 3 pounds, the larger differences being found below the age of 45.

The average weights in the present study rise with advance in age among both men and women, but the pattern differs somewhat for the two sexes. Among men, the averages rise rapidly during the twenties and early thirties, but the rate of increase then slackens off and is very small between the forties and fifties. Among women, the increases in weight with age are fairly steady, but are most rapid between the mid-thirties and mid-forties. The lowest mortality generally occurs among people who are well below average weight. Even among young people, the advantage of a slight degree of over-weight is less pronounced than in earlier studies, and at best can now be considered only a temporary advantage. At the middle and older ages, the results of the new study not only show the disadvantage of over-weight, but also indicate that desirable weights, under current conditions, are somewhat lower than those shown in the tables prepared by the Metropolitan Life Insurance Co. in the early 1940's.

TEMPERATURE CHANGES IN THE ANTARCTIC ATMOSPHERE

DR. H. WEXLER, chief scientist of the U.S.–International Geophysical Year Programme, has published a valuable paper on the subject of seasonal and other temperature changes in the Antarctic atmosphere in the July 1959 issue of the *Quarterly Journal of the Royal Meteorological Society*. His results are based on observations made at U.S. and British International Geophysical Year stations in Antarctica and by the Scandinavian-British expedition to Maudheim during 1950–51.

The variation of temperature with height of the seasonal changes is strikingly different from that over temperate continents. The seasonal changes over Antarctica are greatest in the stratosphere (50–60 deg. C.), moderate at the surface (20–40 deg. C.), and least in the troposphere (10 deg. C.). The effect of the greater cooling of the stratosphere is to destroy for a long period the normal sharp inversion boundary of the tropopause between troposphere and stratosphere. During the sunlit part of the year the stratosphere is heated directly by absorption of solar radiation by the ozone which it contains, and it is cooled during the dark part by loss of heat by radiation from the ozone, carbon dioxide and water vapour, so that the stratospheric temperature falls quickly in autumn and rises very rapidly in spring. The fall of surface temperature is rapid in the autumn as the snow surface cools by radiation. Cloud in the winter causes remarkable increases in surface temperature since it is at a higher temperature than the surface itself and so heats the surface by radiation. An example of an increase of temperature by 30 deg. F. in 24 hr. at the South Pole when cirrus cloud came over is described in some detail. In the summer the snow surface is warmed by solar radiation despite its high albedo. The small temperature change in the troposphere is ascribed to the horizontal influx of warm air from over the surrounding ocean. Reasons are given as to why such advection does not reduce the temperature change in the stratosphere. In the troposphere, and at the surface, there is no marked minimum of temperature a month or so after the winter solstice as there is in temperate latitudes. In Antarctica the temperature drops sharply in autumn and then fluctuates about a low mean until the spring, when it rises sharply again.

The year to year temperature changes in Antarctica are as large as those in the interiors of a continent of the temperate zone, amounting to more than 10 deg. C. in the winter months. Thus, in August 1958 Byrd station in West Antarctica was 13 deg. C. colder than in August 1957.

By comparing recent observations on the Ross Ice Shelf with earlier ones as far back as those of Amundsen in 1911–12, Wexler is able to deduce the secular change of temperature. It is found that the mean annual temperature has risen by 2·6 deg. C. since 1911, which compares with a rise of 6·2 deg. C. at Spitsbergen over the same period.

EFFECT OF TEMPERATURE ON GROWTH IN WEIGHT AND TAIL-LENGTH OF INBRED AND HYBRID MICE

PHYSIOLOGICAL processes of acclimatization to high temperatures have been investigated for a number of organisms, but the effects of temperature on growth have received little attention. It is known, however, that growth in body-weight in the few subjects studied is greatly influenced by external temperature, and that there exists an inverse relationship between temperature and body size. It has also been shown for some organisms that buffering against external environment is better in first-generation hybrids than in inbreds. These considerations were kept in mind in recent experiments carried out by Prof. G. A. Harrison, Mr. R. J. Morton and Dr. J. S. Weiner*.

The material studied consisted of four inbred strains of mice and the six possible hybrids between them. Reciprocal crosses were included. It is shown that growth in body weight is partly determined by environmental temperature (70° F., 61° F. (control) and 90° F.). The weight of young heat-treated mice usually increases more rapidly than that of the controls, but at later ages the latter generally grow more rapidly. The magnitude and direction of the environmentally determined responses depend on the particular genotype.

Growth of F_1 hybrids in the two environments is more similar than the growth of their inbred parents, and differences in hybrid response are smaller than the corresponding inbred differences.

Hybrids in any one environment usually have a smaller variability than homozygotes—indicative of their greater homeostasis. One inbred resembled the hybrids in weight variance and weight responses, and the important conclusion emerges that inbreeding does not necessarily mean marked reduction in somatic fitness. The authors, however, do not put forward any explanation of this circumstance. It is perhaps possible that, as in maize, resistance to inbreeding may be genetically determined.

Growth in tail-length is also in part determined by environmental temperature; the higher the temperature the faster the growth-rate, and the longer the tail. The magnitude of the response again depends on genotype, though maternal environment plays some part. Hybrids have a smaller variability in both environments, and the totality of the evidence supports the hypothesis that the hybrids have a greater developmental flexibility than the inbreds.

S. C. HARLAND

---

* Phil. Trans. Roy. Soc. of London. Series B: Biological Sciences. No. 695, Vol. 242 (4 September, 1959): The Growth in Weight and Tail Length of Inbred and Hybrid Mice Reared at Two Different Temperatures. By Prof. G. A. Harrison, R. J. Morton and Dr. J. S. Weiner. Pp. 479–516. (London: Royal Society, 1959.) 12s.

SCIENTISTS AND ADMINISTRATION

THE description of the Laboratory of the Government Chemist in *State Service* (40, No. 3; March 1960) is a reminder that Government concern with scientific research is no new thing. Even earlier examples were the Royal Observatory (1675) and the Geological Survey (1835), and later the Patent Office (1852), the National Physical Laboratory (1903), the Medical Research Council (1913), the Department of Scientific and Industrial Research (1916) and the Agricultural Research Council (1916).

Quite apart from research to meet the needs of the Armed Services, Government research must be undertaken in order that the Executive may reach all its decisions on the best possible scientific advice, and in order that aspects of national life for which industry is either unable or unwilling to undertake responsibility shall not be neglected; aspects of such are fire, corrosion, afforestation, river pollution, coast erosion as well as problems in the building, transport and mechanical engineering fields. The new challenge of outer space is also throwing up problems calling for Government initiative in research and co-ordination.

The Institution of Professional Civil Servants believes that not only the scientific needs of government in the modern industrial State, but also the scientific needs of the State itself, can be adequately met only if the government is fully responsible for much research work. But the majority of the administrative class of the Civil Service appears to be proud of its scientific ignorance. This attitude is a grave handicap which could be partially overcome through a leavening of the Administrative Class by a deliberate policy of moving scientists into it.

One major difference between government research establishments and those in industry is that the scientists in the latter frequently have the opportunity to move into production and other fields of management.

In this respect the government service lags behind industry. The introduction of men with a scientific background into executive departments would be of benefit to both. Such scientists should undergo a period of administration to fit them to make a full contribution to the art.

When this type of movement occurs there should be no differentiation, either financially or otherwise, between the scientist-administrator and his colleagues trained in other disciplines. The transfer of scientists to administrative work should not be as if to a higher sphere of activity, but to introduce into administration scientists suitable for administrative duties. To ensure the maximum opportunity to develop and demonstrate administrative ability, much more use should be made of secondment to the headquarters offices of their department at all levels.

Apart from such administrative opportunities, the young scientist could obtain valuable experience in connexion with his own research work if he were encouraged to take an independent view and to express his opinions on his own work and the research programmes of his establishment. Research work is essentially a team activity and can only benefit from free discussion among members of the team. Unhappily, in all too many government laboratories there is little or no consultation of this kind. He should also be encouraged to make outside contacts, both industrial and academic. Among outside activities which should be actively encouraged in government research establishments are those connected with the work of technical schools and colleges, particularly lecturing in their own field. These activities could be of value not only in broadening the experience and outlook of the research workers taking part in them but also, by reason of the contacts brought about, in helping the colleges to understand what is required of them in the changing fields of science and technology.

T. H. Hawkins

QUANTITATIVE CYTOCHEMICAL OBSERVATIONS ON A SPECIFIC NUCLEOPROTEIN REACTION IN CELL NUCLEI

By Dr. E. A. BARNARD
Zoology Department, King's College, London, W.C.2

An application of micro-spectrophotometry to a specific protein cytochemical reaction is reported here, forming part of an attempt to understand the significance of a particular bonding observed in nucleoprotein in cell nuclei.

It has been shown[1] that a particular component of the nucleoprotein of cell nuclei can be distinguished cytochemically, by chromogenic reaction with a suitable diazonium hydroxide, after all other diazo-coupling groups in the specimen have been blocked by anhydrous benzoylation. The component responsible for this reaction was identified (in the case of chicken erythrocyte nuclei) as composed of histidine residues in the nucleoprotein. The reaction appears to locate a specific and rather labile bonding between this set of histidine residues in the protein and another set of groups in, or associated with, the nucleic acid.

The conditions for obtaining satisfactory micro-spectrophotometric measurements with this reaction have now been found to be as follows. Freeze-drying is the most suitable method, both on theoretical and empirical grounds. If the cytological preservation is inferior or variable, the staining is decreased or is non-uniform in distribution through the specimen. Sections or smears can be used; but the present results were all obtained on smears of disrupted fresh tissue. Errors due to the cutting of nuclei are thus avoided. It is of interest that freeze-substitution (in alcohols) virtually abolishes the reaction, both in smears and in sections. The smears (on cover-slips) were immediately quenched and frozen-dried in a version of the Edwards and Co. tissue dryer modified for this purpose and incorporating a nitrogen 'cold finger'; the temperature over the smear surface must be uniform (for example, −50°).

The dried smears are fixed in absolute ethanol and treated as previously described[1]. Moisture must be excluded until after benzoylation. Of the naphthols tested, *H* acid (1-amino-8-naphthol-3 : 6-disulphonic acid) gives the best results in the spectrophotometry. The stained, washed specimens are stored in immersion oil (Shillaber's) up to the moment of measurement.

The scanning, integrating micro-spectrophotometer of Deeley[2] was used, with a crushing condenser[3]. This apparatus has been shown to give precise measurements of the Feulgen stain in nuclei[4]. Of several mounting media tried, only glycerol gives technically adequate results, but a slow extraction of the stained component begins to occur after 1–2 days in glycerol.

Frog erythrocytes were used as standard test objects. A uni-modal distribution of the nuclear stain, with small spread (*S.E.* 2–4 per cent) is obtained. Variation between sets of cells in different specimens, prepared from the same blood sample and treated identically, was shown to be insignificant ($P > 0{\cdot}5$). Coupling with tetrazotized dianisidine (0·015 per cent) gives a plateau of maximum stain production for exposures from 14 to 30 min. at 2°. The coupling with *H* acid at the second diazo group shows a plateau over the range 5–15 min. exposure at 2° (followed by warming-up to room temperature for 20 min.). The length of the exposures to ethanol, or of storage in immersion oil prior to measurement, does not affect the intensity.

After a benzoylation period of up to 1 hr., unblocked cytoplasmic stain remains, but after longer periods the cytoplasm is fully blocked, and the nuclear intensity is constant for benzoylation times of 2–20 hr. This confirms the previous conclusion from visual examinations, that the component involved shows a qualitative, and not only a kinetic, difference from other cellular constituents in its behaviour towards benzoyl chloride.

Frozen-dried mouse tissues have been examined (Figs. 1 and 2), using the conditions established for maximum staining. The parenchymal cells of mouse

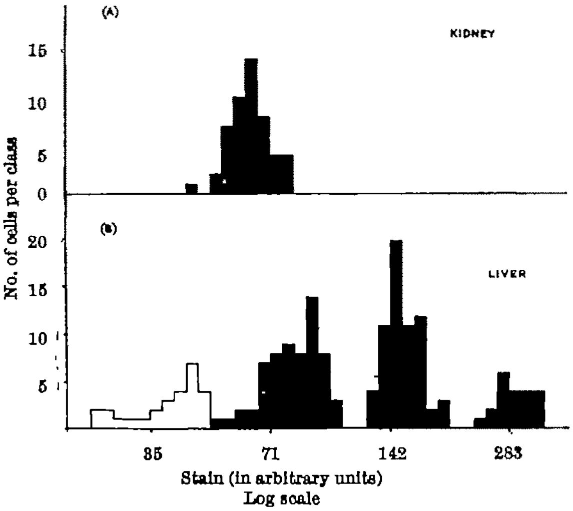


Fig. 1. Distribution of stain in mouse cell nuclei. *A*, typical mouse kidney sample; *B*, typical mouse liver sample; unshaded area, apparent non-parenchymal cells

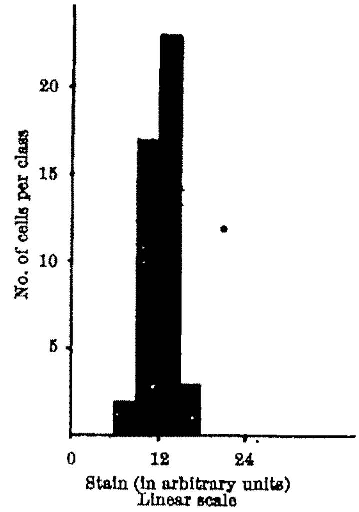


Fig. 2. Distribution of stain in typical sample of mouse sperm

liver show a tri-modal distribution, noticeably similar to that of deoxyribonucleic acid revealed by the Feulgen stain on this tissue[4]. The ratio of the mean values is fairly close to 1 : 2 : 4, and it is presumed that the three classes present correspond to the diploid, tetraploid and octaploid classes of rodent liver. However, an additional class is present here (unshaded area in Fig. 1) with a lower amount of stain. This separate, lowest class appears to consist of non-parenchymal liver cell nuclei (derived from connective tissue, blood vessels, bile ducts, etc.). Some of the larger non-parenchymal nuclei may well be included, however, in the lowest 'diploid parenchymal' class (and possibly *vice versa*), due to difficulties in cell recognition in the smears.

With mouse kidney (Fig. 1) a uni-modal distribution is obtained, again similar to the distribution of deoxyribonucleic acid in the tissue. However, the mean value for kidney does not quite coincide with the 'diploid' value for the stain in the liver of the same animal, and there is a highly significant variation between animals in this kidney value. Samples of kidney tubule cell nuclei from 8 adult mice, maintained under identical conditions (and fed *ad libitum*, stock diet 18, J. Rank Ltd.), each gave distributions similar in form to that shown in Fig. 1*A*, but the mean values ranged from 48·8 (*S.E.* 1·2) to 83·0 (*S.E.* 2·5) units, with a coefficient of variation (C) between animals of 18 per cent. There was no correlation with age between 8 weeks and 6 months. Differences between multiple samples from single animals were insignificant. Standard frog blood smears processed simultaneously with all mouse specimens gave constant results. It is concluded, therefore, that a real individual variation exists in the amount of this component in the nuclei of kidney tubule cells of these animals.

The 'diploid' values for mouse liver appear to lie in a narrower range (72·4, *S.E.* 4·7, to 82·6, *S.E.* 2·8, $C = 6$ per cent), although only 4 animals could be examined. (The present results assume that Beer's law is obeyed, but since the crushing method puts all the extinctions, as actually measured, into the same range, any possible errors are minimized.)

It is clear that the distribution of this nucleoprotein component shows both similarities to, and marked differences from, that of deoxyribonucleic acid. It closely follows deoxyribonucleic acid in intranuclear distribution[1], including location on the chromosomes in mitosis, and similarly in its correspondence with the ploidy classes in liver parenchymal cells ; but the value in sperm is much less than would be predicted on the deoxyribonucleic acid basis (Table 1). Even in somatic cells, however, the amount of this component is not determined by the deoxyribonucleic acid content alone, as can be seen from the results on liver non-parenchymal cells and on frog red cells (Table 1).

Since the liver ploidy classes normally correspond to classes of increasing cell size, a correlation with the latter variable might be suggested. Attention is directed to a correlation, at least for tissues where the required data are available, with the protein content of the nucleus (Table 1). The latter has been determined in mouse tissues on an individual cell basis by means of interferometry by Davies *et al.*[6] ; a fourth, lower class in mouse liver is similarly found. Since nuclei isolated in salt solution were used in those measurements the quantity involved is probably not the total nuclear protein, but a major (and less-soluble) fraction thereof, largely consisting of those proteins associated with the nucleic acid.

It seems likely that the observed variability of the stain in kidney tubule cells, which is in contrast to the constancy of their deoxyribonucleic acid content, is derived from unknown individual differences in physiological or metabolic states. The relative constancy of the stain in sperm heads and in frog erythrocytes, and its variability in kidney tubules, suggest that the component in question is concerned in cellular activity.

Table 1

Species	Cell type	No. of cells measured	Mean stain per nucleus	Relative stain per nucleus*	Total protein per nucleus* (relative)		Deoxyribonucleic acid (in 10^{-12} gm.) per nucleus†
Mouse (*C*57 strain, males)	Sperm	35	11·9	0·15	0·15‡		2·5
	Liver, class 1*A* ‖	39	36·6–41·7	0·50–0·51	0·44‡		5
	Liver, class 1	80	72·4–82·6	1·00	1·00‡	1·0§	5
	Liver, class 2	113	139–146	1·8–1·9	2·1‡	1·9§	10
	Liver, class 3	88	267–282	3·5–3·7	4·1‡	3·6§	20
	Kidney	405	48·8–83·0	0·63–1·1	*N.D.*		5
Frog (*Rana temporaria*, males)	Erythrocyte	503	57·4	0·75	*N.D.*		15

* Taking liver class 1 mean value as 1·00.

† From combination of data from refs. 5 and 9.

‡ Derived from data of Davies *et al.* (ref. 6), taking total protein as total dry mass of isolated nucleus, less deoxyribonucleic acid and less ribonucleic acid. Ribonucleic acid is taken (somatic cells) as ½ deoxyribonucleic acid (ref. 10), but this correction is, in any event, small.

§ For approximate comparison : data of Alfert *et al.* (ref. 11) on rat liver, by Millon micro-spectrophotometry.

‖ Lowest class, see text.

N.D. = not determined.

It is not, however, inferred that this histidine component is distributed uniformly throughout the nucleoprotein, but rather that the amounts of this component appear to be related to nuclear activities which in turn appear to be associated, perhaps indirectly, with the total nucleoprotein content. It is not yet possible to assign these histidine groups to an identifiable fraction of the nucleoprotein. However, it is of interest that recent X-ray diffraction studies[7] indicate that protein bridges form in the nucleoprotein of the nucleus on drying; these have properties, notably disruption by water, similar to those observed here. A possible interpretation, therefore, is that histidine side-chains (and perhaps others) are involved in these bridges. On this view, the present reaction locates specific sites of potential hydrogen-bonding, situated on certain protein surfaces in the deoxyribonucleic acid-protein complex and related to nuclear activities.

A detailed study of the method will appear elsewhere[8]. I should like to thank Prof. J. F. Danielli for his unfailing interest and encouragement; Prof. J. T. Randall and Dr. M. H. F. Wilkins, for the use of instrumental facilities in the Medical Research Council Biophysics Research Unit, King's College, and Dr. B. M. Richards for valuable help in connexion with the micro-spectrophotometry. Part of this work was aided by the British Empire Cancer Campaign and by the Nuffield Foundation.

[1] Barnard, E. A., and Danielli, J. F., *Nature*, **178**, 1450 (1956).

[2] Deeley, E. M., *J. Sci. Instr.*, **32**, 263 (1955).

[3] Davies, H. G., Wilkins, M. H. F., and Boddy, R. G., *Exp. Cell Res.*, **6**, 550 (1954).

[4] Deeley, E. M., Richards, B. M., Walker, P. M. B., and Davies, H. G., *Exp. Cell Res.*, **6**, 569 (1954). Richards, B. M., Walker, P. M. B., and Deeley, E. M., *Ann. New York Acad. Sci.*, **63**, 831 (1956).

[5] Swift, H. H., *Physiol. Zool.*, **23**, 169 (1950).

[6] Davies, H. G., Deeley, E. M., and Denby, E. F., *Exp. Cell Res.*, Supp. 4, 136 (1957).

[7] Wilkins, M. H. F., Zubay, G., and Wilson, H. R., *J. Molec Biol*, **1**, 179 (1959).

[8] Barnard, E. A., in "General Cytochemical Methods", **2** (Academic Press, New York, 1960; in the press).

[9] Vendrely, R., and Vendrely, C., *Experientia*, **5**, 327 (1949). Mirsky, A. E., and Ris, H., *J. Gen. Physiol.*, **34**, 451 (1951).

[10] Dounce, A. L., in "The Nucleic Acids", **2**, 93 (Academic Press, New York, 1955).

[11] Alfert, M., Bern, H. A., and Kahn, R. H., *Acta Anatomica*, **23**, 185 (1955).

COMPARATIVE STUDIES OF YEASTS

By J. A. BARNETT
Low Temperature Research Station, Cambridge

AN attempt is being made in this laboratory to develop improved methods for classifying yeasts. Present knowledge of the many different types of yeast and the methods for distinguishing between them is largely due to the work of the Delft school[1–4] under the influence of Kluyver[5]. This group of workers has developed the first thorough classification of both the sporing and non-spore-forming yeasts[4], the only other major work in any way comparable being that on the classification of the spore-forming yeasts by Kudriavzev[6].

The main divisions in the Dutch classification of yeasts[4] depend on their ability or inability to form spores and on morphology, although some biochemical characteristics are used chiefly for differentiating species[7]. Unfortunately, the factors which influence sporulation in yeasts (except for *Saccharomyces cerevisiae*) are scarcely understood. To make a yeast sporulate it may be necessary to culture it on a large number of alternative media; if, nevertheless, sporulation is not observed, it still does not follow that the yeast is incapable of forming spores. A further difficulty is that it is often impossible to define precisely the morphological criteria used. It is sometimes necessary, for example, to decide whether the buds of vegetative cells "arise on a more or less broad base"[7], whether they have formed pseudo- or 'true' mycelium, whether they are 'lemon-shaped', or whether the spores are "round or oval, reniform, bean- or sickle-shaped, Saturn- or hat-shaped, hemispherical or angular, fusiform or needle-shaped"[7].

The biochemical tests used by the Dutch school were in the first place mainly fermentation tests (that is, ability to produce gas, under fairly low but unknown oxygen tension, from glucose, galactose, sucrose, maltose and lactose[1–4]) and, secondly, growth tests using these sugars as sole sources of carbon[2–4]. In 1948, Wickerham[8] employed additional sugars, as well as glycosides, sugar alcohols, organic acids and other sources of carbon for growth tests, and he applied these new tests, to the classification of the genus *Hansenula*[9]. Kudriavzev[6] has also used many compounds for growth tests and this use of a large number of carbon sources has become popular among yeast taxonomists.

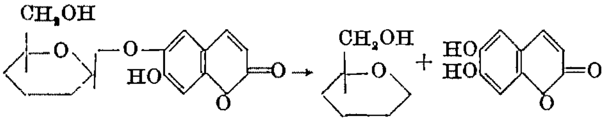
Although the widespread use of these growth tests has increased knowledge of the biochemical potentialities of many kinds of yeast, most of the tests are ill-understood and not carried out under well-defined conditions[10–13]. The Dutch workers have used auxanograms[2–4,10]: yeast cells are inoculated into a molten agar medium which contains all the growth requirements except one, such as a source of carbon; the medium is poured into a Petri dish; alternative carbon sources are placed on the agar surface and the presence or absence of growth observed. Kudriavzev's growth tests were carried out on slopes of medium, each containing a single carbon-source[6]. Wickerham[8,9] used defined liquid media, contained in unshaken tubes to which alternative carbon- or nitrogen- sources or vitamins were added, and the growth response was judged by eye (as for the auxanograms and for Kudriavzev's tests). It is, however, practicable to measure growth in liquid culture by photoelectric methods, using shaken T-tubes which provide uniform growth conditions for the tests[10,14].

As standard biochemical techniques have been introduced, it has become possible to develop a comparative study of yeasts which is based mainly on their biochemistry. In this work, imprecise and subjective morphological observations are avoided and there is no need to search for spores. Work towards this end is being carried out in this laboratory, and it is hoped to develop taxonomic procedures so

Table 1. THE GROWTH OF SOME YEASTS ON CERTAIN POLYOLS

Yeast	Polyol					Reference
	Mannitol	Sorbitol	Galactitol	Ribitol	Erythritol	
Brettanomyces spp. (9 strains)	−	+	−	+	−	20
Brettanomyces spp. (2 strains)	−	+	−	−	−	
Kloeckera apiculata (NCYC 328) *Saccharomyces cerevisiae* (NCYC 77, 176 and 231) *Saccharomyces acidifaciens* (CBS 685 and 739)	−	−	.	−	−	14
Saccharomyces bailii (CBS 680) *Saccharomyces marxianus* (NCYC 111 and 243, CBS 712 and 745)	+	+	.	+	−	

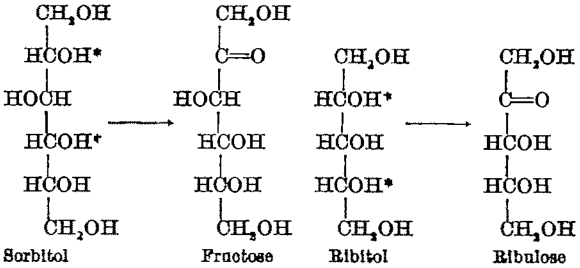
that each test will then reveal the presence or absence of a single enzyme, as suggested by Clarke[17]. For example, according to Wiles[18], *Candida guilliermondii* grows when the coumarin glycoside, æsculin, is the sole source of carbon, but *Candida krusei* does not. Is the reason for this difference that *C. krusei* lacks a suitable glycosidase or that it is poisoned by the æsculetin liberated by hydrolysis[12,14]? Is the same cause responsible for the comparable difference he described between *Hansenula anomala* and *Kloeckera apiculata*? As a further example, yeasts of the species *Saccharomyces cerevisiae* and *Saccharomyces acidifaciens* are unable to use exogenous intermediates of the tricarboxylic acid cycle (for example, malate, succinate, citrate) as sole sources of carbon for growth or respiration, while *Saccharomyces drosophilarum* and *Saccharomyces marxianus* are able to do so[15]. Since this distinction is now used by taxonomists[6,9], it is important to know whether it is due to differences in a major metabolic pathway or whether it reflects some difference of transport mechanism across the plasma-membrane[19], or sometimes the one and sometimes the other. A third example is provided by the work of Wickerham[9], who characterized nine out of fifteen species of *Hansenula* as unable to use erythritol as a sole source of carbon for growth. It is important taxonomically to be aware of three alternative possible reasons for this inability: failure of erythritol to penetrate the plasma-membrane; lack of a suitable dehydrogenase; or lack of a kinase capable of phosphorylating the erythrulose formed from the dehydrogenation of erythritol.


Æsculin (glycoside) Glucose Æsculetin (aglycone)

It has already been possible to throw a little light on some of these questions by working with cell-free extracts and comparing their behaviour with that of intact cells[14]. There are indications that yeasts contain a number of different β-glucosidases and that the phenolic aglycones liberated by their action are inhibitory not only to growth but also to the initial hydrolysis of the glycoside itself[12,14]. There is evidence of the occurrence of the tricarboxylic acid cycle both in yeasts that are capable of using exogenous intermediates of the cycle, and also in those that are not[15]. This makes it likely that the differences between these two types of yeast are in the accessibility of these acids to the enzymes of the cycle.

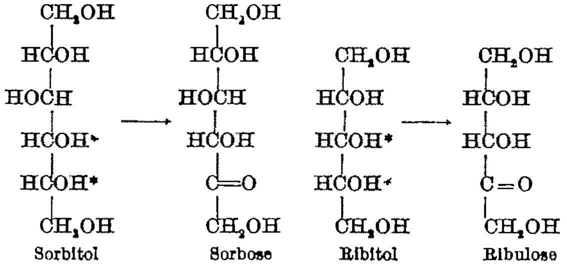
Recent work on *Brettanomyces* species[20] involved a study of their growth on polyols. The results of this work suggest the presence in these yeasts of a polyol dehydrogenase of the type described by Blakley[21,22], capable of oxidizing sorbitol and ribitol, but unable to attack mannitol, erythritol or galactitol. However, recent taxonomic literature[6,9,10,23,24] suggests that Bertrand's D-mannitol dehydrogenase[25,26] is more common among yeasts than the Blakley enzyme. Bertrand's enzyme oxidizes sorbitol, ribitol, mannitol and erythritol (Fig. 1 and Table 1). If the Bertrand enzyme is widespread, the frequent inability of these yeasts to use erythritol could be explained by postulating that it does not penetrate the plasma-membrane. Such suppositions must be checked by work with cell-free extracts, which may show the situation to be vastly more complicated than has been suggested. Meanwhile, it is mistaken to consider sorbitol utilization as a single test when yeasts may be found to possess at least three different enzymes which occur in other organisms and are capable of converting sorbitol to fructose or to sorbose[22,25,27].

The need for understanding the tests used for classifying yeasts has been emphasized from time to time by taxonomists. For example, Wickerham[28] held that the growth tests on various nitrogen sources[2] were spurious because the yeasts could grow on all these sources when given an adequate supply of vitamins; and Kudriavzev[4] considered it important to know whether the enzymes involved in fermentation



Transformations achieved by the Blakley enzyme: L-iditol dehydrogenase

(This enzyme also converts L-iditol to L-sorbose (ref. 22))



Transformations achieved by the Bertrand enzyme: D-mannitol dehydrogenase

(This enzyme also converts mannitol to fructose, erythritol to erythrulose, D-arabitol to D-xylulose (ref. 25).)

Fig. 1. Specificity of two polyol dehydrogenases. (Asterisks indicate arrangement of hydroxyl groups for which the enzyme shows stereospecificity)

tests are adaptive. But very little has been done so far to apply methods of metabolic biochemistry to the study of different kinds of yeast, although the work that has been started along these lines, and has been briefly described above, suggests that it will prove rewarding. Not only should it make it easier to classify yeasts by making the experimental work more precise, it should also help to produce a stable classification if this is devised in such a way that each test is designed to reveal the presence or absence of a single enzyme[13,14,17]. It would also make yeast taxonomy more useful to biochemists and microbiologists in research and industry who want to know the chemical potentialities of each named yeast.

[1] Stelling-Dekker, N. M., *Verh. Akad. Wet. Amst.*, Sect. 2, **28**, 1 (1931).

[2] Lodder, J., "Die Anaskosporogenen Hefen: Erste Hälfte" (N.V. Noord-Hollandsche Uitgeversmaatschappij, Amsterdam, 1934).

[3] Diddens, H. A., and Lodder, J., "Die Anaskosporogenen Hefen: Zweite Hälfte (N.V. Noord-Hollandsche Uitgeversmaatschappij, Amsterdam, 1942).

[4] Lodder, J., and Kreger-van Rij, N. J. W., "The Yeasts" (North Holland Publishing Company, Amsterdam, 1952).

[5] Kamp, A. F., La Rivière, J. W. M., and Verhoeven, W., "Albert Jan Kluyver. His Life and Work" (North Holland Publishing Company, Amsterdam, 1959).

[6] Kudriavzev, V. I., "The Systematics of Yeasts" (Academy of Sciences of the U.S.S.R., Moscow, 1954).

[7] Lodder, J., Slooff, W. C., and Kreger-van Rij, N. J. W., "The Classification of Yeasts" in Cook, A. H., "The Chemistry and Biology of Yeasts" (Academic Press, New York, 1958).

[8] Wickerham, L. J., and Burton, K. A., *J. Bact*, **56**, 363 (1948).

[9] Wickerham, L. J., *Tech. Bull. U.S. Dep. Agric.*, 1029 (1951).

[10] Barnett, J. A., and Ingram, M., *J. App. Bact.*, **18**, 131 (1955).

[11] Barnett, J. A., and Swain, T., *Nature*, **177**, 133 (1956).

[12] Barnett, J. A., Ingram, M., and Swain, T., *J. Gen. Microbiol.*, **15**, 529 (1956).

[13] Barnett, J. A., *Leeuwenhoek ned. Tijdschr.*, **23**, 1 (1957).

[14] Barnett, J. A. (unpublished work).

[15] Barnett, J. A., and Kornberg, H. L., *J. Gen. Microbiol.* (in the press).

[16] Kilkenny, B. C., and Hinshelwood, C., *Proc. Roy. Soc.* B., **139**, 575 (1952).

[17] Clarke, P. H., *J. Gen. Microbiol*, **12**, 337 (1955).

[18] Wiles, A. E., *Wallerstein Labs. Commun.*, **17**, 259 (1954).

[19] Mitchell, P., *Biochem. Soc. Symp.*, **16**, 73 (1959).

[20] Van der Walt, J. P., and Van Kerken, A. E., *Leeuwenhoek ned. Tijdschr.*, **25**, 145 (1959).

[21] Blakley, R. L., *Biochem. J.*, **49**, 257 (1951).

[22] McCorkindale, J., and Edson, N. L., *Biochem. J.*, **57**, 518 (1954).

[23] Phaff, H. J., and Knapp, E. P., *Leeuwenhoek ned. Tijdschr*, **22**, 117 (1956).

[24] Phaff, H. J., Miller, M. W., and Shifrine, M, *Leeuwenhoek ned. Tijdschr.*, **22**, 145 (1956).

[25] Arcus, A. C., and Edson, N. L., *Biochem. J.*, **64**, 385 (1956).

[26] Cummins, J. T., Cheldelin, V. H., and King, T. E., *J. Biol. Chem.*, **226**, 301 (1957).

[27] Shaw, D. R. D., *Biochem. J.*, **64**, 394 (1956).

[28] Wickerham, L. J., *J. Bact.*, **52**, 293 (1946).

A ROLE FOR THIOL AND DISULPHIDE GROUPS IN DETERMINING THE RHEOLOGICAL PROPERTIES OF DOUGH MADE FROM WHEATEN FLOUR

By R. FRATER, DR. F. J. R. HIRD, H. J. MOSS and J. R. YATES

Departments of Biochemistry and Agriculture, University of Melbourne
and Victoria State Laboratories, Victoria, Australia

IN 1940 it was recognized by Sullivan, Howe, Schmalz and Astleford[1] that thiol groups and disulphide bonds were involved in determining the properties of dough. Due to lack of adequate experimental methods for determining these groupings, the precise connexion remained unknown. Recently, however, there has been a renewed experimental interest in the role of sulphur from the point of view of disulphide exchange reactions[2–4].

We report here some definitive experiments which allow the formulation of a hypothesis that relates strength and elasticity of dough to thiol groups, intermolecular disulphide bonds, and the rate at which they interchange. At the same time, evidence is presented which explains the action of certain improvers in terms of disulphide interchange. The experiments were carried out with one flour only—a commercial, unbleached flour milled from Victorian *F.A.Q.* wheat.

Thiol and Disulphide Content of Flour and Extracts of Flour

Thiol and disulphide groups were measured in the whole flour and extracts of flour by amperometric titration of excess methylmercuric iodide[5]. This reagent was added with the dispersing medium in order to limit oxidation of thiol groups during the preparation of the dispersions. The results are given in Table 1. For convenience the results are expressed on the basis of 300 gm. of flour, as this was the weight used in the rheological experiments. The flour contained 12·5 per cent moisture and 1·41 per cent nitrogen. It can be seen that the flour and both fractions derived from it contain thiol and disulphide groups. Further, only a proportion of the total thiol groups found in the presence of urea are readily available for reaction in aqueous suspension with methylmercuric iodide. It is likely that these thiol groups measured in aqueous suspension more nearly represent those available for disulphide bond exchange reactions. Both saline-soluble and gluten proteins can therefore play acceptor and donor parts in such reactions. It is apparent, too, that the saline-soluble fraction on a nitrogen basis is richer in thiol and disulphide groups than the gluten fraction. As the gluten fraction is less soluble, mobility of protein in

Table 1. THIOL AND DISULPHIDE CONTENT OF FLOUR AND FLOUR EXTRACTS

Thiol and disulphide contents calculated on basis of 300 gm. air-dried flour

Material	Medium in which —SH and —S—S— groups measured	µmole —SH	µmole —S—S	Percentage of total nitrogen
Whole flour	Water suspension	184		100
Whole flour	Urea (8 *M*) dispersion	450	2,220	
Saline extract	Urea (8 *M*) dispersion	174	840	
Saline extract	No urea	132		23·7
Residue from saline extract	Water suspension	52		76·3
Residue from saline extract	Urea (8 *M*) dispersion	280	1,560	

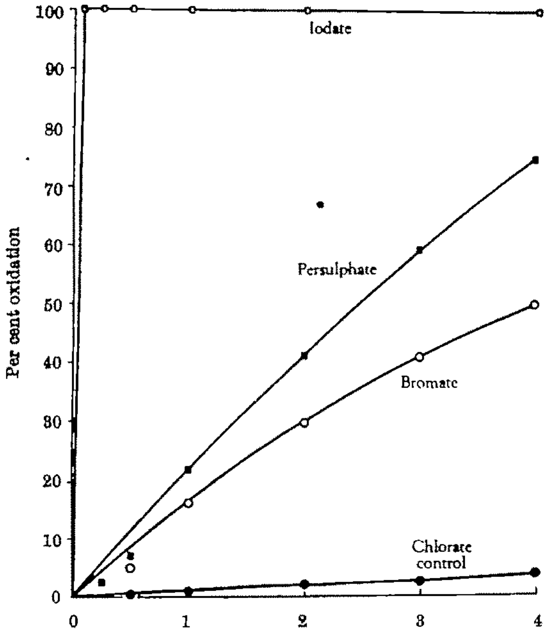


Fig. 1. Oxidation of glutathione by iodate, persulphate, bromate and chlorate plotted against time at pH 6·0 and 28°. Concentration of glutathione, $6·67 \times 10^{-4}$ M; oxidizing agents, 2×10^{-3} M

dough would be due more to the saline-soluble proteins.

Reaction of Thiol Groups with Iodate, Bromate, Persulphate, Chlorate and N-Ethylmaleimide

Oxidation of glutathione, as a model compound, by iodate, bromate, persulphate and chlorate has been followed spectrophotometrically by the method of Boyer[6]. Fig. 1 shows that of the oxidizing agents used, iodate acts very rapidly, bromate and persulphate slowly, and chlorate not at all. Similar results have been obtained with cysteine. Chromatography with phenol/water showed that in the case of cysteine the main product is the disulphide cystine, with small amounts of cysteinesulphinic and cysteinesulphonic acids. Table 2 shows that gluten reduced with sodium borohydride also has its thiol groups oxidized at similar rates by iodate, bromate and persulphate. A full account of the oxidation of thiol groups by iodate, bromate and persulphate is in preparation and will be presented elsewhere. It is of interest that the rates of oxidation of thiol groups by the oxidizing agents used are closely paralleled by their well-known rates of action as improvers in the bread industry[1,7,8].

Table 3 shows that the addition of iodate and N-ethylmaleimide to suspensions of flour brings about a considerable decrease in the readily available thiol groups. In a qualitative way, these decreases support the inferences drawn from the effect of these reagents in the rheological experiments described later. Quantitatively, however, it is likely that, when mechanically mixed, the decrease in total thiol groups of the dough would be greater than that obtained with suspensions of flour.

Table 2. OXIDATION OF REDUCED GLUTEN BY BROMATE, IODATE AND PERSULPHATE

Reduced gluten (10 mgm./10 ml.) finely suspended in citrate buffer 0·5 M at pH 6·0. Oxidizing agent (1·2 mM) added in 1 ml. After appropriate interval, methylmercuric iodide added and excess determined amperometrically. Results calculated on basis of moles/10^5 gm.

Time	Moles of —SH groups expressed per 10^5 gm. by Iodate	Bromate	Persulphate
0	11·5	10·5	11·0
1 min.	2	—	—
3 min.	1	—	—
5 min.	0	—	—
30 min.	0	—	—
3 hr.	—	7·5	10·0
6 hr	—	6·0	7·5
9 hr.	—	5·0	7·0

Table 3. REACTION OF THIOL GROUPS OF FLOUR WITH IODATE AND N-ETHYLMALEIMIDE

Flour (1 gm.) suspended in 0·624 M sodium chloride (10 ml.) and iodate and N-ethylmaleimide added in amounts indicated after reaction time of 5 min.; a further 9 ml. of 0·624 M sodium chloride was then added. Residual thiol groups were then estimated by amperometric titration with methylmercuric iodide. Results calculated to 300 gm. flour which contained 180 μmoles of readily available thiol groups

Iodate		N-ethylmaleimide	
Iodate added (μmole)	Thiol in flour suspension (μmole)	N-ethylmaleimide added (μmole)	Thiol in flour suspension (μmole)
0	180	0	180
		45	132
15	150	90	96
30	138	180	96
75	126	360	90
150	120	720	84
300	111		
1,500	96		

Action of Iodate, N-Ethylmaleimide and Cysteine on the Rheological Properties of Dough

The rheological properties of the dough were studied using the commercial instruments—the Brabender farinograph and extensograph. These instruments respectively measure resistance to mixing against duration of mixing, and resistance to extension against distance extended.

Fig. 2 shows that the presence of iodate and N-ethylmaleimide alter the mixing properties of the dough initially in such way as to increase the resistance to mixing and later to lower it. Similar responses on farinograms have been shown by Mecham[9]. The effects of iodate and N-ethylmaleimide are even more marked when measured with the extensograph (Fig. 3). (See also Goldstein[3].)

From the known chemistry of iodate (Fig. 1) and N-ethylmaleimide (Table 3 and Friedmann *et al.*[9]), the effects obtained can be related to the disappearance of thiol groups. In the case of iodate there is the further possibility described earlier, of formation of new intermolecular disulphide bonds which would

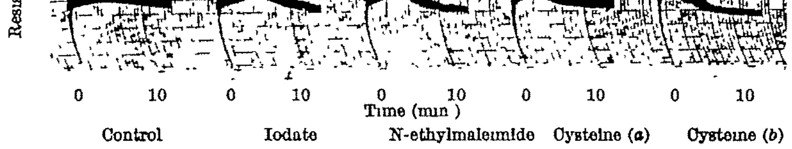


Fig. 2. Farinograms of 300 gm. flour, mixed with 168 ml. water containing 6 gm. sodium chloride and the reagents indicated. Flour contained 450 μmoles thiol and 2,220 μmoles disulphide; iodate, 45 μmoles; N-ethylmaleimide, 150 μmoles; cysteine (a) 75 and (b) 300 μmoles

be expected to strengthen dough. In the case of N-ethylmaleimide, there seems to be only one possible explanation of the effects observed, namely, the disappearance of thiol groups prevents disulphide interchange by removal of one of the necessary components. Expressed in another way, a stable intermolecular disulphide network that does not yield to stress is formed—the result being a tough, non-extensible or stabilized dough.

Figs. 2 and 3 show also that mixing of dough stabilized in this way destroys certain of the bonds responsible for resistance and at the same time increases the extensibility. It follows from these observations that, even in untreated doughs, the rate at which the shearing forces are applied during mixing will affect the rheological properties of the product, depending on the rate at which the exchange reactions can keep pace with the rate at which the stress is applied.

The effect of concentration of iodate and N-ethylmaleimide when mixed with the dough for 1·5 min. is shown in Fig. 4. It is not possible to say whether these two reagents have reacted completely with the thiol groups in the dough under the mixing conditions used but, assuming complete reaction, a rough quantitative estimate (a maximum) of the number of thiol groups involved in the observed effects can be put at 33 per cent of the total thiol groups. With N-ethylmaleimide, the figures, with this proviso, are more certain as this reagent is monofunctional. In the case of iodate, however, there can be no certainty, as the oxidation may proceed within the two extremes:

$$IO_3^- + 6RSH \rightarrow I^- + 3R\text{-}S\text{-}S\text{-}R + 3H_2O \quad (1)$$
$$IO_3^- + RSH \rightarrow I^- + R\text{-}SO_3H \quad (2)$$

However, leaving aside the question of stoichiometry in the reaction between iodate and the thiol groups of flour, its effect is very similar to that of N-ethylmaleimide at similar concentrations.

The effect of adding varying concentrations of cysteine to the dough can be seen in Fig. 2 and Fig. 5. With increasing concentration, strength decreases; and at the higher concentrations the extensibility is so great that the instruments cannot measure the resistance. The figures presented express cysteine added as percentage of total disulphide bonds broken, but reduction in the strength of the dough would be due not only to destruction of intermolecular disulphide bonds but also to an increased rate of their

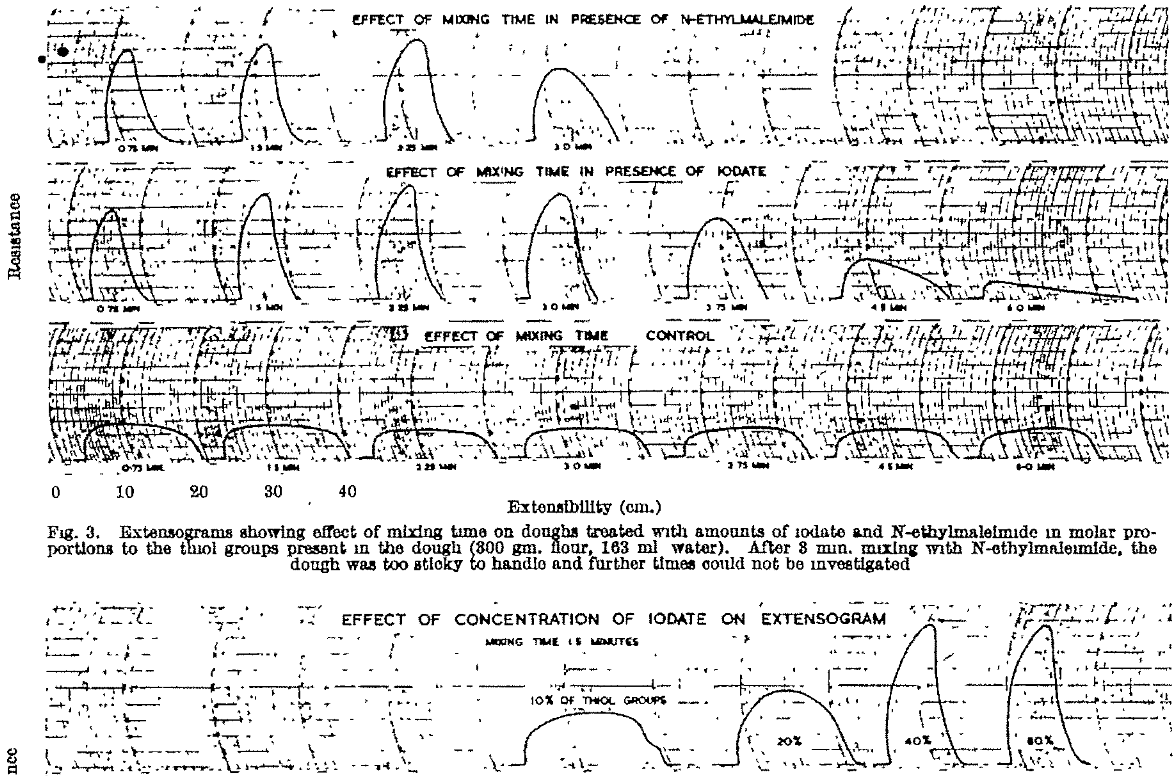


Fig. 3. Extensograms showing effect of mixing time on doughs treated with amounts of iodate and N-ethylmaleimide in molar proportions to the thiol groups present in the dough (300 gm. flour, 163 ml water). After 3 min. mixing with N-ethylmaleimide, the dough was too sticky to handle and further times could not be investigated

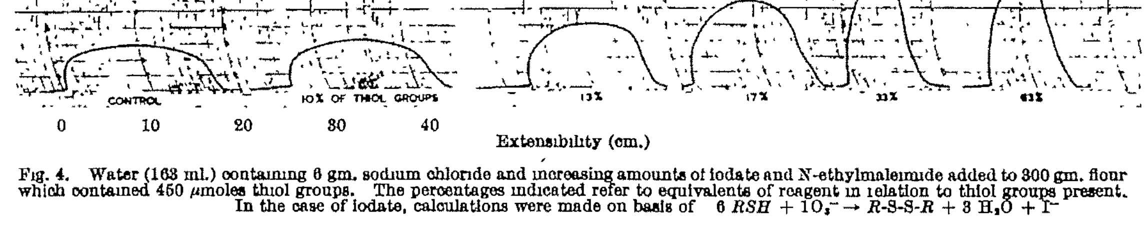


Fig. 4. Water (163 ml.) containing 6 gm. sodium chloride and increasing amounts of iodate and N-ethylmaleimide added to 300 gm. flour which contained 450 μmoles thiol groups. The percentages indicated refer to equivalents of reagent in relation to thiol groups present. In the case of iodate, calculations were made on basis of $6\,RSH + IO_3^- \rightarrow R\text{-}S\text{-}S\text{-}R + 3\,H_2O + I^-$

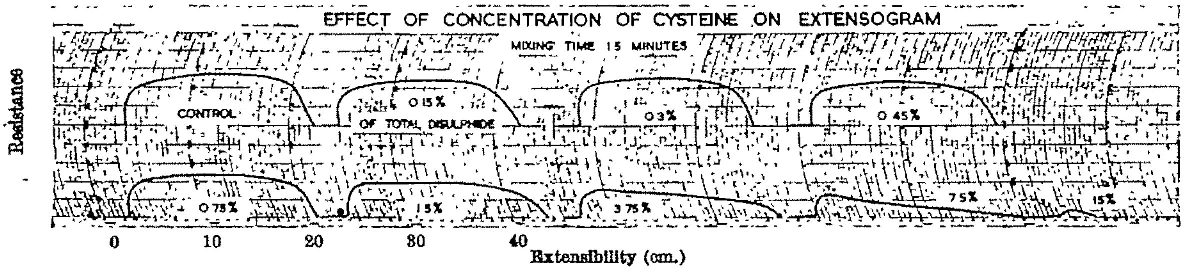


Fig. 5. Extensograms showing the effect of increasing amounts of cysteine. For conditions and disulphide content of flour, see Fig. 2. Percentages given represent μmoles cysteine in relation to μmoles disulphide present in the flour

interchange. However, it can be stated that only small percentage changes in these bring about a marked loss of strength and increased extensibility.

Conclusions

At any given protein content of flour, it appears likely that the rheological properties of dough are directly related to the number of intermolecular disulphide bonds and the rate at which they can interchange with thiol groups. A useful approach to the problem of quality differences in wheats would seem to be, that their related doughs differ with respect to either or both of these properties. In this respect it is likely that both water-soluble proteins and gluten fractions of the flour are involved.

The action of improvers, both thiol-blocking and oxidizing agents, can be related to this concept, namely, strengthening of the dough through inhibition of disulphide exchange reactions. In the case of oxidizing improvers, there is the additional possibility of increase in strength of dough through formation of new intermolecular disulphide bonds. The preference in industry for bromate over iodate as an improver can be related to the slower oxidation of thiol groups by the former, leading to the slow development of a stable structure during the preparation and baking of the dough. The action of reducing agents in destroying the structure of dough can be interpreted both as lowering the number of intermolecular disulphide bonds and/or increasing the rate of their exchange.

In the discussion so far, emphasis has been placed on the quantitative importance of intermolecular disulphide bonds and their rate of exchange in determining the strength of the dough. However, components other than proteins and other types of bonds play a part in determining the total rheological properties. In this connexion it is suggested that hydrogen bonding between the amide groups of the large number of glutamine residues of gliadin[10] play a major part in determining the solubility properties. Intermolecular disulphide bonds could then be regarded as stabilizing the more fluid hydrogen-bonded system.

We wish to acknowledge financial support from the Wheat Industry Research Council. One of us (J. R. Y.) was in receipt of a Commonwealth Scientific and Industrial Research Organization Exchange Studentship.

[1] Sullivan, B., Howe, M., Schmalz, F. D., and Astleford, G. R., *Cereal Chem.*, **17**, 507 (1940).
[2] Mecham, D. K., *Cereal Chem.*, **36**, 134 (1959).
[3] Goldstein, S., *Mitt. Gebiete Lebensm. Hygiene (Bern)*, **48**, 87 (1957).
[4] Bloksma, A. H., *Getreide und Mehle*, **9**, 65 (1958).
[5] Leach, S. J. (personal communication); *Biochim. Biophys. Acta*, **32**, 264 (1959).
[6] Boyer, P. D., *J. Amer. Chem. Soc.*, **76**, 4331 (1954).
[7] Ziegler, E., *Cereal Chem.*, **18**, 167 (1941).
[8] Dempster, C. J., Cunningham, D. K., Fisher, M. H., Hlynka, I., and Anderson, J. A., *Cereal Chem.*, **33**, 221 (1956).
[9] Friedmann, E., Marrian, D. H., and Simon-Reuss, I., *Brit. J. Pharm.*, **4**, 105 (1949).
[10] Tristram, G. R., "Adv. Prot Chem.", **5**, 83 (Acad. Press, 1949).

EXPLORATORY BEHAVIOUR IN THE RAT*

By ROGER G. A. STRETCH
Psychological Laboratory, University of Sheffield†

RECENT studies have shown that a rat, confronted with novel, environmental stimulation, manifests much investigatory activity. This exploratory behaviour reduces the 'newness' of the stimulation, so that as the situation becomes familiar exploration diminishes.

Berlyne[1,2] has been concerned with developing a theory to account for the satiation of curiosity responses in rats. In this he employs Hull's[4] two-factor theory of inhibition. A temporary decline in exploratory behaviour is attributed to accumulation of reactive inhibition, while a more slowly developing, permanent decline is interpreted in terms of the acquisition of a conditioned resting-response, that is, conditioned inhibition. These terms require some explanation. Reactive inhibition may be thought of as a negative drive state akin to avoidance of pain. It is an inhibition produced by response and resembles fatigue; and it is believed to be dissipated during periods of rest. If rest periods are too short to allow for dissipation of reactive inhibition when responses are being elicited continuously, there develops an increasingly strong tendency for the cessation of response. When resting occurs, a quantity of reactive inhibition is dissipated. Dissipation of reactive inhibition during rest constitutes reinforcement, so

---

* Based on a paper at the York meeting of the British Association read on September 8.

† Present address: Department of Parasitology and Entomology, Liverpool School of Tropical Medicine.

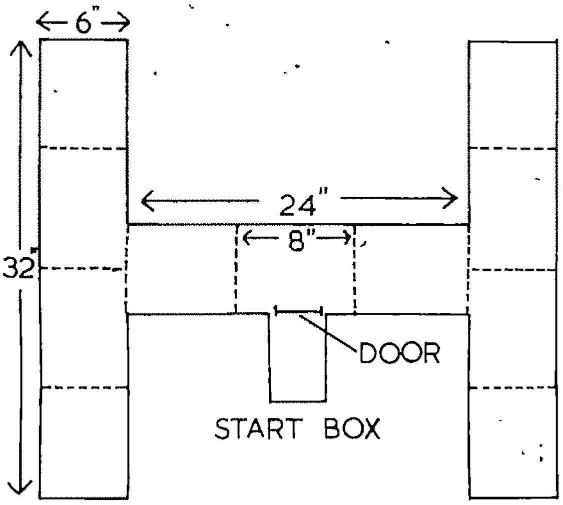


Fig. 1. A plan of the maze used. Exploratory activity was measured by counting the number of 8-in. units an animal entered in each minute. These are shown by the broken lines on the figure

that the response of resting becomes conditioned to whatever stimuli are present in the situation. This acquired tendency to rest is conditioned inhibition.

Thus Berlyne showed[4]: (i) rats enter an alcove in an exploratory box more frequently if it contains a novel object (for example, a wooden cube) than if it is empty; this supports the view that a novel stimulus evokes the curiosity drive; (ii) the amount of curiosity declines rapidly with continuous exposure to a novel object; this decline is interpreted in terms of the accumulation of reactive inhibition, primarily; (iii) there is a relatively permanent decrement in curiosity after initial exposure; rats enter the alcove of an exploratory box to investigate a novel object less frequently as daily trials proceed and this is taken to support Berlyne's application of conditioned inhibition to explain the adaptation of curiosity responses.

While Berlyne found evidence to support this theory, Montgomery[5] did not. Working at Yale University, Montgomery studied exploratory behaviour in simple maze environments. Typically, rats are placed in an *H*-maze, the alleys of which are marked out in 12-in. units. The number of units an animal enters in each minute of a 10-min. trial constitutes a measure of exploratory activity. Rats tend to enter many units initially, whereas few are entered towards the end of a trial. Montgomery also found that if a 10-min. trial is given each day, there is full 'recovery' of maze exploration. Therefore, he concluded that conditioned inhibition was not applicable because he could find no evidence for a permanent decrement in exploratory activity.

Berlyne stated, in reply: "We can only hazard the suggestion that maze runways present a large assortment of novel stimuli, so that a ten-minute exploration period may not allow enough time to satiate the curiosity aroused by most of them to the point at which a permanent decrement occurs" (ref. 2, p. 245). However, he did not test this supposition. Thus, a controversy continues to exist, and an experiment was designed to clarify it.

The apparatus consisted of an enclosed *H*-maze, the main dimensions of which are shown in Fig. 1. The walls of the maze were 6 in. high, and the maze was covered with plate glass. The centre piece of the *H* was painted white and the two arms grey. Each alley was marked off in 8-in. segments. The maze was placed in an arena 5 ft. square, and 4 ft. high. This enclosure was constructed with metal strip, and covered with butter-muslin. Thus, the maze was enclosed in a relatively homogeneous environment. Further, it was illuminated by three red 15-W. lamps suspended above the maze. These afforded a low but even source of illumination. During the maze trials, the room was in darkness, so that the butter-muslin enclosure provided an efficient one-way screen, that is, the observer could watch an animal with little danger of distracting it by his own movements. An animal was placed in the starting box for 1 min. before the door was raised, thus allowing a brief period of adaptation before any trial commenced.

The subjects were 15 male albino rats of 110 days of age. Of these 15 animals, 6 were 'non-reactive', and 9 were 'reactive'. These animals were the offspring of breeding nuclei of the 10th generation of Maudsley Reactive and Non-reactive strains, respectively, which originally formed a part of a selective breeding study of emotionality which is being conducted at the Institute of Psychiatry (Maudsley Hospital), Animal Psychology Laboratory, London[3]. (I am indebted to Dr. P. L. Broadhurst for allowing us to purchase this stock for use in Sheffield.) Unfortunately, it was not possible to submit these animals to the open-field test at the time of this experiment, although this technique[3] was used in later work.

After each animal had been habituated to handling, they were assigned randomly to one of three groups, designated *A*(20), *B*(40) and *C*(60), respectively. There were five rats per group. On day 1, each animal received a 20-min. trial in the maze. On day 2, group *A*(20) received a 20-min. trial, group *B*(40) a 40-min. trial, and group *C*(60), a 60-min. trial. This procedure was repeated on days 3 and 4.

After the appropriate trial on day 4, the animals were returned as usual to their home cages, where they remained, untouched, for 9 days. On the tenth day, each animal was given one 20-min. trial in the maze. Throughout the experiment, all animals were supplied with food and water *ad libitum*, except when in the maze.

The number of maze units entered in each minute of a trial constituted the measure of exploratory activity.

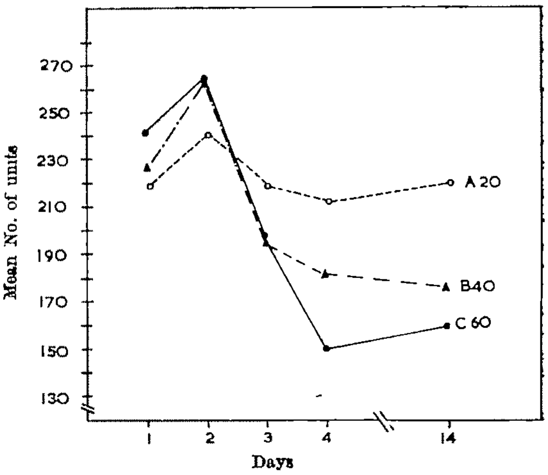


Fig 2. Mean number of maze units entered in the first 20 min. by each of the groups during their daily trials

Four main results emerged from this work. These may be seen from Fig. 2. In the first place, there were no significant differences between the groups in amount of exploration during the 20-min. trial of day 1. Nor were any differences found between the reactive and non-reactive rats on day 1. (The results were analysed by non-parametric techniques.)

Secondly, a comparison of the mean amount of exploration on day 1 with that on day 2 revealed a significant increase for the 15 rats taken as a whole. Further analysis showed that the reactive rats were mainly responsible for this, in that their day 1 to day 2 increase was significant ($P = 0{\cdot}05$), whereas that of the non-reactive animals was not.

Thirdly, differences between the groups failed to reach significance on day 3. However, on day 4, the difference in exploration between groups A(20) and C(60) during the *first* 20 min. was highly significant ($P = 0{\cdot}004$). The difference between groups A(20) and B(40) did not reach an acceptable level.

Lastly, the differences in mean exploration scores after a period of 9 days absence from the maze reveal a decrement for those rats given extended periods of exploration during the first phase of the experiment. The difference between A(20) and B(40) was significant at $P = 0{\cdot}05$ (two-tailed test); the difference between group A(20) and group C(60) was significant at a more acceptable level ($P = 0{\cdot}01$). However, the mean difference between group B(40) and group C(60) was not significant.

The first result, namely, the day 1 to day 2 increase in exploration, has not been reported, previously, by other investigators. However, it has been suggested that novel stimuli may elicit fear as well as curiosity[6], and this effect may be due, therefore, to the extinction of fear responses elicited during the first trial. This view gains support in that emotionally 'reactive' rats manifest this increase more markedly than 'non-reactive' animals. Further research is needed to test this hypothesis.

With regard to a controversy concerning the permanency of a decline in exploratory tendencies after repeated exposure, the results of this experiment lend support to Berlyne's position. They suggest that Montgomery failed to allow rats sufficient time to explore a novel environment to the point at which a more permanent decrement occurs. More research is needed to confirm the adequacy, as opposed to the usefulness, of Berlyne's hypothesis. However, a neurophysiological basis for the inhibitory concepts of this theory may be found in experiments[7] concerning habituation of the arousal response in cats.

I am indebted to Dr. Peter McKellar for supervision and help in conducting a series of experiments of which the present experiment is a part.

[1] Berlyne, D. E., *Brit J. Psychol.*, **41**, 68 (1950).

[2] Berlyne, D. E., *J. Comp. Physiol. Psychol.*, **48**, 238 (1955).

[3] Broadhurst, P. L., *J. Comp. Physiol. Psychol.*, **51**, 55 (1958).

[4] Hull, C. L., "Principles of Behaviour" (1943).

[5] Montgomery, K. C., *J. Comp. Physiol. Psychol.*, **46**, 129 (1953).

[6] Montgomery, K. C., *J. Comp. Physiol. Psychol.*, **48**, 254 (1955)

[7] Sharpless, S., and Jasper, H, *Brain*, **79**, 655 (1956)

THE AFFINITIES OF THE NEW OLDUVAI AUSTRALOPITHECINE

DR. L. S. B. LEAKEY recently reported in *Nature*[1] the discovery of an essentially complete hominid skull without mandible from site *FLK* at Olduvai Gorge. He regards the specimen as an australopithecine that differs more from either of the two known genera, *Australopithecus* and *Paranthropus*, than these two differ from each other. He therefore erected the genus *Zinjanthropus* to accommodate the new specimen.

The description consists largely of a list of twenty 'major' differences between the new specimen and the two previously known genera. Some of these points cannot be dealt with as they are briefly stated in terms which are not useful by themselves for comparison. Others, for example, continuous nuchal crest, enlargement of the mastoid area, prominent temporal lines, large areas for masseter attachment, etc., do not each represent a separate difference; all are reflexions of the fact that this specimen is a little larger and more muscular than the known South African specimens of *Paranthropus*. In at least one case (nuchal crest) comparison with the latter specimens is not possible since there is no known male specimen with the relevant area preserved. The remainder are not real differences and will be dealt with briefly:

(1) The inion is lower relative to the Frankfort plane: In both *Australopithecus* and *Paranthropus* the base of the external occipital protuberance is almost exactly in the Frankfort plane, as seems to be the case with the Olduvai specimen.

(2) The posterior wall of the occipital bone rises more steeply to form, with the parietals, a very high-vaulted posterior region of the skull: This is also the case in *Paranthropus*, less so in *Australopithecus*. *Paranthropus* has an almost spheroidal brain-case which is relatively low and narrow anteriorly but steep-sided and higher posteriorly. *Australopithecus* has a brain-case more nearly like that of a dolichocephalic modern hominine. The Olduvai specimen has the *Paranthropus* type of brain-case.

(3) The form of the tympanic plate is different: Dr. Leakey demonstrated this point to me on the specimen to make clear his meaning. This feature is variable in *Paranthropus* and includes an instance of close resemblance to the Olduvai specimen. The observed range of variation is illustrated in Fig. 1. Being thus variable, it is in any event a feature of low phyletic valence.

(4) The very unusual position of the nasion—almost coinciding with glabella: This is true of *Paranthropus* and in at least some cases of *Australopithecus* also. In *Paranthropus*, as in the Olduvai specimen, the nasals are relatively very wide near the nasion.

(5) The very great absolute and also relative width of the inter-orbital area. The proportionate width of the inter-orbital area to that between the external orbital angles is 26·6 in the Olduvai specimen; 26·2 (*SK* 846), 25·3 (*SK* 48) in two specimens of *Paranthropus*. A single specimen of *Australopithecus* gave a value of 24·1, while a random sample of eight

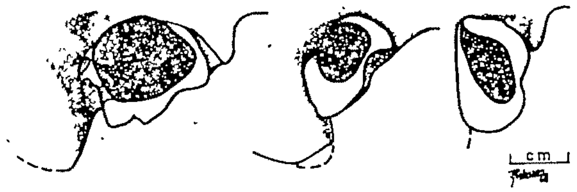


Fig. 1. Variation of the tympanic bone at the lateral end of the external auditory meatus in *Paranthropus* from Swartkrans (*SK* 48, *SK* 52 and *SK* 848). The Olduvai specimen resembles in this feature the condition illustrated in the middle diagram

modern human skulls gave a range of 23·4–30·5. No taxonomic significance can therefore be attached to this point on the present evidence.

(6) The very deep palate which is even more markedly like that of *Homo* than *Australopithecus*, and is quite unlike the form seen in *Paranthropus* : In *Homo*, the degree of vaulting of the hard palate is variable, but the difference in depth at the incisive fossa and the back of the palate is normally relatively slight. This is true also of *Australopithecus*. The palate of *Paranthropus* differs in that it slopes more markedly ; that is, there is always an appreciable difference between the anterior and posterior depths —in some cases there is no depth at all anteriorly, in others the anterior depth is appreciable. The Olduvai specimen shares this characteristic of relatively much greater posterior compared to anterior depth, reflecting the *Paranthropus* condition, not that of *Homo* and *Australopithecus*.

(7) The shape and arrangement of the zygomatic process of the maxilla : The Olduvai specimen has a relatively poorly developed zygomatic process, the lower border of which passes almost horizontally from the zygo-maxillary suture to the main body of the maxilla. In some specimens of *Paranthropus* the process passes from the zygo-maxillary suture downward and medial-ward at a fairly sharp angle like an inverted flying buttress. However, *SK* 52, of the same dental age as the Olduvai specimen, has a trace only of the buttress and *SK* 846 (mature adult) has no trace of it, as in the Olduvai specimen.

(8) The relatively greater reduction of the canines in comparison with the molar-premolar series than is seen even in *Paranthropus* : As the marked change of proportion between anterior and cheek teeth occurs in *Paranthropus* and the Olduvai specimen between canine and P^3, the degree of reduction can be measured by the ratio between the modules of these two teeth. The ratio for the Olduvai specimen is 64·9 while that for three specimens of *Paranthropus* ranges from 61·8 to 78·8.

(9) In the species diagnosis Leakey refers to the presence of a sagittal crest "at least posteriorly". The reason for this statement is not clear, since the crest occupies a position identical to that in *Paranthropus*—on roughly the middle third of the distance between glabella and inion. In neither form is the sagittal crest known to reach as far back as the planum occipitale or even the posterior part of the sagittal suture.

It seems to me that the most fruitful approach to an understanding of the australopithecine skull, within the framework of hominid structure, is in terms of diet and the nature of the dentition. *Australopithecus*, as an omnivore eating at least a moderate amount of flesh, has a dental apparatus very similar to that of the older hominines. The relative sizes of the teeth along the tooth row are closely similar, as is the arrangement of the dental arcades. The anterior teeth, especially the canines, are well developed, but the post-canine ones only moderately so. The skulls are also similarly constructed except for the relatively small cranium, compared to the face, of *Australopithecus*.

In *Paranthropus* the situation is very different. Here the anterior teeth, set in an almost straight line across the front of the palate, are appreciably reduced in size compared to those of *Australopithecus*, while the post-canine teeth are appreciably larger. This difference in arrangement and proportion is very striking and is characterized by the very small canine tooth set firmly against a massive premolar. All this must clearly have functional meaning. The massive crushing and grinding teeth, the relatively unimportant anterior teeth and frequent damage to the enamel which could only have been caused by small, very hard particles (presumably grit), and the large size of the animal suggest a predominantly vegetarian diet. Concentration of heavy dental function in the post-canine region has strongly modified the skull architecture. The massive cheek teeth, especially the molars, have strongly developed root systems and hence are set in heavy bone, and the back of the palate is relatively deep. Owing to the heavy chewing forces, the palate is thick, the jaws are massive, especially where supporting the cheek teeth, the zygomatic arches are strongly built, the circum-orbital bone is strong in the stressed areas, the strongly stressed pillars on either side of the pyriform aperture are thick and the medial and lateral pterygoid plates, especially the latter, are large and strong. However, the large dental battery requires heavy musculature to operate it—hence further changes from the *Australopithecus* and hominine pattern. The areas of origin and insertion of these muscles are sturdy ; hence the large surface area of the mandibular ramus, the massive zygomatic arch—which also is widely spaced from the brain-case to allow for the very large temporal muscle—large medial and lateral pterygoid plates, clearly defined temporal lines, sagittal crest and apparent prominence of the supraorbital tori. The large muscles associated with the large and chunky animal result in well-defined muscular ridges on the occiput and the prominence of the mastoid area—assisted by the large temporal muscles which necessitate appreciable lateral extension of the zygomatic arch. It is probable also that the large temporal muscles have influenced the shape of the brain-case anteriorly to help produce the low and narrow shape characteristic of *Paranthropus*. As is usual in relatively massive skulls where large surface area is necessary, some reduction of weight has occurred by increased pneumatism. The mastoid region (not the mastoid process alone) is strongly cellular and the air spaces in the skull base, the maxillæ and the frontal bone are all very large.

The curious and characteristic features of the *Paranthropus* skull, which parallel some of those of the gorilla skull and mark it off so clearly from that of *Australopithecus*, are all functionally related and determined largely by the specialized diet of this creature as compared to all other known hominids. These functional and structural differences indicate clear adaptational differences between the two forms and hence also differences of evolutionary direction. In modern systematics, adaptational differences of this order and nature are normally accorded generic rank.

The features of the Olduvai specimen fit the *Paranthropus* pattern as here outlined very accurately—

the differences being almost entirely of the sort shown to be variable within a single population by the sample of nearly 200 specimens of *Paranthropus* now in the collections of the Transvaal Museum. The chief feature of the Olduvai form which does not fall within the observed range of variation of this collection is size. The best size comparison is with the only male specimen with good teeth which has P^3–M^1 preserved in sequence and is of the same dental age as the Olduvai specimen. The latter is only 8·4 per cent larger. The average percentage difference for five skull and dental series dimensions compared to those of a fully adult female skull is 17·4 per cent. As Schultz has shown in a number of papers, intra-specific variation in measurable primate anatomical characters can often greatly exceed the above values.

The validity of separate specific status is not clear on the basis of the single specimen, and it is perhaps wisest to leave it as distinct. In the light of the above analysis, however, separate generic status seems unwarranted and biologically unmeaningful. I therefore propose that the name of the Olduvai form be *Paranthropus boisei* (Leakey).

J. T. Robinson

Transvaal Museum,
Pretoria.

---

[1] *Nature*, 184, 491 (1959).

The exact taxonomic label that should be applied to the skull that I have named *Zinjanthropus*, from Olduvai, and which I described in *Nature* of August 15, 1959, seems to me relatively unimportant at the moment. Inevitably, different scientific workers have different ideas of what characters justify specific, generic, and even superfamilial rank. After all, this is purely a question of artificial labels.

Dr. Robinson and I agree that *Zinjanthropus boisei* is closely related to the Australopithecinae; we agree that it has certain resemblances to *Paranthropus*, and we disagree mainly in that he believes the differences to be insufficient to justify separate generic rank, while I think they do.

It is hard enough to reach agreement among zoologists on the taxonomic status of living primates, under conditions in which we possess the skull, skeleton, skin and viscera for study, and it will always be much more difficult to do so when we have only fossils to guide us. I can only say that the very considerable additional work that I have done on the *Zinjanthropus* skull since my preliminary report in *Nature* has greatly strengthened my view that it is entirely different from *Australopithecus* and *Paranthropus*, differing from both these genera more than they do from each other.

I do not feel that any useful purpose would be served by entering into a long discussion with Dr. Robinson in *Nature* at present, since the more detailed study of the Olduvai skull which is now in hand will not, I hope, be too long delayed. However, Dr. Robinson makes certain statements which may mislead those who read them, unless I comment on them. I will therefore do so as briefly as possible.

First of all, whereas in *Paranthropus* and *Australopithecus* (as Dr. Robinson says) the external occipital protuberance lies more or less on the Frankfort plane, in *Zinjanthropus* it lies below it.

Robinson's description of the brain case of *Paranthropus* as "almost spheroidal", but also "relatively low and narrow anteriorly but steep-sided and higher posteriorly", does not seem to make sense, for the two statements seem to cancel each other out. In any event, such a combined description does not fit the brain case of *Zinjanthropus*.

Robinson illustrates the range of the tympanic plate (see in profile), in *Paranthropus*. None of these three illustrations closely resembles the tympanic plate of *Zinjanthropus*, although the one to the left appears to be rather closer than the middle one.

Without knowing the points at which Robinson measures inter-orbital width and external orbital width, I cannot comment upon his comparisons of his *Paranthropus* figures with mine for *Zinjanthropus*.

As to the morphology of the palate, I do not know upon what evidence Robinson is basing his statement, since I have published no measurements of the palatal depth in *Zinjanthropus*. I must repeat, however, quite categorically, that the morphology of the *Zinjanthropus* palate in no way resembles that of *Paranthropus*.

I cannot accept Robinson's statement that the zygomatic process of the maxilla in *Zinjanthropus* is "relatively poorly developed"; I would say rather, as I have said before, that it is developed in an entirely different morphological manner from *Paranthropus*.

As regards the position of the sagittal crest, in *Zinjanthropus* it ceases to be a crest and divides into two temporal lines well behind the line drawn vertically through the ear when the skull is on the Frankfort plane. In *Paranthropus* (in all the published photographs), the sagittal crest extends a long way forward of such a vertical line through the ear when the skull is on the Frankfort plane, and it is therefore wrong to say, as Robinson does, that "the crest occupies a position identical to that in *Paranthropus*".

Finally, I do not understand the significance of a comparison of "the ratio between the modules of these two teeth", that is, the canine and P^3. Robinson has defined a module as the sum of the length and breadth of a tooth divided by two, and I am at a complete loss to understand how the ratios of modules can have any significance. It must be obvious that one can have on one hand a canine tooth 16 mm. long and 6 mm. wide (module equals 11), and a premolar 9 mm. long and 7 mm. wide (module equals 8), while in another specimen one could have a canine which measured 11 mm. × 11 mm., and a premolar which was only 5 mm. long and 11 mm. wide, yet the ratio of the modules in the two sets of teeth would be identical, but completely without significance.

In any event, the ratio between the canine and the premolar alone cannot have any bearing upon the relation of the canine size to the total molar–premolar series, unless the premolar bears a constant relation to the total post canine series.

I therefore repeat my statement that in *Zinjanthropus* there is a relatively greater reduction of the canines in comparison with the total molar–premolar series than is seen in *Paranthropus*, and maintain that Robinson has in no way disproved this statement.

I agree with Robinson that we need to study the *Australopithecus* skull structure and dentition in terms of diet and mode of life, and I shall certainly do so as far as *Zinjanthropus* is concerned in my fuller report.

L. S. B. Leakey

Coryndon Museum,
Nairobi,
Kenya.

LETTERS TO THE EDITORS

PHYSICS

Comparison of the Charges of the Electron, Proton and Neutron

We have noted the communication from Bondi and Lyttleton[1] criticizing our experiment[2] and we would like to clarify the alleged obscurities.

Bondi and Lyttleton suggest that a supply of electric charges may be detached from the walls of the nozzle, and that if the gas is not electrically neutral it will attract these charges into the gas until it is neutralized. For this mechanism to work two conditions must be satisfied. First, it is necessary to find a process for the production of free charges, and secondly, a process which arranges that the charge carried away by the gas is controlled by the space-charge field, so that charge is carried away just until the space charge has been neutralized. We examine these two conditions in turn.

(1) The observed probable upper limit of the space-charge of the emerging gas was 3×10^{-14} coulomb on 81 litres, or $3 \cdot 6 \times 10^{-13}$ coulomb/m.^{3}. Consider whether a gas with five times this space-charge density (that is, $1 \cdot 8 \times 10^{-12}$ coulomb/m.^{3}) could produce neutralizing charges. Such a space-charge would produce a field intensity, E_s, of 5×10^{-4} V./m. at the surface of the tube, which is too small by a factor of 10^9 to produce field emission of electrons and too small by a larger factor for the production of ions. Surface ionization, the capture of an electron from an impingeing atom, resulting in a surface charge can occur when it is energetically possible. In the present case, the ionization potentials of argon and nitrogen are 15·6 and 14·5 volts respectively, whereas the work function of brass is only about one-third of these values. Proportional counters have been operated successfully with a continuous flow of gas and with fields at the walls many orders of magnitude greater than E_s, indicating that the flow causes no production of ions. Presumably dust or water drops would have to be present in the gas in order to liberate charges from the walls, which is not the case in our experiment.

(2) We now consider the motion of charges supposed to be released at the wall surface. The field due to the space-charge is far from "amply sufficient to drag along charges", for in addition to the field E_s acting on the charge there is a field due to the image charge in the conductor attracting the free charge back, and this exceeds E_s within 1·0 mm. of the wall (or more than a third of the cross-sectional area). Also there are contact potential differences of the order of 10 mV. between different points of the brass surface, giving field intensities of ~ 1 V./m. Even in the latter field, ions or electrons would move much faster by thermal diffusion than their average motion along the lines of force. Hence the motion of any ions or electrons liberated from the surface by friction would be determined mainly by random diffusion (modified by turbulence), to a lesser extent by the irregular surface fields, with the space-charge fields a few thousand times weaker still. Equilibrium ion and electron densities must therefore be determined mainly by the rates of production and of diffusion loss, and in any event not by making the field component due to space-charge equal to zero. It is, in fact, precisely because the motion of the charges is governed by diffusion that objects can become charged by frictional effects. In these cases the charges are moved in opposition to fields many orders of magnitude greater than those under discussion here.

The remaining points referred to by Bondi and Lyttleton appear to arise from a misunderstanding of the experimental method. They state that it is not clear what happens to the free charges collected by the ion trap. Even if the fate of these ions were really obscure, which it is not, it is clear that the charges do not leave the box *A* which contains the battery. They cannot therefore influence the potential difference between boxes *A* and *B*. Bondi and Lyttleton also state that a "potential of the same order as would be expected in the absence of balancing electrons is actually applied to the very box the potential of which it is wished to measure". The potential applied was in fact considerably larger than the potential measured, but the measurements made are of changes of potential. No one has ever suggested that the potentials of thousands of volts applied to the collectors of ion chambers make the small changes due to the collection of ions inherently more difficult to detect.

Bondi and Lyttleton also have difficulty in finding the "meaning of the large ionization current in the air, the fluctuations of the measured current, and the sudden changes of potential". The ionization in the air around box *A* was due to natural radioactivity and cosmic rays. There is a partial separation of charges by the contact potential differences between the different metals used in the construction, resulting in a current if a suitable compensating potential is not applied. The changes of potential involved in an experimental run (~ 10^{-4} V. at the input of the feedback vibrating reed electrometer) did not change the ionization current significantly. The fluctuations in background current were at least mainly due to ions carried by air eddies (normally one sign of ion is in excess). The sudden jumps of potential occurred when the pressure was changed in the slightly flexible outlet tubes to start the gas flowing: the facts that this caused a small movement and that a small movement caused potential changes were verified. In any event the jumps were independent of the amount of gas released.

Bondi and Lyttleton refer to the "minute difference of charge concerned". In the context of the experiment, this may be misleading. The postulated charge difference is equivalent to about 100 electronic charges per c.c. This is much larger than the charge density in an ion chamber under normal conditions, and about the same as the number of ions in air at sea-level. By commonly accepted standards, the charge involved in our experiment is quite large, but the fields are very small.

In addition to the comments of Bondi and Lyttleton, it has been pointed out to us by J. Leverett

Davis that it is possible to make a plausible extrapolation of our measured points which leads to an upper limit for the charge which is nearly twice the value quoted in our communication, but still too small to remove the conflict with the hypothesis of Bondi and Lyttleton.

We do not wish to imply that our experiment is infallible, but we believe that if a loophole exists it is one that has not yet been mentioned. Nevertheless, we consider that a hypothesis as important as that suggested by Bondi and Lyttleton cannot be dismissed by one experiment, or two of a similar type, and feel that it is highly desirable that other experiments should be made which do not depend on flowing gases.

A. M. Hillas

Department of Physics,
The University,
Leeds 2.

T. E. Cranshaw

Atomic Energy Research Establishment,
Harwell, Berks.

---

[1] Bondi, H., and Lyttleton, R. A., *Nature*, 184, 974 (1959).

[2] Hillas, A. M., and Cranshaw, T. E., *Nature*, 184, 892 (1959).

Profile of Upper-Atmosphere Air Density at the Height 180–212 km. derived from the Orbit of *Sputnik* III

The resistance of the air to a moving object like a satellite causes a steady decrease of the semi-major axis and eccentricity of the orbit. The motion of the satellite grows faster and the satellite itself submerges deeper and deeper into the atmosphere at every revolution. When the satellite has descended to a certain level, where the heating from impact of air molecules on the frontal surface becomes great enough, the satellite burns out. For the purposes of ephemerides and for the prediction of the lifetime of the satellite, it is necessary to know how its orbital elements will be changed by the resistance of the air—supposing that we have some knowledge of the density of the air at the height where the satellite is moving, and of the drag coefficient of the satellite. Unfortunately, these data are not usually known with sufficient accuracy. But we can reverse this problem and search for a solution of how the air density could be determined from observed changes in size and shape of the orbit when the drag coefficient of the satellite is known. If we do not know this drag coefficient (which depends on the size, shape and mass of the satellite), we can still determine at least the gradient of the air-density. G. V. Groves published two valuable papers[1,2] last year, in which very accurate methods for such a determination have been developed. The only assumption made here, which could be accepted as a general approximation, is that air-density varies with height according to the relation:

$$\ln \frac{\rho}{\rho_{00}} = -\frac{1}{H_1}(h - h_{00}) + \frac{1}{H_2^2}(h - h_{00})^2 \quad (1)$$

where ρ_{00} is the density of the air at the height h_{00}, H_1 is the scale-height in the case of an isothermal atmosphere, and H_2 enables us to take account of the variation of atmospheric temperature with height. From the data of six different satellites with perigees between 180 and 650 km., Groves has found that, for $h_{00} = 200$ km.:

$$\rho_{00} = 3{\cdot}8 \times 10^{-13} \times (1 \pm 0{\cdot}1) \text{ gm./cm.}^{-3}$$
$$H_1 = 46 \pm 5 \text{ km.}$$
$$1/H_2^2 = (0{\cdot}028 \pm 0{\cdot}013)/46^2$$

In the second paper, methods have been developed for the determination of H_1 and H_2 without any knowledge of the drag coefficient. In this case, of course, the determination of ρ is not possible.

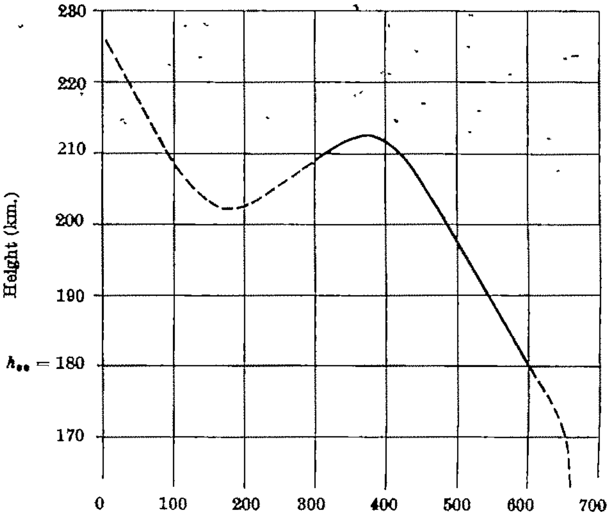


Fig. 1

At the time when these papers were published, only a few not very accurate data of the orbits were available. Meanwhile, the third Soviet satellite, 1958δ2, was launched on May 15, 1958, and a great number of observations with improved instrumentation have provided accurate orbital elements and their changes. I have analysed all the data available so far. Nearly 100 sets of orbital elements have been taken into consideration. Not all have the same weight; it seems that the accuracy was improved after March 1959. For this reason I have restricted the analysis

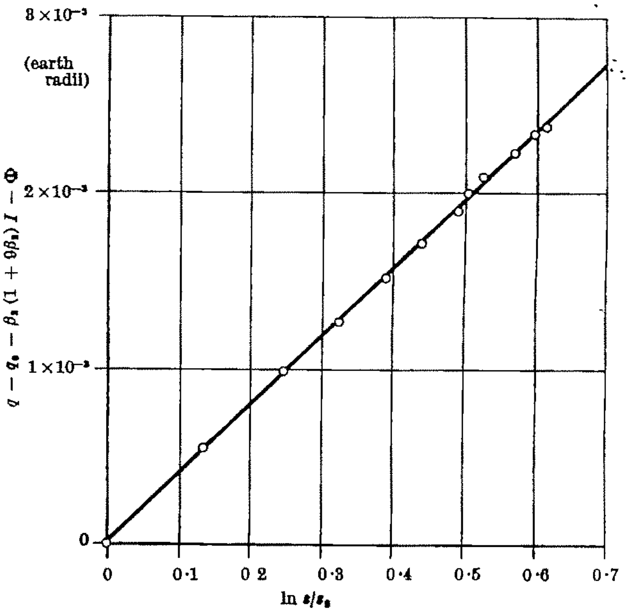


Fig. 2

in the present communication to the time interval between March 11, 1959, and January 5, 1960, that is, between 300 and 600 days after launching.

During this time-interval: (1) the perigee radial distance decreased from 1·03091 to 1·02824. The dependence of perigee radial distance q on time t could be approximated by the equation:

$$q = 1{\cdot}02137 + 0{\cdot}003713 \log (671 - t) \qquad (2)$$

with a standard deviation ± 0·9 km.; (2) the eccentricity decreased from 0·08215 to 0·04191 in the same time-interval; (3) the perigee height changed in a more complicated manner, as shown graphically on Fig. 1; first, it rose from 208·7 km. to its second maximum of 212·2 km. at $t = 370$ days; after that date it was steadily decreasing and at the end of the time interval, $t = 600$ days, it was only 180·1 km.

These changes in the perigee height were produced by the motion of the angular perigee distance ω, which brought the perigee point above various latitudes of the Earth. The height-interval of 31·1 km. seems to be great enough to enable the determination of both constants H_1 and H_2. We used for this purpose smoothed orbital elements at twelve points where the perigee height was on the rising branch 210, 211 and 212 km., and then on the descending branch 212, 211, 210, 205, 200, 195, 190, 185 and 180 km. The computation was carried out according to the equation:

$$q - q_0 = \tfrac{1}{2}H_1(1 + 3\beta_2) \ln \frac{s}{s_0} + \beta_2 (1 + 9\beta_2) I + \Phi \qquad (3)$$

where $\beta_2 = H_1^2/H_2^2$ and $s = qe/(1 + e)$. The integrals I and Φ depend on orbital elements and their changes with time and also on β_2. For details, one must refer to the original paper[2].

The result of my analysis is shown in Fig. 2, where $q - q_0 - \beta_2(1 + 9\beta_2)I - \Phi$ is plotted against $\ln s/s_0$. The straight line fitted to the twelve computed points by the method of least squares is in satisfactory agreement with equation 3, the mean error being only $\pm 2{\cdot}0 \times 10^{-5}$ earth radii ($= \pm 0{\cdot}13$ km.). The gradient of the line, $\tfrac{1}{2}H_1(1 + 3\beta_2)$, is equal to $\pm 388{\cdot}73 \times 10^{-5}$. With this value equation 3 has been recomputed to determine β_2; thus:

$$\beta_2 = 0{\cdot}024 \pm 0{\cdot}006$$

With this value, equation 3 has been used for the determination of H_1, and I have found:

$$H_1 = 46{\cdot}3 \pm 0{\cdot}7 \text{ km.}$$

As shown by the small probable errors, both values β_2 and H_1 are reliably determined. They agree well with the values obtained by G. V. Groves[1]. The scale-height is again 2–3 times greater than that derived from various theoretical models of the upper atmosphere. It is also noticeable that no seasonal effect was detectable during 300 days covered by this analysis, although during the same time the other artificial satellites with higher perigees were strongly influenced by changes of air density of long duration.

Z. V Bochníček

Ul.február.vítěz., blok A II,
Bratislava, Czechoslovakia.

---

[1] Groves, G. V., *Proc. Roy. Soc.*, A, 252, 16 (1959).

[2] Groves, G. V, *Proc. Roy. Soc.*, A, 252, 28 (1959).

RADIOPHYSICS

The Mesopause Region of the Ionosphere

In a recent communication, Gregory[1] suggested that the presence of free electrons at heights in the atmosphere between 80 and 90 km. may be due to the photo-ionization of dust which accumulates at the mesopause. Rocket measurements[2] have shown that the electron density at this height is about 1,000 el./c.c. on a normal day. This is also the order of magnitude of electron density required to account for the absorption of radio waves in the D region. It is of interest to see whether photo-ionization of the dust is able to give this observed electron density.

Noctilucent clouds are observed at the mesopause. While their composition is uncertain we arrive at an upper limit to the density of dust by assuming the clouds are composed of dust particles. From the luminosity and colour of the clouds Ludlam[3] estimated the particle density to be 0·01–1 particle per c.c. and the radius to be 1000 Å.–100 Å., the lower density corresponding to the larger radius.

Now the shortest wave-length of appreciable intensity of ultra-violet radiation from the Sun falling on the dust particles is about 2000 Å., except for the Lyman-alpha line (λ1216 Å.). The total Lyman-alpha flux[4] would only produce about 3×10^{-6} electron per c.c. per second by photo-ionization of the dust particles, whereas a rate of production of at least 0·06 electron per c.c. per second is required to give the observed electron density in this region[5]. Thus the Lyman-alpha photons can play no significant part in this process. A similar argument applies to short X-ray radiation.

The wave-length of 2000 Å. corresponds to a photon energy of about 6 electron-volts. The threshold energy for photo-electric ejection is about 3 electron-volts, so that the potential of the dust particles cannot exceed 3 volts. This potential determines the maximum positive charge on the particles and hence the maximum electron density. This turns out to be 2 el./c.c. for $r = 1000$ Å. and 20 el./c.c. for $r = 100$ Å., at least 50 times too small.

If the number density of particles is allowed to increase 50 times (for $r = 100$ Å.) to give the required electron density, a further difficulty arises. When an electron collides with a positively charged dust particle, there is an 80 per cent chance that the electron would be absorbed, so that the free electrons would disappear with a time constant of about 8 sec. Gregory, however, observes that the layer at 80 km. persists all night.

While it seems probable that the layer is associated with the mesopause, the suggestion that it is formed by photo-ionization of the dust particles appears to be untenable.

J. D. Whitehead

Physics Department,
Otago University,
Dunedin,
New Zealand.

---

[1] Gregory, J. B., *Nature*, 181, 753 (1958).

[2] Seddon, J. C., *J. Geophys. Res.*, 63, 209 (1958).

[3] Ludlam, F. H., *Tellus*, 9, 341 (1957).

[4] Byram, E. T., Chubb, T., Friedman, H , and Gallar, N , *Phys. Rev* , 91, 1278 (1953).

[5] Bates, D. R., and Seaton, M. J., *Proc. Phys Soc* , 63, B, 129 (1950).

Apparent Radio Radiation at 11-m. Wave-Length from Venus

In 1956 several preliminary communications reported the apparent reception of 11-m. radiation from the planet Venus[1]. In particular, one communication reported coherent or quasi-coherent radiation, designated Class II, which was also thought to originate from Venus. From further observations and subsequent analyses it now appears definite that these signals were not from Venus but were in all cases almost certainly interference of terrestrial origin.

Regarding the reports of the noise-type of radiation, designated Class I, a careful re-examination of the results indicates that the evidence is not sufficient to be sure that such radiation from Venus was observed. Attempts by others to detect the radiation have also been unsuccessful[2]. The validity of any deductions based on these observations, such as the rotation period of the planet, is, therefore, extremely doubtful.

Although some records, such as the one in Fig. 11 of a later article[3], show interferometer patterns which could be due to radiation from Venus, they are not conclusive. However, the fact that these records do suggest 11-m. radiation from Venus makes it difficult to rule out the possibility of such radiation completely. To determine the existence or non-existence of such radiation beyond any doubt, further observations are needed using a radio telescope of much higher resolution and better stability than was available in 1956.

J. D. KRAUS

Radio Observatory,
Ohio State University,
Columbus 10, Ohio.
March 4.

[1] Kraus, J. D., *Nature*, 178, 33, 103, 159, 687 (1956)

[2] Smith, H. J., *Astro. J.*, 64, 41 (1959).

[3] Kraus, J. D., *Proc. Inst. Rad. Eng.*, 46, 266 (1958).

An Estimate of the Peak Sunspot Number in 1968

The smoothed peak sunspot number during the current cycle of solar activity attained a value in 1958 which has not been exceeded since accurate observations were begun more than 200 years ago. Conditions in the atmosphere of the Sun near the epoch of peak activity, and the closely related changes in the ionosphere, have already been the subject of comment[1].

It has been suggested that the uninterrupted rise in successive peak sunspot numbers since 1928, and its culmination in the unprecedented high peak of 1958, may indicate that the Sun is undergoing a long-term change and that the next peak, which will probably occur in about 1968, will be even higher than that of 1958. The opposing view is that, since the peaks of 1948 and 1958 were very high, the 1968 peak will be a very low one. These possibilities are of more than academic or scientific interest; they have a bearing on the effectiveness of the world-wide network of high-frequency radio-communication links, the successful operation of which depends on the reflexion of radio waves from the ionosphere. The operating conditions on such radio links are profoundly modified by changes in solar activity, and Hitchcock[2] has pointed out that, with the present-day overcrowding of the high-frequency radio spectrum, the occurrence of a solar cycle which attained only a low peak might lead to unforeseen difficulties.

It is of some importance, therefore, to estimate the probable limits within which the forthcoming peak sunspot number will lie. Obviously it is impossible to make a precise estimate; the present objective is merely to examine the purely statistical evidence contained in the sequence of twenty peak values which have occurred since 1750 and to decide whether there are any grounds for believing that the next peak will be either very high or very low. The cycle-matching technique described by Herrinck[3] has not been used because it cannot be safely extended beyond the end of the present cycle[4].

From a study of the lengths of sequences of uninterrupted increases and decreases in the peaks for successive cycles, it is possible to estimate the probability of occurrence of a sequence of three increases such as that which took place between the peaks of 1928 and 1958. The conclusion reached is that such an event is not an improbable one ($P \simeq 0{\cdot}12$), and it follows that its occurrence ought not to be interpreted as an indication of a long-term upward trend in solar activity. It is estimated on similar grounds that the probability of a fourth increase, leading to an even higher peak in 1968 than in 1958, is approximately 0·3.

The range of values within which the next peak will lie can be estimated from the frequency distributions of either the magnitudes of the twenty observed peaks or the differences between successive peaks. From such evidence it is found that there is a high probability that the 1968 peak will be between 110 and 160. The autocorrelation function for the twenty peaks (R) since 1750 has been evaluated, but the correlation coefficients differ significantly from zero only for R_n, R_{n+1} and R_n, R_{n+2}. The regression lines for these two cases have been used to forecast the peak in 1968; and the values obtained, with their standard errors of estimate, are 154 ± 38 and 97 ± 36 respectively. These values are consistent with the range of values (110–160) based on the frequency distributions referred to earlier.

The various independent estimates of the next peak have been combined, taking into account their respective probabilities and making an allowance for the fact that the estimates are based on a sample of only twenty values. It is concluded that there is a probability of at least 0·75 that the next smoothed peak sunspot number, which will occur about 1968, will be in the range 110–160. Thus it seems reasonable to expect that ionospheric and radio-communication conditions during the 1964–74 solar cycle will be roughly comparable with those which occurred during the 1934–44 and 1944–54 cycles.

This communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research; the work will be described more fully elsewhere.

C. M. MINNIS

Radio Research Station
(Department of Scientific and Industrial Research),
Slough, Bucks.
March 18.

[1] Ellison, M. A., *Nature*, 180, 1173 (1957). Minnis, C. M., *ibid.*, 181, 543 (1958). Naismith, R., *ibid.*, 181, 954 (1958).

[2] Hitchcock, R. J., *Brit. Comm. Electron.*, 6, 350 (1959).

[3] Herrinck, P., *Nature*, 184, 53 (1959)

[4] Chadwick, W. B., *Nature*, 184, 1787 (1959).

METEOROLOGY

Wind Profile in Thermally Stratified Flow

THE variation of horizontal wind-speed u with height z in the air flowing over uniform ground is, in conditions of neutral equilibrium, well represented by the expression:

$$\frac{\partial u}{\partial z} = \frac{u^*}{kz} \qquad (1)$$

where u^* is the 'friction velocity', defined as $u^{*2} = \tau/\rho$, τ being the horizontal shearing stress caused by the wind and ρ the air density. k is von Kármán's universal dimensionless constant. This relationship, well based theoretically and amply verified by experiment (see, for example, Sheppard[1]), is expected to apply at all heights within the layer of constant shearing stress.

Attempts to extend this formulation to the case of thermally stratified flow have, however, met with severe difficulties, and up to the present time such treatments as have been given, mainly of a quasi-theoretical or frankly empirical nature, have met with only partial success and this limited to small departures from the neutral state.

It will be shown here that it is possible to derive a formal solution to the problem devoid of all arbitrary constants, expressing the variation of wind with height uniquely in terms of the shearing stress and the vertical heat flux H associated with the thermal stratification. No restriction is imposed on the magnitude of these latter quantities, and the result is applicable at all heights within which τ and H remain constant.

In a steady state of turbulence, the rate of viscous dissipation of turbulent kinetic energy at a given point, ε per unit volume of air, is represented by:

$$\varepsilon = \tau \frac{\partial u}{\partial z} + \frac{gH}{c_p T} \qquad (2)$$

g is the acceleration of gravity, c_p the specific heat of air at constant pressure and T the temperature of the air. The terms on the right-hand side of (2) are, respectively, the rate of working of the shearing stress on the mean rate of strain, and the work done per unit time against gravity by buoyancy.

I now introduce a new height variable X, defined according to the equation:

$$\tau \frac{\partial u}{\partial X} = \tau \frac{\partial u}{\partial z} + \frac{gH}{c_p T} \qquad (3)$$

X, which will be seen intuitively to be a function of z, τ and H, thus permitting the combination of contributions from both sources of energy in the pseudo-shearing stress term $\tau\, \partial u/\partial X$.

A similarity assumption is now made that:

$$\frac{\partial u}{\partial X} = \frac{u^*}{kX} \qquad (4)$$

The hypothesis here is that, just as in (3), the new height X is able to accommodate in the one term the energy supply both from the mean motion and from buoyancy, so in (4) it will preserve, in conditions of thermal stratification, the linear inverse relationship between wind shear and height characteristic of simple shear flow. It must be emphasized that, at this stage, (4) is no more than a reasonable assumption the validity of which remains to be assessed by the accuracy of its consequences now to be derived.

Elimination of u between equations (3) and (4) leads to the differential equation:

$$1 = \frac{dX}{dz} - \frac{X}{L} \qquad (5)$$

where L, of dimension length, has been introduced to represent $-\dfrac{c_p \rho T u^{*3}}{kgH}$. (The notation here follows that of Monin and Obukhov[2].)

Integration of (5), invoking the condition that as $L \rightarrow \infty$, $X \rightarrow z$, yields:

$$X = L\,\{\exp(z/L) - 1\} \qquad (6)$$

from which, after a little manipulation,

$$\partial u/\partial z = u^*/kL\,\{1 - \exp(-z/L)\}^{-1} \qquad (7)$$

A recent attempt, by Monin and Obukhov (*loc. cit.*), to solve the problem now under discussion proceeds by dimensional arguments to postulate that:

$$\frac{\partial u}{\partial z} = \frac{u^*}{kz}\left\{1 + \alpha_1\left(\frac{z}{L}\right) + \alpha_2\left(\frac{z}{L}\right)^2 + \ldots\right\}$$

where the coefficients remain to be determined by experiment. The present formulation lends support to this hypothesis, as expansion of the exponential term in (7) shows. Furthermore, it follows from (7) that:

$$1 + \alpha_1\left(\frac{z}{L}\right) + \alpha_2\left(\frac{z}{L}\right)^2 + \ldots = \frac{z}{L}\left\{1 - \exp(-z/L)\right\}^{-1}$$

Integration of (7) between the levels z_1 and z_2 gives:

$$u_2 - u_1 = \frac{u^*}{k}\ln\left[\frac{1 - \exp(z_2/L)}{1 - \exp(z_1/L)}\right] \qquad (8)$$

A similar relation applies to levels z_3 and z_4, whence division eliminates u^*/k to yield:

$$\frac{u_2 - u_1}{u_4 - u_3} = \ln\left[\frac{1 - \exp(z_2/L)}{1 - \exp(z_1/L)}\right] \Big/ \ln\left[\frac{1 - \exp(z_4/L)}{1 - \exp(z_3/L)}\right] \qquad (9)$$

By numerical, or preferably graphical, interpolation equation (9) then permits the determination of L from observed winds, whence substitution of the appropriate L in equation (8) yields u^*. H, the heat flux, can then be determined from the defining expression for L.

The extensive wind observations of Monin and Obukhov (*loc. cit.*) have been analysed within the framework of the present analysis, and yield remarkably consistent values of L and u^* over the whole height-range of 0·5–15 metres, and over a wide range of stabilities. The relevant values of z/L vary from $-7{\cdot}5$ to $3{\cdot}75$. Furthermore, u^* so determined accords almost exactly with its value calculated in an entirely different manner (involving the use of drag coefficient at the lowest level of wind measurement where the analysis shows the effects of buoyancy to be negligible). Equation (8) yields an explicit formulation for the 'roughness length', determinations from which show excellent agreement. In brief, it may be said that the present indications are that the law of wind variation contained in equation (8) promises to be capable of universal application without restriction as regards stability, and at all heights within the layer of constant heat flux and shearing stress.

Analysis of other observational material is now in hand, and an experimental programme in progress designed to assess the validity of the present treatment by comparison of its predictions against values of the shearing stress and heat flux determined directly by the eddy-correlation method.

A full account of the work summarized here, together with that now being undertaken, will be published elsewhere in due course.

W. C. SWINBANK

Division of Meteorological Physics,
Commonwealth Scientific and
Industrial Research Organization,
Aspendale, S.13,
Victoria, Australia.
Feb. 8.

---

[1] Sheppard, P. A., *Proc. Roy. Soc.*, A, 188, 208 (1947).

[2] Monin, A. S., and Obukhov, A. M., Works of the Geophysical Institute Acad Sci., U.S.S.R., No. 24, 151 (1954).

GEOLOGY

Uraninite and Thorianite

WASSERSTEIN[1] suggested that the generation by radioactive decay of Pb^{4+} of smaller ionic radii within the crystal lattice of uraninite caused a shrinkage in the unit cell proportionate to the geological age and the shrinkage was of the order of 0 0025–0·0041 Å. per hundred million years. The anomaly in the relation of cell dimensions of Bisundni and Gaya uraninites with the age, reported by Holmes[2], was explained by Wasserstein[3] by classifying uraninites into two different types—α-type for Bisundni uraninite and γ-type for Gaya uraninite, the latter being apparently anomalous and requiring heat treatment under oxidizing conditions in order to reduce the cell size to correspond to that of an α-type analogue. Wasserstein did not, however, state the temperature and period of heating and the conditions under which the cell size of γ-uraninite was reduced to correspond to age values consistent with those of the α-type.

A number of specimens of uraninite from Bisundni and Gaya from the collection in the Indian Museum made by H. Crookshank[4] and G. H. Tipper[5], and thorianite from Ceylon by A. K. Coomaraswamy[6], were used for the present study. The cell dimensions of Bisundni uraninites (a_0 5·436–5·440 Å.) and Gaya uraninites (a_0 5·459–5·467 Å.) are different from those reported by Wasserstein[1] (5·448 Å. for Bisundni and 5 481 Å. for Gaya). A thoria correction[1] of −0·0013 Å. for each percentage thorium oxide when ($ThO_2 + UO_2$) totals 100 per cent will reduce the cell size of Bisundni uraninite by 0·002 Å. (a_0 5·436 Å. mean value) and Gaya uraninite by 0·017 Å. (a_0 5·445 Å. mean value) if the ratio of uranium oxide to thorium oxide is calculated on the basis of Holmes's analysis (Table 1).

The finely powdered uraninite (a few mgm.) was heated at 800° C. in an open silica boat (1) within an electric muffle furnace and (2) also within a closed silica retort tube (of 2-cm. diameter placed inside an electric tube furnace at 800° C.) which was continuously evacuated to maintain a vacuum of the order of 10^{-2} mm. of mercury.

Table 1

Indian Museum No. and locality	Uraninite (UO_2 a_0)	Heated at 800° C. for 30 min. in vacuum	Heated at 800° C. for 15 min. in a muffle furnace
Uraninite, Bisundni (*ex* Holmes (ref. 2)). Age 735 (± 5) m.y., U = 72 9, Pb = 7·95, Th = 1 4 per cent			
R 763 Bisundni, Ajmer-Merwara	5 440	UO_2 major a_0 5 437, plus *X* scarce	U_3O_8 major, plus *X* minor
S 128 Bisundni mine, Ajmer-Merwara	5·436	UO_2 major a_0 5·433, plus *X* minor	U_3O_8 major, plus *X* minor
Uraninite, Gaya (*ex* Holmes (ref. 2)). Age 955 (± 40) m.y., U = 64·3, Pb = 8 92, Th = 8·12 per cent			
N 811 Pichchli, Gaya	5·459	UO_2 major a_0 5·450, plus *X* scarce	U_3O_8 major, plus UO_2 minor a_0 5·455, plus *X* scarce
L 301 Abraki, Singar, Gaya	5·462	UO_2 major a_0 5·452, plus *X* scarce	U_3O_8 major, plus *X* minor
L 176 Singar, 6 miles west-north-west of Abraki, Gaya	5·467	UO_2 major a_0 5·456, plus *X* scarce	U_3O_8 major, plus UO_2 minor a_0 5 461, plus *X* scarce
Thorianite, Ceylon (Nag and Mousuf (ref. 7)), U = 21·2, Th = 60 2 per cent. Holmes (ref. 13), age 490 m.y., U = 11·67, Pb = 2 80, Th = 67·03 per cent			
J 658 Thorianite from a gem sand near Kondurugala, Balangvda Dt., Ceylon	Thorianite (Th,U)O_2 a_0 5·575	Thorianite a_0 5·556, plus a few faint extra lines	Thorianite (powder lines sharp) a_0 5·575, plus a few faint extra lines
J 659 Thorianite, Bambarabotuwa, Ceylon	Thorianite a_0 5 573	Thorianite a_0 5 555, plus extra lines	Thorianite (powder lines sharp) a_0 5 578, plus extra lines

The cell size was determined with an accuracy of ± 0 003 Å. using aluminium as internal standard with 114 59 mm. diameter Philips' powder camera having two fiducial marks and copper *Kα*-radiation ($\lambda = 1\cdot5405$ Å.).

Brooker and Nuffield[8] observed a shrinkage of the cell size of uranium dioxide (on heating in vacuum at 900° C. for 30 min.) of the order of 0 02–0·05 Å. depending on the degree of oxidation, the ratio of U^{4+} to U^{6+} in the original lattice, and reported the formation of the unknown compound *X* (U_3O_8 ?). In the present study (Table 1) the shrinkage of the cell size of uranium dioxide is followed by a close doubling of the higher-angle diffraction lines (development of an additional phase) and the formation of the compound *X*. The oxidation of uraninite out of contact with oxygen suggests that in the oxygen-rich lattice of natural uraninite the excess of oxygen occupies the available interstitial positions (½ 0 0) in six-fold co-ordination with uranium[9,10], and this shrinkage of cell size implies simultaneous replacement of U^{4+} cations (1·05 or 0·97 Å.) by the U^{6+} cations (0·80 Å.), that is, the substitution of cations of smaller ionic radii and higher charge, is preceded by readjustment of interstitial anions in the fluorite-type lattice (space group *Fm*3*m*). The cell size of 5·47 Å. for synthetic uranium dioxide decreases to 5·39 Å. for $UO_{2\cdot6}$, but the structure is preserved[8] even when the alteration of $U^{4+} : U^{6+} : O$ ratio apparently extends up to about $UO_{2\cdot6}$. The progressive reduction of the cell size of uranium dioxide due to the substitution of Pb^{4+} (0·84 Å.) for U^{4+} within the lattice with time (which has not been evaluated but only visualized by Wasserstein[1,2]) is likely to be quite negligible compared to the more pronounced shrinkage due to alteration of $U^{4+} : U^{6+} : O$ ratio in the oxygen-rich lattice of natural uraninite.

Moreover, lead in lower valency state (Pb^{2+} 1·21 Å.) is a greater possibility[11].

Wasserstein's proposed classification of thorianite into γ-type may be interpreted from the observed evidence on synthetic members of the series (U$_x$Th$_{1-x}$O$_2$) by Anderson *et al.*[12]. On high-temperature vacuum heating the type of interaction[13] between uranium and interstitial oxygen in the original lattice alters with the conversion of U^{4+} to U^{6+} and consequent shrinkage of the unit cell (Table 1); Th^{4+} ions do not react because of their reluctance to donate electrons.

I wish to thank Dr. B. C. Roy, director of the Geological Survey of India, for permission to publish this communication.

BIBHUTI MUKHERJEE

Geological Survey of India,
Calcutta. Jan. 2.

[1] Wasserstein, B , *Nature*, 168, 380 (1951).

[2] Holmes, A., *Geol Mag.*, 86, 288 (1949).

[3] Wasserstein, B., *Nature*, 174, 1004 (1954).

[4] Crookshank, H., *Trans. Min. Geol. Met. Inst. India*, 42, No. 2, 105 (1946).

[5] Tipper, G. H., *Rec. Geol. Surv. India*, 50, 256 (1919).

[6] Coomaraswamy, A. K , *Spolia Zeylanica*, 2, Pt. 6, 57 (1904); 1, Pt. 4, 112 (1904)

[7] Nag, B. D., and Mousuf, A. K , *Proc Nat. Inst. Sci. India*, 12, 341 (1946).

[8] Brooker, E. J., and Nuffield, E. W., *Amer. Min.*, 37, 363 (1952).

[9] Goldschmidt, V. M., and Thomassen, L., *Norske vidensk. Kristiania, Skr. Mat.-naturvid. Kl.*, No. 2, 1 (1923).

[10] Alberman, K. B., and Anderson, J. S., *J. Chem. Soc.*, Supp. 2, 303 (1949).

[11] Goldschmidt, V. M., "Geochemistry", 398 (1954).

[12] Anderson, J. S., Edington, D. N., Roberts, L. E. J., and Wait, E., *J. Chem. Soc.*, 3324 (1954).

[13] Holmes, A., *Proc. Geol. Assoc. Canada*, 7, Pt. 2, 101 (1955).

Silicon in the Metal Phase of Enstatite Chondrites

I HAVE recently measured the lattice parameters of the metal phases from a number of chondrites. In five common varieties the kamacite lattice parameter was within the range 2·8682 ± 0·0005 Å. This corresponds to an average of 5 per cent nickel in solid solution[1]. Owen and Burns[1] found that the kamacite lattice parameters from 15 meteoritic irons were within the range 2·8686 ± 0·00015 Å. This is in good agreement with the above result, and indicates the presence of about 6 per cent nickel. I also examined the kamacite from 6 enstatite chondrites. In these, the lattice parameters were found to be abnormally low, and below that of pure iron (Table 1). The metal phases of these chondrites had previously been analysed and found to contain normal amounts of nickel—between 6 and 8 per cent. Since the solid solution of nickel 'increases' the lattice parameter of pure iron, it was inferred that appreciable amounts of some other component were also present in solid solution and that this component had caused the lattice parameter to contract.

A process of elimination led to the conclusion that the additional component was silicon. This is the only element which forms extensive solid solutions with iron, causing marked contraction of the lattice parameter, and at the same time, occurs in sufficient quantities in chondrites to produce the observed contraction. A literature survey revealed that 2 (atomic) per cent of silicon had previously been recorded in the metal phase of the enstatite chondrite Blithfield[2]. Furthermore, in the metal phases of other enstatite chondrites—Khairpur[3], Daniels Kuil[3] and Saint Marks[4]—the analysts have commented upon an apparent 'excess' of silica, but could not account for its origin. Kamacite from three of the meteorites has been examined by X-rays. The lattice parameters were substantially less than that of pure iron, and it therefore seems highly probable that the excess silica found by the analysts was derived from elemental silicon in solid solution. The analytical results in Table 1 have been recalculated on this assumption.

Table 1. SOME PROPERTIES OF KAMACITE FROM ENSTATITE CHONDRITES

Reference	Meteorite	Atoms per cent nickel in kamacite	Lattice parameter of kamacite Å.	Atoms per cent silicon in kamacite from X-ray data	Atoms per cent silicon in kamacite from chemical data
2	Blithfield	6·4	2·8657	5	2·0
3	Daniels Kuil	6·2	2·8655	5	3·8
9	Hvittis	7·6	2·8655	5	
10	Indarch	6·7	2·8619	10·5	
3	Khairpur	7·0			1·9
11	Pillistfer	8·4	2·8652	6·5	2·6
4	Saint Marks	6·4	2·8632	9	18
12	Kamacite from five ordinary chondrites	Average 5	2·8680 ± 0·0005		
1	Kamacite from 15 meteoritic irons	6·2	2·8686 ± 0·00015		
	Pure iron	0	2·8665		

In all enstatite chondrites studied, the only metal phase present was kamacite.

A sample of kamacite was magnetically separated from a large sample of the Pillistfer enstatite chondrite and purified by grinding, repeated fusion with sodium hydroxide and washing on a superpanner. Chemical analysis of the pure kamacite has indicated the presence of approximately 2·6 atoms per cent of silicon. X-ray examination of this sample again revealed a contraction of lattice parameter compared to iron.

The variation of lattice parameters of iron–silicon solid solutions as a function of composition is well known[5]. If one makes the reasonable assumption that the relative variation is not greatly modified by the presence of 6–8 per cent of nickel in solid solution, it is possible to estimate the silicon content of kamacite from the difference between the observed lattice parameter and that of a normal iron–nickel solid solution of the relevant composition. These estimates are set out in Table 1.

The above results indicate that silicon is an important component of the metal phase of enstatite chondrites, the amounts present ranging between 2 and 18 atomic per cent. This occurrence is consistent with the highly reduced state of enstatite chondrites, which contain iron-free silicates and reduced chromium, calcium and phosphorus minerals (daubreelite, oldhamite, schreibersite).

Ringwood[6,7] and MacDonald and Knopoff[8] have independently suggested the presence of substantial amounts of silicon in the Earth's core. Occurrence of silicon in the metal phase of enstatite chondrites is very relevant to this hypothesis. A detailed discussion of the present results and their bearing upon this hypothesis will be published elsewhere.

I gratefully acknowledge the gift of meteorite specimens by Mr. O. Chalmers (Australian Museum), Dr. H. B. Wiik (Geological Survey of Finland), Dr. K. Fredriksson (Geological Survey of Sweden), and Mr. K. R. Dawson, Geological Survey of Canada.

A. E. Ringwood
Research School of Physical Sciences,
Australian National University,
Canberra.

[1] Owen, E. A., and Burns, B. D., *Phil. Mag.*, **28**, 497 (1939).
[2] Johnston, R. A. A., and Connor M. F., *Trans. Roy. Soc. Can.*, (111), **16**, 187 (1922).
[3] Prior, G. T., *Min. Mag*, **18**, 1 (1916).
[4] Klein, E., *Ann. S. Afr. Mus.*, **5**, 8 (1906).
[5] Farquar, M. C. M., *et al.*, *J. Iron and Steel Inst.*, No. 2, **152**, 457 (1945).
[6] Ringwood, A. E., *Geochim. et Cosmochim. Acta*, **15**, 199 (1958)
[7] Ringwood, A. E., *Geochim. et Cosmochim. Acta*, **15**, 257 (1959).
[8] MacDonald, G. J. F., and Knopoff, L., *Geophys. J.*, **1**, 284 (1958).
[9] Borgstrom, L., *Bull. Com. Geol. Finlande*, **3**, No. 14, 24 (1903).
[10] Wiik, H. B., *Geochim. et Cosmochim. Acta*, **9**, 279 (1956).
[11] Lacroix, A., *Bull. Soc. Franc. Min.*, **28**, 70 (1905).
[12] Ringwood A. E. (unpublished work).

METALLURGY

Formation of Beryllium Carbide during the Corrosion of Beryllium in Carbon Monoxide and in Carbon Dioxide Gas

Previous workers[1] have concluded from a comparison of the reaction between beryllium in dry carbon dioxide at 650° C. and in dry oxygen at 650° C. under kinetic conditions that the higher gain in weight of the specimen in carbon dioxide was due to the formation of beryllium carbide, which rendered the beryllium oxide non-protective. However, no metallographic evidence for the deposition on to the specimen of carbon, either as elementary carbon or as carbide, was given to support their hypothesis.

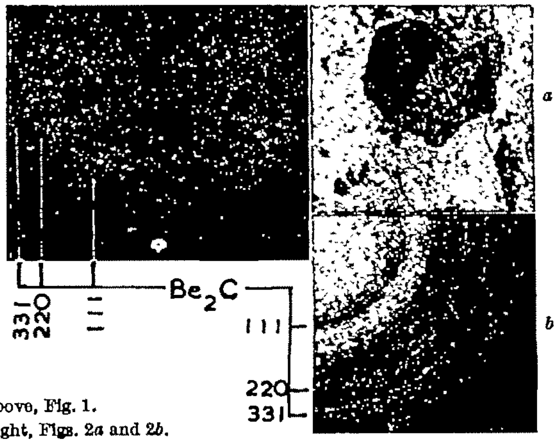
More recently (Jepson, W. B., and Antill, J. E., private communication), experiments designed to investigate the corrosion behaviour of beryllium using radioactive carbon monoxide and carbon dioxide under static conditions have shown that carbon (as the isotope carbon-14) is indeed deposited on the beryllium. Two typical specimens from this work have been examined by optical and electron microscopy and electron diffraction at the Atomic Weapons Research Establishment, Aldermaston, in order to locate the deposited carbon and to investigate whether beryllium carbide was formed.

The beryllium specimens were cut from rolled sheet 0·031 in. thick produced from French Flake beryllium. They were chemically polished and outgassed before insertion into the reaction vessel.

The first of the two specimens was heated at 700° C. in carbon monoxide and in this case spalling of the reaction product occurred. The uptake of carbon was measured from the decrease in count-rate of the gas, and the total gain in weight of the specimen was calculated from the measured volume of reacting gas.

A taper section through a piece of the specimen showed a well-defined boundary between the beryllium metal and the hard grey-looking scale on the surface, and immediately beneath this layer occurred a region some 100μ in depth of extensive cavitation which, by comparison with a corresponding section of as-received metal, was concluded to have been produced during the corrosion.

A reflexion electron diffraction pattern from the specimen surface is illustrated in Fig. 1. Measurement of the rings showed the presence of beryllium oxide, a hexagonal structure with $a = 2{\cdot}2679$ Å. and $c = 4{\cdot}380$ Å.[2], and in addition, three extra rings not attributable to beryllium oxide. Using the oxide rings for calibration these extra rings were found to have *d*-spacings of 2·51 Å., 1·53 Å. and 1·31 Å. respectively. No similar patterns have been presented in any previous corrosion work on beryllium. The crystal structure of beryllium carbide (Be_2C) is reported from X-ray observations[3] as of the anti-fluorite type, that is, cubic with $a = 4{\cdot}33$ Å. The first three carbide diffractions are given as (111), (220) and (311) with *d*-spacings of 2·51 Å., 1·53 Å. and 1·31 Å. respectively. The close agreement between the X-ray results and the present electron diffraction results is considered to be direct evidence for beryllium carbide having been formed during corrosion in carbon monoxide.



Above, Fig. 1.
Right, Figs. 2*a* and 2*b*.

Fragments of the corrosion product were stripped from the specimen using plastic films and the extraction replicas examined in the electron microscope. Particles ranging in size from 0·1 to 10μ were observed adhering to the replica. An electron diffraction pattern (Fig. 2*b*) from the edge of one particle of about 5μ diameter, Fig. 2*a* (× 4,000), is similar to Fig. 1 and clearly shows the presence of beryllium oxide and beryllium carbide. Some extracted particles gave only beryllium oxide diffractions, but no particles consisting entirely of beryllium carbide were observed.

Examination of a specimen subjected to carbon dioxide at 700° C. again gave diffraction patterns showing the formation of beryllium oxide and beryllium carbide.

From these experiments it is concluded that beryllium carbide is formed together with beryllium oxide during the reaction at 700° C. of beryllium with static carbon monoxide gas and also with static carbon dioxide gas, and that the carbide particles are dispersed within the oxide layer.

Thermodynamical results[4] indicate that free carbon could also be formed during the above reactions, although carbon was not identified in the present electron diffraction investigation. If, therefore, carbon is present in the reaction products it must be disseminated in such a way that there is an insufficient quantity accessible to the electron beam for detection.

Further work is in progress to study the diffusion of carbon into beryllium and the effect of the presence of the carbide phase on the mechanical properties of the metal.

I wish to thank Dr. W B. Jepson and Mr. R. J. Hussey of the Chemistry Department, University of Exeter, and Dr. J. E. Antill of the Metallurgy Division, Atomic Energy Research Establishment, Harwell, for providing the beryllium corrosion specimens. This work was carried out in the Crystallography Section of the Metallurgy Branch, Atomic Weapons Research Establishment, Aldermaston, under the direction of Dr. A. Moore.

V. D. SCOTT

Atomic Weapons Research Establishment,
Aldermaston, Berks.

---

[1] Munro, W., and Williams, J., A.E R.E. Report *M/M*108 (1956).

[2] Swanson, H. E , and Tatge, E., Nat. Bur. Stand. (U.S.A.), Circ. 539, 1, 86.

[3] von Stackelberg, M , and Quatrum, F., *Z. phys. Chem* , B, 27, 51 (1934).

[4] Kubaschewski, O., and Evans, E Ll., "Metallurgical Thermochemistry" (Pergamon Press, London, 1956).

Photo-stimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide

WHILE studying the influence of liquids[1] on the tribo-excited emission phenomena of exo-electrons (Kramer effect[2]) from metals, we have found that the amphoteric metals like aluminium, zinc and tin as well as brass and some soldering alloys containing tin give a comparatively strong emission of exo-electrons when irradiated with visible light, after the freshly abraded surface is sprayed with strong concentrated sodium hydroxide or potassium hydroxide.

Aluminium gives this strong emission even when the surface is not abraded.

This emission can also be measured from abraded cadmium. In this case, we think the emission is due to traces of zinc impurity in the cadmium.

The intensity of measured photo-stimulated emission decreases with the thickness of the covering layer of sodium hydroxide or potassium hydroxide. This seems to be due to the absorption of exo-electrons from the metal-solution interface region.

In darkness no significant emission is detected.

The preliminary measurements seem to show that each of the amphoteric metals has a different 'decay constant' for the emission from their reacting surface layers.

The emission was measured in atmospheric air with the aid of a point counter with a grid. The pulses in the counter could be completely suppressed by a retarding potential applied between the grid and the reacting metal[3].

The observed effect is not due to the exothermic character of the reactions. To prove it, the reactions of abraded zinc and aluminium with concentrated hydrochloric acid have been examined using the same experimental conditions. In neither case was any photostimulated emission of exo-electrons observed.

The effect could not be observed for the metals iron, copper, bismuth, nickel, lead and magnesium when they were tested under the same experimental conditions.

Magnesium, which is known to give very intensive emission of exo-electrons under visible light after the abrasion of the surface (like aluminium) but which is known not to be amphoteric, shows a remarkable decrease of emission intensity after the emitting surface is sprayed with concentrated sodium hydroxide or potassium hydroxide. Aluminium, tin and zinc in contrast always show a strong increase under those conditions.

A detailed report will be published in *Acta Physica Polonica*.

J. WAWRZYNIAK
B. SUJAK*

Institute of Experimental Physics,
University of Wrocław,
Wrocław, Poland.
March 23.

---

* On leave of absence at the Clarendon Laboratory, Oxford

[1] Lewowski, T., and Sujak, B., *Acta Phys. Pol.* (in the press).

[2] "Exoelektronentagung", *Acta Phys. Austriaca*, 10, 313 (1957).

[3] Sujak, B., *Physikalische Blätter*, 15, 209 (1959).

Thin Films of Silver–Cadmium Alloy

WE have undertaken a detailed electron diffraction study of thin films of silver–cadmium alloy obtained by evaporating the constituent metals consecutively in vacuum. Films of various compositions have been formed in this way and their phases and structures identified.

Near equi-atomic composition of this alloy system a crystallographic transformation has been reported by many workers employing X-ray diffraction and other methods to occur in the bulk state[1]. By such studies it has been established that, in bulk state, the low-temperature β^1-phase (body-centred cubic ordered) structure changes to ξ-phase (closest-packed hexagonal) around 250° C., although the exact transformation temperature is a matter of controversy. Employing high-temperature electron diffraction technique, we have tried to investigate this transformation with the view of determining the exact transformation temperature in the case of thin alloy films. Careful and repeated observations with well-homogenized films about 500 Å. thick, giving a characteristic pattern of pure β^1-phase (body-centred cubic structure) at room-temperature, failed to reveal any change at all in the phase up to a temperature as high as 300° C. The study could not be extended to higher temperatures because of the rapid volatilization of cadmium from the alloy films, leaving the films less rich in cadmium and consequently changing to α-phase.

The details of the investigation will be published elsewhere.

K. BAHADUR
P V. SASTRY

National Physical Laboratory,
Hillside Road, New Delhi, 12.
March 19.

---

[1] Hansen, "Constitution of Binary Alloys", 13 (McGraw-Hill Book Co , Inc., London, 1958).

CHEMISTRY

Preparation of Tritiated Water Samples by Distillation

IN many experiments using tritium as a tracer it is necessary to prepare a sample of pure water from organic material. During measurements of total body water using tritiated water in a dilution technique we have obtained pure water samples from urine by distillation. The urine is placed in a small vessel (Fig. 1) the bulb of which is put in an oil-bath maintained at 110° C. The distillate collects in the

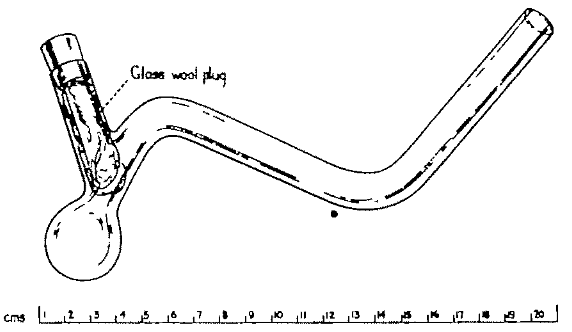


Fig. 1. Distillation tube

bend of the side-arm, which is cooled by a piece of wet paper or cloth. The glass-wool plug prevents urine frothing over into the side-arm. This technique has proved more effective and convenient than decolorizing with activated charcoal.

However, we were concerned that there might be a considerable isotope effect in the evaporation of ordinary and tritiated water, leading to the initial distillate being weak in tritium. The apparent 10 per cent difference in the molecular weights of water and HTO will be effectively reduced if water is associated at its boiling point, but the exact degree of association seems uncertain[1]. For a simple system containing water and HTO the relative evaporation rates of the two components would be expected to equal the ratio of the vapour pressures. This ratio has been measured by Price[2] between 25° and 80° C. Extrapolation of his results indicates a vapour pressure difference of about 4 per cent at the boiling point of water and a difference of boiling point of 1–2° C.

As the fractionation of liquids with different boiling points depends upon the exact conditions of distillation, particularly the reflux ratio, we distilled a water sample containing a known activity of HTO in our apparatus, collecting the distillate in four approximately equal fractions. The activities of all fractions and an aliquot from the original sample were measured by liquid scintillation counting. The major source of error was probably that associated with dispensing, as counting statistics contributed only about 0·1 per cent. The results are set out in Table 1.

Table 1

Specimen	Relative specific activity
Original sample	100
First quarter of distillate	99·7
Second quarter of distillate	99·7
Third quarter of distillate	100·3
Fourth quarter of distillate	100·4

It would appear that, with our apparatus, little separation of the isotopes occurs, and it is permissible to distil and measure only a fraction of the initial sample.

We are indebted to Dr. G. Boyd for suggestions regarding the distillation vessel.

J. D. Simpson
J. R. Greening

Medical Physics Unit,
University of Edinburgh.

---

[1] Dorsey, N. E., "Properties of Ordinary Water Substance" (Reinhold, New York, 1940).

[2] Price, A. H., *Nature*, 181, 262 (1958).

Oxidation of Beryllium in Carbon Dioxide and in Carbon Monoxide

The metal beryllium has been suggested as a possible canning material in the advanced gas-cooled thermal reactor, so that its oxidative behaviour at elevated temperatures in carbon dioxide, carbon monoxide and mixtures of these two gases is of some technological importance. Published work on the oxidation of beryllium in carbon dioxide is limited to the investigation of Munro and Williams[1], which covered the temperature range 500–700° C.; here the course of the oxidation was followed by intermittent weighing, the sample being cooled to room temperature for each measurement. The purpose of this communication is to report briefly some of the results of a recent study of both the chemistry and the kinetics of the reaction between French Flake beryllium and carbon dioxide, carbon monoxide and their mixtures (usually at a pressure of 10 cm.) and at temperatures in the range 500–750° C. The samples were chemically polished before use.

With the aid of a specially developed radioactive tracer technique using carbon-14 labelled carbon dioxide, it has been established that when beryllium is oxidized in carbon dioxide, the following reactions occur:

$$\mathrm{Be} + \mathrm{CO_2} = \mathrm{BeO} + \mathrm{CO} \qquad (1)$$

$$2\mathrm{Be} + \mathrm{CO_2} = 2\mathrm{BeO} + \mathrm{C} \qquad (2)$$

There is no evidence for reaction[2] of deposited carbon with carbon dioxide:

$$\mathrm{C} + \mathrm{CO_2} \rightleftharpoons 2\mathrm{CO} \qquad (3)$$

or for the reaction:

$$\mathrm{Be} + \mathrm{CO_2} = \mathrm{BeO} + \mathrm{C} + \tfrac{1}{2}\mathrm{O_2} \qquad (4)$$

even though this is thermodynamically possible[3,4]. Chemical analysis of the reaction product shows that some 38 per cent of the deposited carbon is combined with beryllium as beryllium carbide. It is believed that the latter is formed after the carbon has been deposited, by the reaction:

$$2\mathrm{Be} + \mathrm{C} = \mathrm{Be_2C} \qquad (5)$$

rather than by:

$$4\mathrm{Be} + \mathrm{CO_2} = 2\mathrm{BeO} + \mathrm{Be_2C} \qquad (6)$$

The overall rate of reaction (oxide formation and carbon deposition) has been studied on a vacuum microbalance and at temperatures up to and including 700° C.; the rate of oxidation continuously decreases with time (Fig. 1) to reach a very small value after long periods, the rate after 300 hr. varying from 0·01 μgm./cm.^{2} hr. at 500° C. to 0·07 μgm./cm.^{2} hr. at 700° C. Oxidation is thus protective over the range 500–700° C., in general agreement with the results of Munro and Williams[1]. At 750° C., on the other hand, the rate of oxidation first decreases and then increases with time, indicating a breakaway reaction.

The amount of deposited carbon, both elementary and combined, in the oxide film is small, varying in a somewhat irregular manner with temperature from 1·8 μgm./cm.^{2} at 550° C. to 11 μgm./cm.^{2} at 750° C.

When the carbon dioxide is admitted to the outgassed sample at reaction temperature there is (see Fig. 1) a very rapid initial weight gain (which as a fraction of the total weight gain after 300 hr. varies

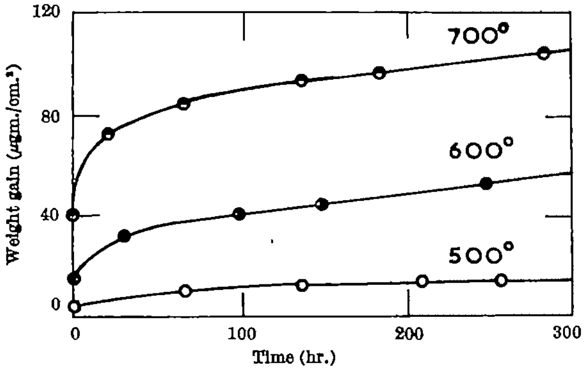


Fig. 1. Oxidation of beryllium in carbon dioxide at 500°, 600° and 700° C. The gas was admitted to the preheated sample

from 28 per cent at 500° C. to 41 per cent at 700° C.), and it appears that most of the carbon deposition occurs over this initial period; if, however, the beryllium was heated in carbon dioxide from room to reaction temperature, the initial gain in weight was no longer obtained, carbon deposition occurred over a longer period, and the amount deposited was less. The oxidation curves corresponding to these two differing modes of heating up the sample approach each other with increasing time.

For the oxidation of beryllium in carbon monoxide the reaction:

$$2Be + CO = Be_2C + \tfrac{1}{2}O_2 \quad (7)$$

is excluded on thermodynamic grounds[3,4] so that there are only the possibilities:

$$Be + CO = BeO + C \quad (8)$$

and:

$$3Be + CO = BeO + Be_2C \quad (9)$$

Since there are no volatile reaction products, kinetic measurements do not distinguish between reactions 8 and 9 and it is necessary to resort to chemical analysis of the reaction product. This shows that 15 per cent of the deposited carbon is chemically combined with beryllium as carbide and is probably formed by reaction 5 rather than reaction 9. There was no evidence for the decomposition of carbon monoxide on the surface, to deposit carbon and evolve carbon dioxide (reaction 3). For a given temperature, the rate of oxidation of beryllium in carbon monoxide is considerably greater than in carbon dioxide and a further important difference is that at 550° C. and above, the oxidation of beryllium in carbon monoxide is non-protective, the reaction product spalling from the sample during the run.

For oxidation in mixtures of carbon monoxide–carbon dioxide there is the possibility of reaction with either one or both of these gases, but runs at 650° C. in mixtures containing up to 7·5 per cent carbon monoxide showed that the oxidation followed the same course as in carbon dioxide alone. Supplementary measurements at a number of temperatures suggest that there exists a critical concentration of carbon monoxide above which the reaction changes from one with carbon dioxide to one with carbon monoxide, the rate of carbon deposition, and hence the rate of oxidation, then markedly increasing. At 700° C. this critical concentration of carbon monoxide is about 88 per cent by volume.

A detailed description and discussion of these results will be published elsewhere. We are grateful to Dr. J. E. Antill for several helpful discussions, and wish to acknowledge the financial support which this work has received from the United Kingdom Atomic Energy Authority.

S. J. GREGG
R. J. HUSSEY
W. B. JEPSON

Department of Chemistry,
The University,
Exeter.

[1] Munro, W., and Williams, J., A.E.R.E. *M/M* 108 (1956).
[2] Davies, M. W., *G.E.C. Atomic Energy Rev.*, 2, 11 (1959).
[3] Kubaschewski, O., and Evans, E. Ll., "Metallurgical Thermochemistry" (Pergamon Press, London, 1956).
[4] Pollock, B. D., *J. Phys. Chem.*, 63, 587 (1959).

Behaviour of Some Aldehydes on a Sulphonated Polystyrene Resin

5-HYDROXYMETHYL 2-FURALDEHYDE is a well-known product from the browning reaction[1] between certain sugars and amino-compounds. In the course of its isolation from such a reaction mixture it was assumed that it would be easily eluted, together with the unreacted sugar present, from a column of 'Zeokarb 225 [H⁺]' resin. Instead it was found that the volume of 0·3 *N* hydrochloric acid required to elute it was approximately 0·6 of that required to elute D-glucosamine. Passage of 2-furaldehyde and salicylaldehyde down the same column (Fig. 1) revealed that these were even more strongly absorbed. Since 5-hydroxymethyl 2-furaldehyde showed no evidence of behaving as a base on paper ionophoresis in either 0·75 *M* formate buffer *p*H 2 or 0·3 *N* hydrochloric acid, the explanation for its retention must lie in some other mechanism of interaction with this sulphonated polystyrene resin.

One possibility is that the aldehydes form weak addition compounds with the sulphonic acid function. By analogy with the reaction between benzaldehyde, benzene sulphonyl chloride and sodium cyanide,

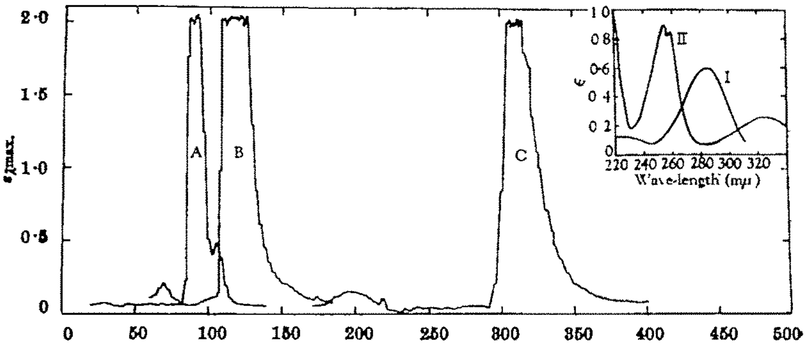
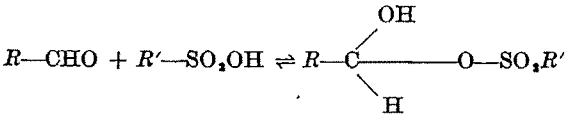


Fig. 1. Histogram showing the position of elution of 5-hydroxymethyl 2-furaldehyde (*A*), furfuraldehyde (*B*) and salicylaldehyde (*C*) from a column of sulphonated polystyrene resin ('Zeokarb 225'). Inset are the absorption curves of 5-hydroxymethyl 2-furaldehyde (I) and salicylaldehyde (II)

which afforded α-cyanobenzyl benzene sulphonate[2], this addition compound could be formed thus:



$$R\text{—CHO} + R'\text{—SO}_2\text{OH} \rightleftharpoons R\text{—}\overset{\text{OH}}{\underset{\text{H}}{\text{C}}}\text{—O—SO}_2R'$$

Another factor influencing the absorption of the aldehydes could be van der Waals adsorption forces, since it is known that compounds containing aromatic residues are adsorbed on polystyrene ion-exchange resins[3-5]. 'Amberlite *IR* 120 (H^+)', which is equivalent to 'Zeo-Karb' 225 [H^+]', has been used[6] to separate phenol, *p*-cresol and 4-tert. butyl phenol. Gabrielson and Samuelson[7] have investigated the adsorption of aldehydes and ketones on 'Amberlite *IRA*-400' (bicarbonate form), which is an anion exchanger of the strongly basic type. They reported that salicylaldehyde and vanillin were strongly absorbed, whereas formaldehyde, acetaldehyde and 2-furaldehyde were eluted almost quantitatively. In this case absorption was attributed to the acidic character of the two aromatic aldehydes.

The unexpected property of derivatives of 2-furaldehyde may prove useful not only in the identification of intermediates in the browning reaction but also those products of acidic degradation of sugars which form the basis of so many colour reactions for the quantitative determination of sugars.

One of us (K. M.) thanks Glaxo, Ltd., for the award of a scholarship.

S. A. BARKER
K. MURRAY
M. STACEY

Chemistry Department,
The University,
Birmingham, 15.

---

[1] Hodge, J. E., *J. Agric. Food Chem.*, **1**, 928 (1953).

[2] Dodson, R. M., and Turner, H. N., *J. Amer. Chem. Soc.*, **73**, 4517 (1951).

[3] Partridge, S. M., *Biochem. J.*, **44**, 521; **45**, 459 (1949).

[4] Weiss, D. E., *Nature*, **166**, 66 (1950).

[5] Davies, C. W., *Biochem. J.*, **45**, 38 (1949).

[6] Seki, T., *J. Chem. Soc. Japan, Pure Chem. Sect.*, **75**, (12), 1297 (1954).

[7] Gabrielson, G., and Samuelson, O., *Acta Chem. Scand.*, **6**, 729 (1952)

Symmetry of Insulin Dimers and Hexamers

RECENT X-ray crystallographic studies of orthorhombic crystals of bovine insulin sulphate have provided information about the symmetry of the insulin dimer (molecular weight 2 × 5733). This dimer appears to be the stable unit in acid aqueous solution, except under special conditions[1]. The dimer is the protein component of the asymmetrical unit in the wet, type *A* and type *B* sulphate and type *A* citrate, crystals[2], and also in the air-dried sulphate crystals[3]. Studies of the shrinkage stages of the type *A* insulin sulphate crystals[4] have disclosed the existence of several new crystal forms. The space group of all but one of these is $P2_12_12_1$ ($Z = 4$), that of all previously examined orthorhombic insulin crystals. One shrinkage stage (type *C*) has the space group $I2_12_12_1$ ($Z = 8$). In this crystal twofold rotation axes relate pairs of insulin molecules. On the basis of crystallographic and other evidence, it was possible to establish the strong probability that the insulin dimer has basically an invariant structure, with point group 2, in all these crystal forms and in acid solution; that is, the two insulin molecules of the dimer are related to each other by a twofold rotation axis.

This conclusion was strengthened by Patterson studies of the wet type *A* insulin sulphate crystals[5]. The position of the highest non-origin peak in the three-dimensional Patterson function is that of a pseudo-origin in each of two Patterson projections—that is, the distributions of peaks about this position are similar to those about the origins of these projections. However, the pseudo-origin character appears slight or non-existent in the third (*a*-plane) projection and in the three-dimensional Patterson function. These observations have been explained on the basis of a non-crystallographic twofold (or pseudo-twofold) rotation axis parallel (or nearly parallel) to *a*. Given two independent sources of evidence, the symmetry, or, if the dimer structure is not invariant, at least the pseudo-symmetry, of the insulin dimer seems to be established.

The predominant insulin species in solution near neutral *p*H is the hexamer[1b]. A threefold rotation axis relating three dimer units has been found in rhombohedral zinc insulin crystals, space group *R*3, grown under these *p*H conditions[6]. It appears to us that the dimer as a subunit of the hexamer may well have the point group 2. Indeed, it is quite possible that the hexamer has the point group 32 with each single molecule equivalent. (If the hexamer has the point group 32, then the three twofold rotation axes relating the molecules to each other in the dimer subunits lie in a plane normal to the threefold axis and at angles of 120° to each other.) If non-crystallographic twofold axes should exist in the rhombohedral zinc insulin crystal form, they should be detectable, with greater or lesser ease dependent upon their orientation to the threefold axis, by analysis of the vector structure.

This investigation was supported by a senior research fellowship *SF*-246*C* from the Public Health Service to one of us (B. W. L.). It was carried out during the tenure of a National Science Foundation post-doctoral fellowship (J. R. E.).

BARBARA W. LOW
J. RALPH EINSTEIN

Department of Biochemistry,
College of Physicians and Surgeons,
Columbia University,
New York 32.

---

[1] (*a*) Moody, L. S., Ph.D. Dissertation, Univ. of Wisconsin (1944), quoted by Williams, J. W., "Ann. Rev. Phys. Chem.", **2**, 412 (1951). (*b*) Oncley, J. L., Ellenbogen, E., Gitlin, D., and Gurd, F. R. N., *J. Phys. Chem.*, **56**, 85 (1952). (*c*) Kupke, D. W., and Linderstrøm-Lang, K., *Biochim. Biophys. Acta*, **13**, 153 (1954).

[2] Low, B. W., and Shoemaker, C. B., *Acta Cryst*, **12**, 893 (1959), Low, B. W., and Berger, J. E. (in preparation).

[3] Low, B. W., *Nature*, **169**, 955 (1952).

[4] Einstein, J. R., Ph.D. thesis, Harvard University (1958). Einstein, J. R., and Low, B. W. (in preparation).

[5] Shoemaker, C. B., Einstein, J. R., and Low, B. W. (in preparation).

[6] Crowfoot, D., and Riley, D., *Nature*, **144**, 1011 (1939).

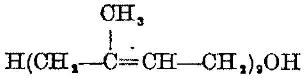
BIOCHEMISTRY

Dolichol: a Naturally Occurring Isoprenoid Alcohol

IN 1956[1] a long-chain isoprenoid alcohol, solanesol, was isolated from tobacco and tobacco leaves. While searching for solanesol in animal tissues we have isolated an isoprenoid alcohol of greater chain-length for which we propose the name 'dolichol'.

The characterization of ubichromenol from 46·5 kgm. of human kidney has been described[2,3]. Two fractions weighing 6·41 gm. were eluted between ubiquinone and ubichromenol on chromatography. The infra-red spectrum of the bulked material strongly resembled that of an isoprenoid alcohol[4]. Dolichol was purified from these fractions by forming the acetate, which was then chromatographed, crystallized from ethanol–petrol, and finally saponified to regenerate the alcohol. The alcohol was then crystallized from ethanol–petrol. Both the alcohol and the acetate were colourless viscous liquids at room temperature and white crystalline compounds at low temperature.

Dolichol showed no specific absorption in the ultra-violet region and its infra-red spectrum (all infra-red spectra were examined as films) was very similar to that of solanesol.



$$H(CH_2-\overset{CH_3}{\overset{|}{C}}=CH-CH_2)_9OH$$

Both showed bands indicating a hydroxyl, unconjugated double bonds and the *trans* configuration of those double bonds. The infra-red spectrum of solanesol, however, showed a band at 10μ due to the presence of the allylic alcohol grouping. Dolichol, on the other hand, showed C—O stretching absorption at 9·4μ. Hydrogenation of solanesol and dolichol gave their perhydro-derivatives, and the infra-red spectra of these materials were identical apart from differences in relative intensities consistent with a difference in chain-length. In particular, both saturated materials showed hydroxyl deformations due to the C—O stretching absorption at 9·4μ, and it would seem likely that dolichol contains a primary alcohol grouping but with no αβ-unsaturation.

The analysis of dolichol (C : 86·07 ; H : 12·18 ; C—CH_3 : 16·64 per cent) fitted a very long chain isoprenoid monohydric alcohol. A molecular weight determination by depression of the freezing point of *cyclo*hexane gave a value of 1,200.

The *p*-phenylazobenzoyl and *p*-nitrobenzoyl esters of dolichol were formed by refluxing with the acid chloride in pyridine. The esters were purified by chromatography on alumina, and the *p*-phenylazobenzoate could be crystallized from ethanol–petrol at low temperature. The ultra-violet absorption spectra of these esters were examined and were compared with the esters formed from other alcohols (Table 1).

Table 1. ULTRA-VIOLET ABSORPTION (IN *cyclo*HEXANE)

p-Phenylazobenzoates (λ_{max} at 324 mμ)

	E(1%, 1 cm.) 324 mμ	Molecular weight of ester	ε 324 mμ
Dolichyl	171·3	—	—
Farnesyl	616·6	430 6	26,550
Cholesteryl	438 0	594·9	26,060
Solanesyl	330·0	839·3	27,700

p-Nitrobenzoates (λ_{max} at 256 mμ)

	E(1%, 1 cm.) 256 mμ	Molecular weight of ester	ε 256 mμ
Dolichyl	95·0	—	—
Farnesyl	379·5	371·5	14,090
Phytyl	303·5	445·6	13,520

The mean molecular extinction value (ε) for the *p*-phenylazobenzoates was 26,770 and from this and the *E*(1%, 1 cm.) of dolichyl *p*-phenylbenzoate the molecular weight of the ester was calculated as 1,563. The molecular weight of dolichol was therefore 1,354. Similarly the mean molecular extinction coefficient for the *p*-nitrobenzoates was 13,800 and hence the molecular weights of the ester and dolichol were 1,453 and 1,300 respectively. A terpenoid alcohol with 19 isoprene residues, $C_{95}H_{153}OH$, has a molecular weight of 1,312 while one with 20 isoprene units, $C_{100}H_{161}OH$, has a molecular weight of 1,380.

The degree of unsaturation of dolichol and dolichyl acetate was examined by determining their iodine values (Dam's method) and by quantitative catalytic hydrogenation (for method see ref. 3). Table 2 shows that the results are in accord with dolichol being a long-chain isoprenoid alcohol.

Table 2. DEGREE OF UNSATURATION

	Double bonds	Moles H_2/100 gm.	gm. I_2/100 gm.
Dolichol		1 465	382 0
$C_{95}H_{153}OH$	(19)	1·448*	367 5*
$C_{100}H_{161}OH$	(20)	1·449*	367·9*
Dolichyl acetate		1·424	369·4
$C_{95}H_{153}O.COCH_3$	(19)	1·404*	356 2*
$C_{100}H_{161}O.COCH_3$	(20)	1·406*	357 0*

* Calculated.

Allylic alcohols will react readily with manganese dioxide[5] to produce αβ-unsaturated aldehydes but saturated alcohols are oxidized by manganese dioxide only with difficulty[6]. Farnesol was refluxed with excess manganese dioxide in petroleum ether (40–60°) for 1 hr. and gave a good yield of farnesaldehyde. Refluxing dolichol and manganese dioxide for 2 hr. in petroleum ether gave a smaller yield of a product which could be crystallized from ethanol–petrol after chromatography on alumina. The product showed only feeble ultra-violet absorption in *cyclo*hexane. The infra-red spectrum of the product showed no hydroxyl band but absorption at 5·75μ characteristic of a saturated aldehyde. Farnesaldehyde showed a band at 5·97μ characteristic of an αβ-unsaturated aldehyde with another band at 6·21μ due to the double bond conjugated to the carbonyl. It seems quite probable that the product from oxidation of dolichol was the expected aldehyde, dolichaldehyde.

Treatment of dolichaldehyde and farnesaldehyde with a saturated solution of 2 : 4-dinitrophenylhydrazine in 1 per cent ethanolic hydrochloric acid gave the corresponding derivatives, which were purified by chromatography on alumina and crystallization at low temperature. The farnesaldehyde derivative showed in ethanol $\lambda_{max.}$ 382–385 mμ, ε = 29,760, while dolichaldehyde 2 : 4-dinitrophenylhydrazone showed $\lambda_{max.}$ 360 mμ *E*(1%, 1 cm.) 156·1 (for a molecular weight of 1,312 the molecular extinction coefficient is 20,480). Derivatives of 2 : 4-dinitrophenylhydrazine with no αβ-double bond normally give rise to maximal absorption near 360 mμ with molecular extinction coefficients of 20,000–23,000[7]. A double bond in conjugation with the dinitrophenylhydrazine chromophore causes a bathochromic shift with an increased intensity as shown by the farnesaldehyde derivative.

Ozonolysis of dolichyl acetate yielded acetone and lævulinaldehyde, which were characterized as their 2 : 4-dinitrophenylhydrazones.

It is apparent that the molecule contains 19 or 20 isoprene residues* with a primary alcoholic group. This alcohol grouping has no αβ-unsaturation as in solanesol and the double bond may have been displaced to give βγ-unsaturation or a vinyl grouping. Dolichol has also been isolated from ox kidney, pig kidney, pig heart, pig liver, rat liver and ox intestine.

**Note added in proof*. Specially purified dolichyl acetate has molecular weight 1,422 (20 isoprene residues). We are indebted to Messrs. Hoffmann

La-Roche, of Basle (through Drs. O. Isler, U. Gloor and J. Würsch), for this result, based on isotope dilution of ^{14}C-labelled acetate.

J. F. Pennock
F. W. Hemming
R. A. Morton

Department of Biochemistry,
University of Liverpool.

[1] Rowland, R. L., Latimer, P. H., and Giles, J. A., *J. Amer. Chem. Soc.*, 78, 4680 (1956).

[2] Laidman, D. L., Morton, R. A., Paterson, J. Y. F., and Pennock, J. F., *Chem. and Indust.*, 1019 (1959).

[3] Laidman, D. L., Morton, R. A., Paterson, J. Y. F., and Pennock, J. F., *Biochem. J.*, 74, 541 (1960).

[4] Hemming, F. W., Morton, R. A., and Pennock, J. F., *Biochem. J.*, 74, 38P (1960).

[5] Evans, R. M., *Quart. Rev.*, 13, 61 (1959).

[6] Harfenist, M., Bavley, A., and Lazier, W. A., *J. Org. Chem.*, 19, 1608 (1954).

[7] Gillam, A., and Stern, E. S., "Electronic Absorption Spectroscopy", 54 (Edward Arnold, Ltd., London, 1954).

Fractionation of Heparin on an Anion Exchanger

Preparations of heparin have been shown to be heterogeneous by a variety of techniques[1,2], but no method is available for the fractionation of bulk quantities of heparin or of other sulphomucopolysaccharides. These compounds carry a strong negative charge over a wide range of *p*H, and, therefore, it seemed possible that they could be purified on basic resins. Five anion-exchange resins ('Dowex-1', 'Dowex-2', 'Dowex-3', 'Amberlite *CG*-45', and 'Duolite *A*-4'), each buffered at *p*H 6·0, readily adsorbed heparin, which was easily eluted with strong salt solutions, but the eluates differed from the original material in having greater absorption at 400 mμ than at 535 mμ in the carbazole reaction[3]. However, 'Ecteola'[4,5] (exchange capacity = 0·3 m.equiv./gm.) resolved a commercial preparation of bovine heparin (obtained from Nutritional Biochemicals Corp.) into four major and one minor carbazole-positive fractions (Fig. 1), each with maximum absorption at 535 mμ, and all showing metachromasia[6]. 90 per cent of the original material was recovered. Heparin-^{35}SO$_4$, extracted from a mast-cell tumour of the mouse[7], gave only one peak on chromatography on 'Ecteola' (Fig. 2), and only 50 per cent of the material was eluted.

Independently, Mozen (personal communication) has used 'Ecteola' for the resolution of heparin and found that those fractions that came off the column latest had the highest anti-coagulant potency, as well as the highest sulphate content.

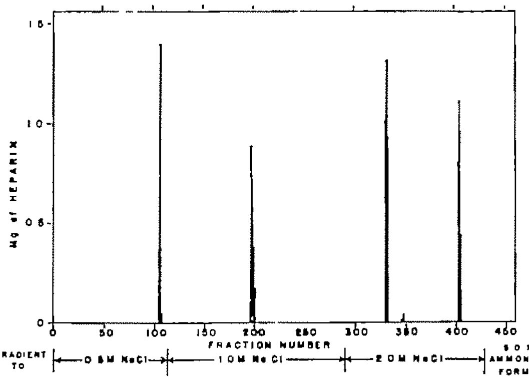


Fig. 1. Chromatography of 10 mgm. of heparin on 'Ecteola' (10 gm.; 2 × 9 cm.; flow-rate 4·0 ml./hr.). The heparin was applied in 100 ml. water. A gradient elution system was used, with a single mixing chamber containing 400 ml. water. Each fraction contained 5·5 ml.

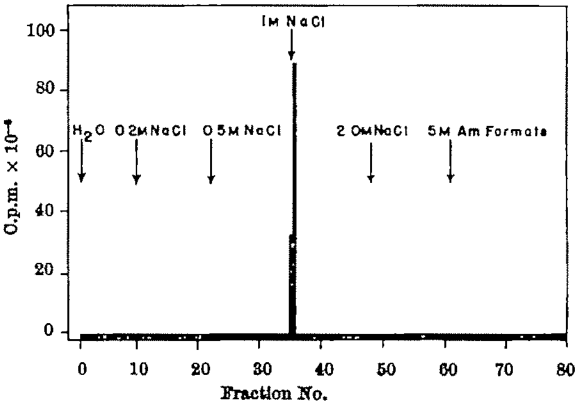


Fig. 2. Chromatography of mouse mast-cell heparin-^{35}SO$_4$ on 'Ecteola'. Each fraction contained 10 ml.

This work was supported by the American Heart Association and the Life Insurance Medical Research Fund. I am indebted to Dr. Margaret Day for providing the mast-cell tumour and to Miss Bella Wu and Mr. Mark Lavietes for technical assistance.

J. P. Green

Department of Pharmacology,
Yale University School of Medicine,
New Haven,
Connecticut.

[1] Foster, A. B., and Huggard, A. J., "Advances in Carbohydrate Chemistry", 10, 335, edit. by Wolfrom, M. L. (Academic Press, New York, 1955).

[2] Jaques, L. B., Bell, H. J., and Cho, M. H., in First International Conference on Thrombosis and Embolism, 281 (Benno Schwabe and Co., Basle, 1955).

[3] Dische, Z., in "Methods of Biochemical Analysis", 2, 313, edit. by Glick, D. (Interscience Publishers, New York, 1955).

[4] Peterson, E. A., and Sober, H. A., *J. Amer. Chem. Soc.*, 78, 751 (1956).

[5] Bendich, A., Pahl, H. B., Korngold, G. C., Rosenkranz, H. S., and Fresco, J. R., *J. Amer. Chem. Soc.*, 80, 3949 (1958).

[6] Roberts, M., Green, J. P., and Day, S. M., *Fed. Proc.*, 18, 438 (1959).

[7] Green, J. P., and Day, M., *Biochem. Pharm.* (in the press).

Mammalian α-L-Fucosidase

According to our surmise that the enzymes, β-N-acetylglucosaminidase, α-mannosidase and β-galactosidase, with their particularly high activity in the epididymis[1,2], are concerned in the breakdown of mucosubstances, they should be accompanied by an L-fucosidase. Serological evidence suggests that the L-fucose (6-deoxy-L-galactose) residue present in many mucopolysaccharides has the α-configuration[3,4]. Rat epididymis has now been found to have an α-L-fucosidase activity of about 20,000 units per gm. moist weight, compared with activities of about 4,000 units per gm. in organs such as liver, where 1 unit of enzyme liberates 1 μgm. *p*-nitrophenol in 1 hr. at 37° from *p*-nitrophenyl α-L-fucoside in an arbitrary concentration of 1 m*M*. The maximum activity is displayed at about *p*H 6. There is no α-D-fucosidase activity in mammalian tissues, but the limpet, *Patella vulgata*, with a high α-L-fucosidase activity, has a feeble effect on the related α-D-fucoside. This may well be a side-action of α-D-galactosidase.

Whereas β-glycosidases are always inhibited by the aldonolactones of corresponding configuration, the α-glycosidases only sometimes display this phenomenon[5,6]. It was shown that the hydrolysis of either of the α-fucosides was not depressed by the appropriate fuconolactone. Attempts to prepare suitable β-fucosides for enzyme work have thus far been unsuccessful.

G. A. Levvy

Rowett Research Institute,
Bucksburn,
Aberdeen.
Dec. 18.

---

[1] Conchie, J., Findlay, J., and Levvy, G. A., *Biochem. J.*, 71, 318 (1959).

[2] Conchie, J., Findlay, J., and Levvy, G. A., *Nature*, 183, 615 (1959).

[3] Kabat, E. A., "Blood Group Substances" (Academic Press, New York, 1956).

[4] Bettelheim-Jevons, F. R., "Adv. in Protein Chemistry", 13, 35 (Academic Press, New York, 1958).

[5] Conchie, J., and Levvy, G. A., *Biochem. J.*, 65, 389 (1957).

[6] Findlay, J., Levvy, G. A., and Marsh, C. A., *Biochem. J.*, 69, 467 (1958).

Supercontraction of Wool Fibres and Creep in the Post-yield Region

It is now well established that hydrogen bonding takes a major role in the stabilization of wool keratin. This is well demonstrated by the recent finding[1] that wool fibres supercontract by 70 per cent of their length in 1 *N* hydrochloric acid containing 4 *M* concentrations of sodium iodide. In agreement with earlier workers[2], it was considered that the process took place in two phases corresponding to areas of strong and weak hydrogen bonding lying in series along the microfibrils.

I have been applying this technique to wool samples exhibiting marked variations in their post-yield creep properties and have noted two significant features.

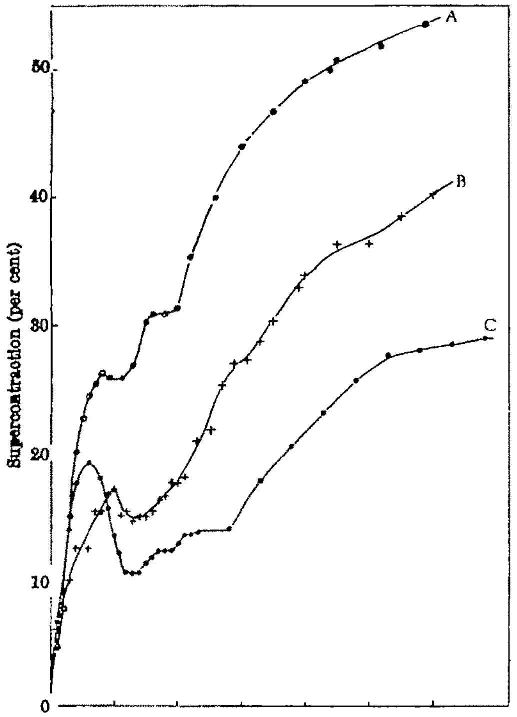


Fig. 1. Typical kinetic contraction curves of single fibres drawn from samples *A*, *B* and *C* at 98·5° C. in 1 *N* hydrochloric acid containing 4 *M* concentrations of sodium iodide

First, as has already been observed, there are large variations between samples (Fig. 1) and between fibres drawn from the same sample. Secondly, the later stages of the 1 hr. supercontraction bear a relation to the post-yield creep of the fibres (Table 1).

Table 1

Sample	Creep constant (arbitrary units)
A	53·6
B	21·9
C	13·5

It appears, therefore, that the 'strong' hydrogen bonds responsible for the later phases of supercontraction may also account for a major part of the technologically significant variations in the creep properties of wool fibres[3].

K. J. Whiteley

School of Wool Technology,
University of New South Wales,
Kensington, N.S.W.

---

[1] Crewther, W. G., and Dowling, L. M., *Text. Res. J.*, 29, 541 (1959).

[2] Griffith, J., and Alexander, A. E., *Text. Res. J.*, 27, 755 (1957). Haly, A. R., and Feughelman, M., *ibid.*, 27, 919 (1957).

[3] Ripa, O., and Speakman, J. B., *Text. Res. J.*, 21, 215 (1951). Burley, R. W., and Speakman, J. B., *ibid.*, 23, 702 (1953). Whiteley, K. J., and Speakman, J. B., *ibid.*, 30, 46 (1960).

PHYSIOLOGY

Absence of Catecholamines in Cardioactive Acetone Extracts of Ox Spleen

It has been shown that acetone extracts of freeze-dried ox spleen are capable of stimulating hypodynamic papillary muscle[1]. Evidence has been reported recently[2] which suggests that the cardio-activity cannot be explained in terms of choline or its esters, histamine, 5-hydroxytryptamine, adrenaline or noradrenaline. Further experiments reported below confirm the absence of catecholamines in an active extract.

The amplitude of cardiac contractions was recorded by a Cushny myocardiograph sutured to the right ventricles of artificially respired guinea pigs anæsthetized with pentobarbitone sodium (45 mgm./kgm. intraperitoneally). The animals were pretreated with atropine sulphate (2 mgm./kgm. subcutaneously), promethazine hydrochloride (5 mgm. intramuscularly) and ergotamine tartrate ('Gynergen') 0·15 mgm./kgm. intramuscularly. A small moistened cotton-wool cover was arranged to prevent drying of the thoracic tissues without interfering with the movements of the heart, lungs or myocardiograph. Injections of drugs were made into the right jugular vein in small volumes, approximately 0·1 ml., and washed into the circulation with 0·2 ml. normal saline.

Injection of 1–2 μgm. noradrenaline caused transient positive inotropic actions which were approximately matched by 10–25 mgm. doses of spleen extract (corresponding to quantities of fresh spleen between 6·7 and 17·2 gm.). Following doses of dichloro*iso*prenaline, a specific antagonist to the inotropic and chronotropic actions of the catecholamines[3], the effects of noradrenaline were almost completely abolished, whereas the inotropic effect of the spleen extract was not significantly altered (Fig. 1).

Further evidence that the inotropic principle in extracts of spleen differed from the catecholamines was obtained from paper chromatographic tests using Vogt's[4] modification of the technique described by Crawford and Outschoorn[5] using an atmosphere

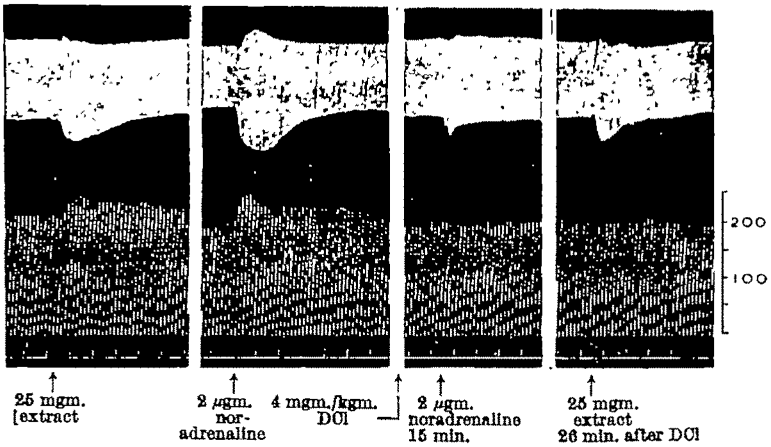


Fig. 1. Effect of dichloroisoprenaline (DCI) on the inotropic and chronotropic effects of noradrenaline and spleen extract in the intact anæsthetized guinea pig

of carbon dioxide in the tank. Samples of spleen extract sufficient to cause inotropic effects on papillary muscles in a 20-ml. bath were applied to Whatman No. 1 paper from a concentrated solution. Adrenaline, noradrenaline and dopamine (3-hydroxy-tyramine) were applied in 10-μgm. quantities to the paper. After development and removal of solvents, the chromatogram was sprayed with the ferricyanide reagent of James[6]. The catecholamines showed up clearly and good separation was achieved from a mixture. No colour reaction was observed with the samples of spleen extract, indicating that catecholamines were not present in significant quantities.

This evidence, together with that previously reported[2], seems to point conclusively to the absence of catecholamines in acetone extracts of freeze-dried spleen and suggests that the inotropic activity of these extracts is due to some other factors.

We are indebted to Dr. C. E. Powell for a generous gift of dichloro*iso*prenaline.

L. B. COBBIN
R. H. THORP

Department of Pharmacology,
University of Sydney.

[1] Cobbin, L. B., and Thorp, R. H., *Nature*, 180, 242 (1957).
[2] Cobbin, L. B., and Thorp, R. H., *Brit. J. Pharmacol.*, 14, 333 (1959).
[3] Moran, N. C., and Perkins, M. E., *J. Pharmacol.*, 124, 223 (1958).
[4] Vogt, M., *Brit. J. Pharmacol.*, 7, 325 (1952).
[5] Crawford, T. B. B., and Outschoorn, A. S., *Brit. J. Pharmacol.*, 6, 8 (1951).
[6] James, W. O., *Nature*, 161, 851 (1948).

Active Transport of γ-Aminobutyric Acid in Brain Cortex Slices, with Special Reference to Phosphorus-32 Turnover of Phospholipids in Cytoplasmic Particulates

WHEN slices of guinea pig brain cortex were incubated aerobically at 37° C. in a saline medium containing amino-acid such as γ-aminobutyric acid or glutamate, the amino-acid was accumulated in the brain slices actively from the medium against its concentration gradient in the presence of glucose as a substrate. Terner *et al.*[1] reported that L-glutamate accumulated in brain slices accompanied by potassium ions when they were incubated aerobically in the medium containing glucose. Also as reported previously[2], non-metabolizable D-isomer of glutamic acid accumulated in the brain slices in the same manner.

If γ-aminobutyric acid, a neutral amino-acid, which has an important effect on nervous functions, was present in the medium in the concentration of 5 m*M* instead of glutamate, it also accumulated actively in the brain slices depending upon energy-yielding processes (Table 1). In this case, however, there was very little change in the intracellular potassium and water content on a dry-weight basis calculated by chloride assumption. The active transport of γ-aminobutyric acid in the slices was observed only with brain tissue, not with liver or kidney. In calcium-free medium, γ-aminobutyric acid was more actively transported in the slices; on the other hand, on omitting potassium ions from the medium, γ-aminobutyric acid transport was markedly suppressed (Table 1). By the addition of pyridoxal in the concentration of 1 m*M*, the accumulation of γ-aminobutyric acid was also augmented remarkably just as in the case of glycine uptake by carcinoma cells, as described by Christensen *et al.*[3].

Slice/medium ratio indicated in Table 1 was indicative of amino-acid transport in the slices. If this value represents more than 1·0, γ-aminobutyric acid should accumulate actively from the medium against its concentration gradient, since the intrinsic concentration of the acid in the nerve cell might be considered to be about 5 m*M*/kgm. as in the medium. Under these conditions, only γ-aminobutyric acid is transported across the cell membrane as a neutral substance without any considerable movements of extra cations.

We were interested in the carrier system of γ-aminobutyric acid transportation across the nerve cell membrane against the concentration gradient in relation to phosphorus-32 turnover of phospholipid

Table 1. ACCUMULATION OF AMINO-ACID INTO GUINEA PIG BRAIN CORTEX SLICES

Conditions	Amino-acid slice/medium ratio	(Cl-space) Intracellular water (ml./gm. dry weight)	(Cl-space) Intracellular K+ (m.equiv./gm. dry weight)
		Mean ± *S.D.*	
No substrate	None	1·65 ± 0·12 (4)	0·203 ± 0·05 (4)
Glucose–Ringer		1·85 ± 0·20 (11)	0·368 ± 0·01 (11)
With γ-aminobutyric acid (5 m*M*)			
No substrate	2·30 (3)	1·75 ± 0·24 (5)	0·194 ± 0·048 (5)
Glucose–Ringer	3·60 (4)	2·06 ± 0·56 (4)	0·380 ± 0·022 (4)
+Calcium-free	4·06 (5)	2·22 ± 0·10 (3)	0·320 ± 0·014 (3)
+Potassium-free	1·89 (4)	1·56 ± 0·42 (3)	0·177 ± 0·038 (3)
+Pyridoxal (1 m*M*)	4·96 (2)		
+2,4-Dinitrophenol (5×10^{-5} *M*)	2·59 (2)		

Slices were incubated in Krebs–Ringer phosphate (sodium, 140 m.equiv./l.; potassium, 7·26 m.equiv./l.; calcium, 2·75 m.equiv./l.; magnesium, 2·62 m.equiv./l.; chloride, 139 m.equiv./l.; phosphorus, 10·8 m*M*/l.) with 5 m*M* γ-aminobutyric acid. Amino-acids were measured paper chromatographically by ninhydrin colour development. Sodium and potassium were estimated by flame photometry and chloride by Lowry's method (ref. 7) after the extraction of dried tissue by 0·1 *N* nitric acid.

Table 2. PHOSPHORUS-32 INCORPORATION INTO PHOSPHOLIPID FRACTIONS OF CYTOPLASMIC PARTICULATES OF GUINEA PIG BRAIN

	Specific activity	Increase (per cent)	Total counts (c.p.m./gm. tissue)		
			Phosphatidic acid	Phosphatidyl-choline	Mono-phospho-inositide
Control	118	100	6,050	379	2,070
+γ-Amino-butyric acid (5 m*M*)	154	131	8,880	520	1,170
+Calcium-free +γ-amino-butyric acid	190	161	11,200	1,190	2,350
+Potassium-free + γ-amino-butyric acid	116	98	5,930	509	1,620
+Pyridoxal (1 m*M*) + γ-amino-butyric acid	189	160	15,900	882	1,420
Potassium-rich (sodium, 90 m*M*; potassium, 50 m*M*)	312	264	14,300	2,610	2,740

Slices were incubated in 2-ml. medium containing equal radioactivity of phosphorus-32. Specific activity was expressed as the value of the counts per min. per phospholipid phosphorus. The total counts of each phospholipid represented as counts per min. per gm. wet weight tissue.

fractions in brain tissue, which are present in fairly high concentration in the membrane structure. Guinea pig brain cortex slices (300–400 mgm.) were incubated for 60 min. in the medium containing 5 m*M* γ-aminobutyric acid and phosphorus-32 as a tracer. After the incubation period, slices were homogenized in 0·25 *M* sucrose in the cold. The cytoplasmic particulate fraction was obtained by centrifugation at 40,000 r.p.m. (105,000*g*) for 15 min. in the cold after the removal of cell debris; then the particulates were washed once, resuspended in 0·25 *M* sucrose and centrifuged again. Ethanol/ether (1 : 1) soluble lipids were extracted in the acidic state at 4° C. overnight from the cytoplasmic particulates fraction. The phospholipids extracted were separated by chromatography on silicic acid-impregnated paper with di*iso*butylketone/acetic acid/water in the proportions of 40 : 30 : 7 as described by Hokin *et al.*[4]. A contact radioautogram was taken with X-ray film. The identification of spots on the radioautogram was made by reference to the mild alkaline hydrolysis method of Dawson[5] rather than Hokin's procedure.

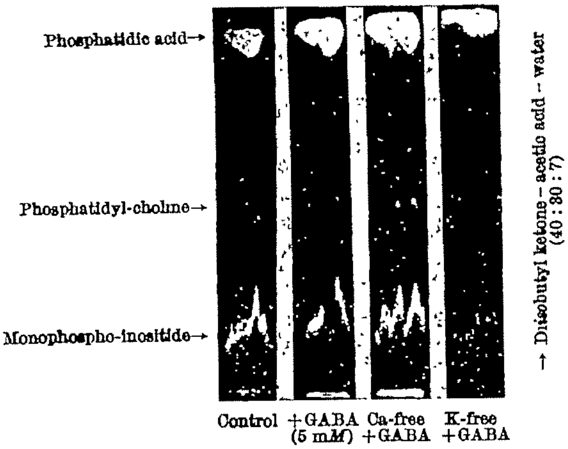


Fig. 1. Phosphorus-32 radioautogram of phospholipid in brain particulates

The incorporation of phosphorus-32 into the phospholipids, particularly phosphatidic acid and phosphatidyl choline, in the washed cytoplasmic particulate fraction was clearly increased accompanied by the accumulation of γ-aminobutyric acid in the slices. Moreover, on the addition of calcium-free medium or of pyridoxal (1 m*M*), phosphorus-32 incorporation was accelerated. On the contrary, when γ-aminobutyric acid did not accumulate in the slices on the condition of potassium-free medium, incorporation of phosphorus-32 in the phospholipids was diminished as shown in Table 2 and Fig. 1.

As reported previously[6], potassium-rich medium containing sodium ions (potassium : 50 m.equiv./l., sodium : 90 m.equiv./l.) stimulated the metabolism of brain slices such as oxygen uptake, glycolysis and incorporation of phosphorus-32 into phosphoprotein fractions. In these circumstances, the incorporation of phosphorus-32 into phospholipids of brain cytoplasmic particulates was also strongly stimulated. This suggests that some relationship exists between active transport of cations such as potassium influx and sodium efflux across the cell membrane and phosphorus-32 turnover of phospholipids.

From these results, phospholipids in cytoplasmic particulates of brain tissue, which are thought to be a main structure of the cell membrane electronmicroscopically, would play an important part as carriers in the active transport of amino-acid or cations across the nerve cell membrane.

Details will be published elsewhere later.

YASUZO TSUKADA
YUTAKA NAGATA
SHUSUKE HIRANO

Department of Physiology,
School of Medicine,
Toho University,
Ohmori,
Tokyo. Nov. 19.

[1] Terner, C., Eggleston, L. V., and Krebs, H. A., *Biochem. J.*, 47, 139 (1950).
[2] Takagaki, G., Nagata, Y., and Hirano, S., *J. Neurochem.*, 4, 124 (1959).
[3] Christensen, H. N., Riggs, T. R., and Coyne, B. A., *J. Biol. Chem.*, 209, 413 (1954).
[4] Hokin, L. E., and Hokin, M. R., *J. Biol. Chem.*, 233, 822 (1958).
[5] Dawson, R. M. C., *Biochim. Biophys. Acta*, 14, 374 (1954).
[6] Tsukada, Y., Takagaki, G., and Hirano, S., *J. Biochem.* (Japan), 45, 489 (1958).
[7] Lowry, O. H., Roberts, N. R., Leiner, K. Y., Wu, M. L., and Farr, A. L., *J. Biol. Chem.*, 207, 1 (1953).

Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat

IN our investigations of the relation between cell activity and deoxyribonucleic acid content of the nucleus in endocrine glands, we had the opportunity to study the influence of stimulation of the testicular interstitial cells by means of interstitial cell-stimulating hormone on the mean deoxyribonucleic acid content of their nuclei.

Ten male adult rats, 7–8 months old, were used. While 5 of these were controls, to each of the other rats 50 I.U. of interstitial cell-stimulating hormone have been given intramuscularly per 24 hr., for 14 successive days. All animals were beheaded simultaneously. The testes were fixed in alcohol/

Table 1

	Deoxyribonucleic acid content of interstitial cell nuclei					
	No.	$\bar{x}$	$\log \bar{x}$	n	s	$s_{\log \bar{x}}$
Controls	338 339 340 341 342	1,111 1,088 1,053 1,096 1,178	3·0458 2·0367 3·0223 3·0397 3·0710	50 50 50 50 50	0·0630 0·0570 0·0492 0·0490 0·0475	0·00893 0·00742 0·00695 0·00692 0·00673
	Average	1,102	3·0424	250	0·0550	0·00356
Treated with interstitial cell-stimulating hormone	353 354 355 356 357	1,199 1,203 1,193 1,213 1,178	3·0789 3·0801 3·0766 3·0837 3·0710	50 50 50 50 50	0 0599 0·0536 0·0454 0·0487 0 0506	0 00849 0·00642 0·00642 0·00688 0·00716
	Average	1,198	3·0784	250	0 0561	0 00348

formalin/acetic acid (75 : 20 : 5) and cut at 10μ. Sections were prepared on the same slide in order to submit them to the Feulgen reaction under identical conditions. The deoxyribonucleic acid content was measured in individual nuclei by the histophotometrical method of L. Lison[1] and expressed in arbitrary units.

Table 1 summarizes the results ; since the individual nuclear contents vary following a log-normal distribution, the log $\bar{x}$ values were used for statistical computations.

When comparing the pooled results of the two groups, it is seen that after treatment with interstitial cell-stimulating hormone there is an 8·7 per cent increase in the mean deoxyribonucleic acid content of the nuclei of the interstitial cells (t = 7,651 ; $P \ll 0{\cdot}001$). These results demonstrate once more a stimulation of cell activity accompanied by increase of the mean deoxyribonucleic acid content of the nuclei.

S. L. Liu

Laboratory of Human and Comparative Anatomy,
University of Ghent.

---

[1] Lison, L., *Acta Anat.*, **10**, 333 (1950).

Spontaneous Potential Changes at Crayfish Neuromuscular Junctions

An important feature of vertebrate neuromuscular transmission is that acetylcholine is released from the nerve terminals in 'packets'. At rest, a spontaneous discharge of these packets gives rise to 'miniature end-plate potentials'[1]. We were therefore interested whether this mechanism of transmitter release also occurs at a non-cholinergic crustacean neuromuscular junction.

In the abductor of the dactylopodite of the first walking leg of the crayfish (*Orconectes virilis*), spontaneous potentials of up to 0·8 mV. were recorded with intracellular electrodes (20–25° C., pH 7·2). The time course of these potentials (Fig. 1*A*) was similar to that of an excitatory junctional potential set up by stimulation of the motor axon. The largest spontaneous potentials were found in those fibres with the smallest diameters (about 100μ) and a relatively high input resistance (about 0·5 MΩ). They could be recorded from any point in the muscle fibre, in the same manner as excitatory junctional potentials[2]. The amplitude of consecutive spontaneous potentials varied considerably (Fig. 1*B*). Smaller potentials seemed to have a longer rise time (Fig. 1*A*), suggesting that they arose at a greater distance from the recording electrode. Frequencies in different fibres were between 0·1 and 10 per second. The potentials appeared to occur at random intervals. Statistical tests[3] confirmed that there was no noticeable interaction between single events. Our findings are similar to those of Burke[4], who recorded 'miniature end-plate potentials' in the frog's slow muscle fibres which also have motor nerve endings distributed over the entire fibre surface.

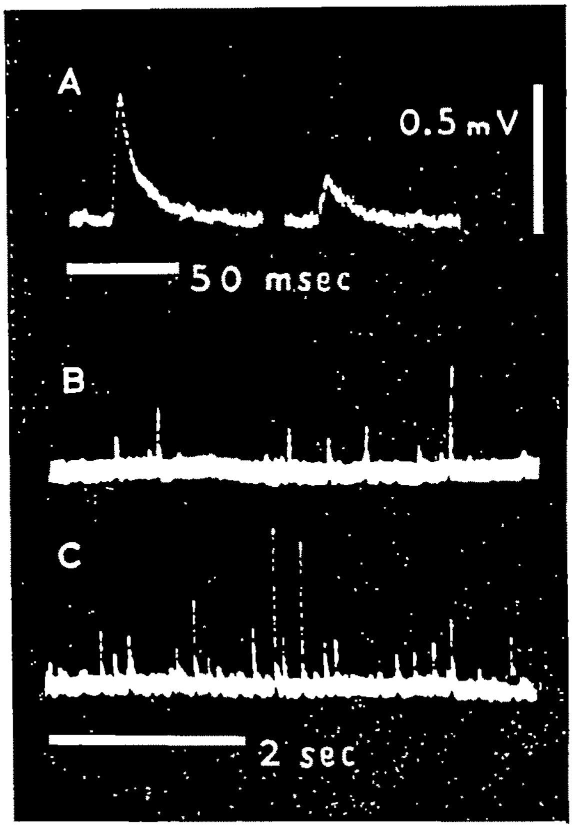


Fig. 1. Spontaneous potentials from a crayfish muscle fibre with intracellular recording, resting potential 78 mV. *A* and *B* in normal van Harreveld solution. *C*, molarity of van Harreveld solution increased by addition of 125 m*M* sucrose. Voltage calibration same for *A*, *B* and *C* ; 50 msec. calibration for *A*, 2 sec. for *B* and *C*

At vertebrate neuromuscular junctions the frequency of 'miniature end-plate potentials' is increased when the osmolarity of the extracellular fluid is raised[3]. This also applies to crustacean neuromuscular junctions. Thus in Fig. 1*C* a 50 per cent increase in osmolarity raised the frequency three times over that in Fig. 1*B*. Doubling the osmotic pressure resulted in a seven-fold rise in frequency. It seems unlikely that the spontaneous potentials arise from spontaneous conducted impulses in branches of the motor axon. Thus a five-fold increase in calcium concentration (to 67 m*M*/l., replacing sodium) prevented the appearance of an excitatory junctional potential following stimulation of the motor axon, but did not appreciably affect the spontaneous discharge. We could further exclude the release of inhibitory transmitter as the cause of spontaneous activity. When the membrane potential was shifted by passing current across the membrane the inhibitory junctional potential reversed its sign at the chloride equilibrium potential as previously seen by others[5]. The spontaneous activity, however, was not affected.

If the spontaneous potentials arise from transmitter released from excitatory nerve endings, one might expect the frequency of the discharge to be altered following stimulation of the excitatory nerve[6]. Fig. 2 shows that during the first second following a burst of excitatory junctional potentials at 100 per sec. for 1 sec. the frequency of the spontaneous potentials was increased; afterwards, however, the frequency was markedly decreased for a considerable period. If the duration of the excitatory stimulation was lengthened from 1 to 10 sec., only the decrease in frequency was observed for the entire 30-sec. interval between bursts of stimulations.

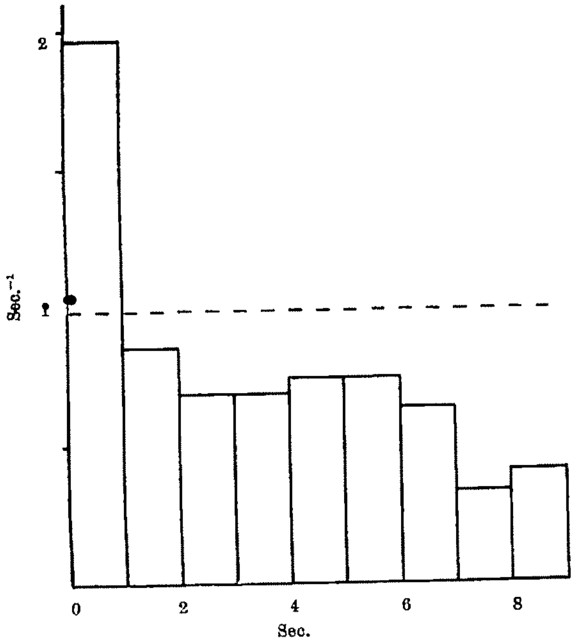


Fig. 2. Change in frequency of spontaneous potentials following stimulation of the motor axon. Abscissa: time after end of stimulation of excitatory axon at 100/sec for 1 sec., every 10 sec. Ordinate: number of spontaneous potentials observed per sec., average of 27 consecutive intervals between stimulations. The dotted line indicates the average frequency of spontaneous potentials at rest

All the observations are consistent with the assumption that the spontaneous potentials are analogous to 'miniature end-plate potentials' of vertebrates. However, until the chemical identity of the excitatory transmitter in these muscle fibres is known, more direct evidence that these potentials arise from the spontaneous release of transmitter from the nerve terminal will be difficult to obtain.

JOSEF DUDEL*
RICHARD K. ORKAND†

Marine Biological Laboratory,
Woods Hole, Mass.

* Present address: Harvard Medical School, Neurophysiological Laboratory, Boston 15, Mass.

† U.S. Public Health Service Predoctoral Research Fellow (*GF*-7925). Department of Pharmacology, Salt Lake City, Utah.

[1] Castillo, J. del, and Katz, B., "Prog. Biophys.", 6, 121 (1956).
[2] Fatt, P., and Katz, B., *J. Exp. Biol.*, 30, 433 (1953).
[3] Fatt, P., and Katz, B., *J. Physiol.*, 117, 109 (1952).
[4] Burke, W., *J. Physiol.*, 135, 511 (1957).
[5] Boistel, J., and Fatt, P., *J. Physiol.*, 144, 176 (1958).
[6] Castillo, J. del, and Katz, B., *J. Physiol.*, 124, 574 (1954).

Spontaneous Potentials from Explants of Brain Tissue in Culture

SINCE July 1959 we have been recording spontaneous potentials from explants of brain in tissue culture. The tissue used was cerebellum from chick embryos of 8 days incubation and older. The supernatant was a 0·25 per cent solution of human serum protein in a physiologically balanced salt solution. The composition of the physiological balanced salt solution is as follows:

Potassium chloride	0·28	gm./litre
Sodium chloride	7·0	,,
Calcium chloride	0·28	,,
Magnesium sulphate	0·15	,,
Di-sodium hydrogen phosphate	0·08	,,
Di-potassium hydrogen phosphate	0·04	,,
Sodium bicarbonate	1·05	,,
Sodium acetate	0·05	,,
Dextrose	1·75	,,

The other techniques were those described in publications from this laboratory[1-3].

Spontaneous potentials have been obtained from cultures both in Kahn tubes and in flow systems as bursts of activity and as sustained activity from the time of explantation until another 14 days in culture. We have used a d.c. amplifier of our own design and a Dumont oscilloscope or Texas Instrument's 'Rectiriter'. The actual disturbance is illustrated in Fig. 1 and is composed of step-like combinations of positive and negative potentials lasting from a half to one and a half seconds each with a magnitude of up to 25 µV. Each culture had a simultaneous electrically inert control (dead brain tissue, pure epithelium cartilage or cornea without iris) with a repeated exchange of recording channel between control and brain tissue to exclude artefacts. We have been un-

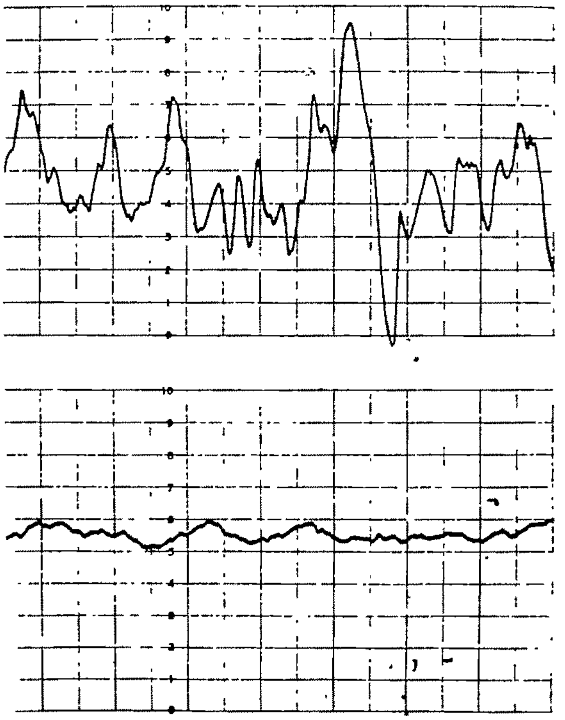


Fig. 1. Simultaneous dual-channel recording of spontaneous electrical activity from explants of chick embryo cerebellum in culture (upper channel) and control of dead brain tissue (lower channel). Full-scale vertical deflexion equals 25 µV. Time interval between each major horizontal division is 2·5 sec.

able to find any other record of spontaneous potentials from explants of brain tissue in culture.

Further investigations on these potentials are in progress.

This work was done under a U.S. Navy contract, *NONR* 1598 (04).

A. W. B. Cunningham
Marshall Dougherty
B. J. Rylander

Pathology Department,
University of Texas Medical Branch,
Galveston, Texas. Oct. 22.

[1] Cunningham and Estborn, *Lab. Invest.*, 7, 156 (1958).
[2] Estborn, Cunningham *et al.*, *Lab. Invest*, 7, 524 (1958).
[3] Cunningham and Herbst, *Lab. Invest.* (in the press).

Activity of Muscle Receptors in the Kitten

In recent experiments[1] it was found that the tonic stretch reflex is lacking in the distal muscles of the limbs of the newly born kitten. Evidence was also presented that the gradual appearance of this reflex is due to a postnatal development of its afferent link, because its efferent link can easily be activated from other sources than stretch receptors at birth. The postnatal development of the afferent link is partly a maturation of the central connexions and functions of the muscle afferents[2-4], but as will be reported here it also consists of a development of the stretch receptors.

Whether or not the muscle spindles are functioning properly in the muscles lacking tonic stretch reflexes was, of course, one of the first questions asked. The study of these receptors in a newly born animal, however, met with great technical difficulties. Out of these has only to be mentioned that the fibre diameter of the largest afferents from, for example, the gastrocnemius muscle is about 2μ, making the isolation and recording from single functioning receptors extremely difficult. Recordings from a great many receptors have, however, been obtained by now allowing an evaluation of the experimental results.

The discharge of the stretch receptors in the gastrocnemius muscle has been studied both in dissected fibres of the dorsal roots *L* 7 and *S* 1 and in the muscle nerve. The ventral roots *L* 7 and *S* 1 were stimulated with square-wave shocks of 0·5 msec. duration given either singly or in a short tetanus. Muscle tension was recorded isometrically. The temperatures of the whole animal and of the muscle used were continuously controlled.

Recordings from the dorsal root of the muscle nerve of the discharge of the stretch receptors in the gastrocnemius muscle have shown that a sustained discharge in response to stretch is usually lacking in the newly born animal. When later present the frequency of the response is very low (Fig. 1*A* and Fig. 2) and soon adapts to zero. Repeated stretching of the muscle, however, gives rise to a response every time, as shown in Fig. 1*B*, even in the newly born animal. The lack of a sustained discharge makes a differentiation by behaviour during contraction between the responding receptors difficult. Intra-arterial injection of subparalytic doses of succinylcholine iodide, which is known to activate the muscle spindles selectively[5], sometimes makes the spindles fire continuously in the newly born animal, but always sensitizes them to respond with a few spikes on the falling phase of the contraction. By the use of this drug it was possible to differentiate between the responding receptors. It has thus been found that both muscle spindles and tendon organs in the gastrocnemius muscle of a newly born animal can be activated by stretch, but usually only phasically. It has constantly been found, however, that sustained discharges are obtained from proximally lying muscles around the hip and spine which usually are difficult to get rid of by denervation. In listening to the discharge of these receptors in the loudspeaker on stimulation of the ventral roots it can be heard that both spindles and tendon organs are present among the continuously firing receptors.

The muscles in the newly born kitten are known to have different properties from those in the adult animal[6]. It has here been found that they, besides having a slow contraction, are extremely plastic (see Fig. 2). The intrafusal fibres of the muscle spindles are known to grow out from extrafusal ones[7], and the plasticity could thus offer one explanation for the fast adaptation and inability of the muscle spindles to set up sustained discharges in response to stretch. If this was the only explanation, continually re-adjusting the tension to high values would set up sustained discharges. That has, however, not been found to be the case. The observation by Hursh[8], repeatedly confirmed during this investigation, that the absolute refractory period is twice as long as in the adult nerve before the developing fibres reach a conduction velocity of 18–20 m./sec., points to properties of the nerve fibres in the newly born animal that might prevent repetitive firing, at least with high frequencies.

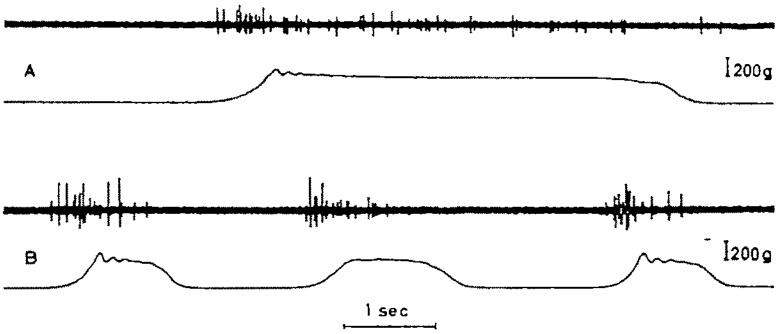


Fig. 1. The response of stretch receptors in the gastrocnemius muscle of a 3-day-old kitten recorded in a small twig of the medial nerve to the muscle during 8-mm. stretch

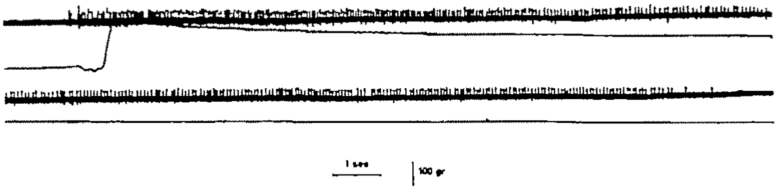


Fig. 2. The response of stretch receptors in the gastrocnemius muscle of a 10-day-old kitten to 12-mm. stretch, recorded in a fine filament of the dorsal root *S* 1. Note the fall in tension due to plasticity in the muscle, which is kept at constant length

A combination of immaturity of the sense organ with regard to mechanical properties and of the afferent fibre with regard to excitability (not necessarily a function of its diameter which is but a good correlative measure) explains the adaptation and the inability to respond to both high tensions and succinylcholine iodide with sustained discharges respectively. In conformity with this, it has been found that the stretch receptors usually fire continuously when the conduction velocity of the afferents has reached 18–20 m./sec., which happens 8–10 days postnatally, but as can be imagined from Fig. 2 adaptation due to plasticity will still play a great part in small extensions.

In trying to find out when the gamma-efferents start activating the muscle spindle, it was found that stimulation slightly above threshold for the alpha-fibres often activated a few spikes during the early phase of a muscle contraction. This is thought to be an alpha-activation of the spindle[9] which appears earlier postnatally than the well-known gamma-excitation, which is obtained 18–20 days postnatally.

STEN SKOGLUND

Institute of Anatomy,
University of Uppsala.

[1] Skoglund, S., *Uppsala lakaref. forh.*, 1–2, 92 (1959).

[2] Malcolm, J. L., in "Biochemistry of the Developing Nervous System", 104 (Academic Press, Inc., New York, 1955).

[3] Skoglund, S., *Nature* (in the press).

[4] Skoglund, S., *Nature* (in the press).

[5] Granit, R., Skoglund, S., and Thesleff, S., *Acta Physiol. Scand.*, 28, 134 (1953).

[6] Denny-Brown, D. E., *Proc. Roy. Soc.*, B, 104, 371 (1929).

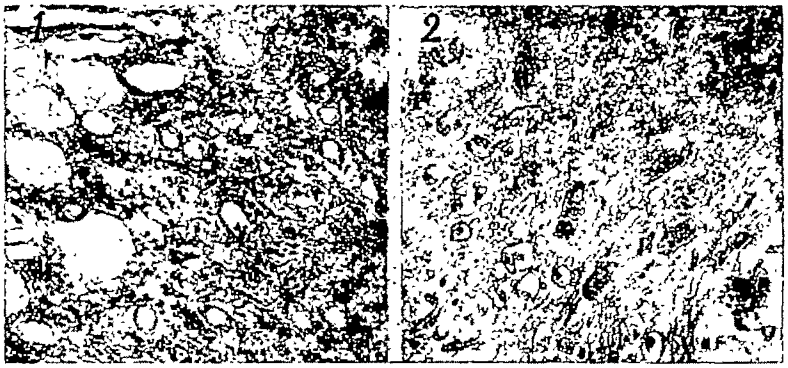
[7] Cuajunco, F., *Carnegie Inst. Contrib. Embryol.*, 19, 45 (1927).

[8] Hursh, J. B., *Amer. J. Physiol.*, 127, 140 (1939).

[9] Granit, R., Pompeiano, O., and Waltman, B., *J. Physiol.*, 147, 399 (1959).

Histochemical Demonstration of Ascorbic Acid in the Locus Coeruleus of the Mammalian Brain

Diehl and Neumann[1] have determined the content of ascorbic acid in the various portions of the human brain and found a characteristically high content in the autonomic centres (tuber cinereum and medulla oblongata). By means of the histochemical method the neurosecretory nuclei of the hypothalamus were reported to contain many silver granules due to reduction of silver nitrate by ascorbic acid[2–4]. Although in the above chemical and histochemical reports particular attention was not paid to the locus coeruleus, the locus was recently found by a histochemical method (Shimizu *et al.*[5,6]) to demonstrate the pronounced activity of monoamine oxidase, and by several physiological investigations[7–9] to regulate respiration, as the pneumotaxic centres. As the locus coeruleus was thus supposed to display some autonomic (visceral) functions, which might be related to amine metabolism, we thought it reasonable to search for the histochemical presence of ascorbic acid in the locus coeruleus.



Figs. 1 and 2. Distribution of ascorbic acid in the brain, stained by the Giroud and Leblond method. The silver granules are due to a reduction of acidified silver nitrate by ascorbic acid. Fig. 1. Locus coeruleus of rat. A large amount of silver granules is demonstrated mainly within the nerve cells of the locus coeruleus. Several large nerve cells of the mesencephalic nucleus of the trigeminal nerve (at the left hand of the figure) are essentially devoid of silver granules (× c. 330). Fig. 2. Locus coeruleus of guinea pig. Moderate amounts of silver granules are encountered in several nerve cells of the locus coeruleus (× c. 330)

Experimental animals used consisted of healthy adult mice, rats and guinea pigs and also scorbutic guinea pigs. Thin slices of the brain were fixed in the acidified silver nitrate solution for 30 min. according to Giroud and Leblond's method (cf. Gomori[10], and Lison[11]) following intravascular perfusion first with an isotonic fructose solution and then the silver nitrate solution.

In the brain of the normal animals tested silver granules due to the presence of ascorbic acid occurred most abundantly in mice, intermediately in rats and least of all in guinea pigs. In mice and rats large amounts of silver granules were demonstrated constantly in the locus coeruleus (Fig. 1), where the silver granules were mainly encountered within the nerve cell bodies. The same observation was also made in the paraventricular and supra-optic nuclei of the hypothalamus as other investigators[2–4] already reported. Similar but less evident deposition of silver granules was further revealed in the dorsal nucleus of the vagus nerve and area postrema of mice. Regions of the brain other than the above nuclei showed rather irregular deposition of silver granules, which were present in small (rats) or moderate amounts (mice). For example, varying amounts of silver granules were found in the nerve-cell bodies of the cerebral and cerebellar cortices.

The brains of normal healthy guinea pigs showed the deposition of silver granules much less clearly than those of rats and mice and the silver granules were demonstrable exclusively in limited portions of the brain in contrast to the observation in rats and mice. Moderate amounts of silver granules (Fig. 2) were shown in the nerve cell-bodies of the locus coeruleus as well as in those of the paraventricular nucleus. Small numbers of the granules were present, furthermore, in the supra-optic nucleus, dorsal nucleus of the vagus nerve and area postrema. These silver granules were completely abolished in the scorbutic guinea pigs, which were fed on the vitamin C deficient diet for about twenty days. This observation indicates that the deposition of silver granules in the above nuclei might be due to the presence of ascorbic acid.

Our observations that ascorbic acid is concentrated in the locus coeruleus, dorsal nucleus of the vagus nerve and area postrema as well as in the hypothalamus lead us to suppose that this vitamin might be implicated in the metabolism of the autonomic centres of the brain. Ascorbic acid is said to be required for the oxidation of tyrosine and in this process it does not seem to act as a specific cofactor and its role is probably that of a reducing agent (cf. Mehler[12], Fruton *et al.*[13]). Co-existence of ascorbic acid with monoamine oxidase might constitute a suitable condition for the active aromatic amine metabolism in these nuclei.

NOBUO SHIMIZU
TOMOKAZU MATSUNAMI
SATOKO ONISHI

Department of Anatomy,
Osaka University Medical School,
Osaka-shi, Japan.

[1] Diehl, F., and Neumann, H., *Klin. Wochenschr*, 18, 418 (1939).
[2] Schiebler, T. H., *Acta Anat*, 13, 233 (1951).
[3] Sloper, J. C, *J. Anat.*, 89, 301 (1955).
[4] Imoto, T., *Arch. Hist. Jap.*, 13, 491 (1957).
[5] Shimizu, N., Morikawa, N., and Okada, M., *Z. Zellforsch.*, 49, 389 (1959).
[6] Shimizu, N., and Morikawa, N., *Nature*, 184, 650 (1959).
[7] Johnson, F. H., and Russel, G. V., *Anat. Rec.*, 112, 348 (1952).
[8] Baxter, D. W., and Olszewski, J., *J. Neurophysiol.*, 18, 276 (1955).
[9] Ngai, S. H., and Wang, S. C., *Amer. J. Physiol.*, 190, 343 (1957).
[10] Gomori, G., "Microscopic Histochemistry" (Univ. of Chicago Press, Chicago, 1952).
[11] Lison, L, "Histochimie et cytochimie animales", 2e éd. (Gauthier-Villars, Paris, 1953).
[12] Mehler, A. H., "Introduction to Enzymology" (Academic Press, New York, 1957).
[13] Fruton, J. S., and Simmonds, S., "General Biochemistry", 2nd ed. (John Wiley, New York, 1958).

Serotonin Content of the Pineal Glands of Man and Monkey

GIARMAN *et al.* have demonstrated the presence of certain neurohumours and some of their associated enzymes in the bovine pineal gland[1,2]. While determining the relative distribution of serotonin in specific areas of human brain, we have obtained the pineal glands of deceased mental patients. The glands were removed within 24 hr. *post mortem*, and kept at the temperature of dry ice, usually for 24 hr., when extraction of serotonin was carried out. Only minimal losses are encountered with such a procedure. The pineals were homogenized with 2 ml. of isotonic salt solution and the amine extracted with 95 per cent acetone by a modification of the method of Amin, Crawford and Gaddum[3]. Estimation of the content of serotonin in the extracts was made by assay on the heart of *Venus mercenaria*[4]. For purposes of comparison freshly excised pineal glands from non-psychotic deceased patients and from 17 rhesus monkeys were treated and assayed in the same manner. Table 1 summarizes the results presented here and includes some values obtained previously[2] from freshly excised and fresh-frozen bovine glands.

It is clear that the pineal gland of both man and monkey is considerably richer in serotonin than that of the cow. In fact, the serotonin-levels found in the majority of human and simian glands are the highest ever reported for any neural structure of any species examined. These values approach the levels found in the spleen and portions of the gastro-intestinal tract. Moreover, pretreatment with the monoamine oxidase inhibitor, iproniazid ('Marsilid'), fails to give values in this range either in whole rat's brain[5] or in specific areas of the dog's brain[6]. Our study of other regions of the human brain has shown high values of 0·48 γ/gm. in the central grey of the midbrain and 0·43 γ/gm. in the reticulum of the medulla oblongata (Freedman, D. X., Picard-Ami, L., and Giarman, N. J., unpublished work). Costa and Aprison have reported high values of 0·5–1·0 γ/gm., which they found in mesencephalic and diencephalic structures of the human brain[7].

Table 1 SEROTONIN IN HUMAN, SIMIAN AND BOVINE PINEAL GLANDS

Species	Age	Diagnosis	Weight of pineals (gm.)	Serotonin content (γ/gm.)
Human male	89	Cerebral arterio-sclerosis	0·120	1·00
Human male	76	Manic depressive	1·890	0·36
Human female	78	Chronic schizophrenic	0·450	10·60
Human male	84	Senile brain disease	0·480	5·33
Human male	37	Schizophrenic reaction, chronic	0·305	0·59
Human male	40	Schizophrenic reaction, chronic	0·285	1·54
Human male	90	Chronic brain syndrome	0·115	2·08
Human male	45	Chronic brain syndrome; also delirium tremens	0·210	22·82
Human female	44	Cirrhosis of liver	0·130	5·77
Human male	86	Bronchogenic carcinoma	0·095	2·63
Human male	74	Myocardial infarct.	0·110	2·18
17 Rhesus monkeys (adult male)			Mean Range	3·28 1·20–10·00
13 Steers			Mean Range	0·40 0·20–0·63

The greatest variability of serotonin content was found in the human pineal gland, with values ranging from 0·36 γ/gm. to 22·82 γ/gm. (see Table 1). While these human glands (especially those from psychotic patients) showed great variation in weight, there was clearly no correlation between weight and serotonin content. In contrast, the serotonin content of the bovine pineal glands fell within the relatively narrow range of 0·20 γ/gm.–0·63 γ/gm., and their weight was an almost uniform 0·20 gm. The variability in the serotonin content of the simian glands fell between that of the human and that of the bovine glands. It was established in control experiments that the prior ingestion of bananas failed to correlate with elevated serotonin-levels found in the simian pineal glands.

The seemingly greater variability of values in the glands taken from patients with psychiatric disorders than in those from the three representatives of the 'normal' population cannot be interpreted because of the small sample and wide range of diagnoses represented. Any apparent trend requires replication of studies from selected diagnostic categories and investigation, among other factors, of histology and of relative monoamine oxidase activities. One inference we might currently make refers to the apparent unrelatedness of serotonin content of the human pineal to age in the group 35–90 years of age.

Despite a long-standing philosophical and scientific interest in the pineal gland and a large number of somewhat sporadic investigations[8] the function of the pineal and the relation of this function to its chemistry or pathology are still unknown. Similarly, any proposed relationship of the pineal gland and mental function[9] lacks confirmation by other investigators. On the other hand, possible inter-relationships of the pineal with the adrenal cortex, gonads, and the pituitary gland have been reported. Farrell *et al.*[10] noted that destruction of the pineal region reduced secretion of aldosterone by the adrenal cortex, while infusion of bovine pineal extract restored such secretion to normal (Farrell, G., unpublished results sent in personal communication from E. S. Redgate).

Lerner *et al.*[11] have isolated a skin-lightening hormone, melatonin, from the bovine pineal gland, and found it to antagonize the skin-darkening effect of melanocyte-stimulating hormone, secreted by the neurohypophysis. Wurtman *et al.*[12] reported that pinealectomy in young female rats led to pituitary and gonadal hypertrophy, which was reversible by injection of pineal extract. These findings and our earlier reports[1,2] on the presence of neurohumours and associated enzymes in the bovine pineal gland tend to support the view that the pineal satisfies certain criteria for physiological function, and further investigation into the nature of this function is necessary.

This research was aided in part by grant *B*940 from the National Institute of Neurological Diseases and Blindness and in part by grant *M*-1204 from the National Institutes of Mental Health. We are indebted to Dr. D. Howie, pathologist at the Fairfield State Hospital, for autopsy material, and to Dr. V. L. Loosanoff, U.S. Fish and Wildlife Service, Milford, Conn., for supplying us with the *Venus mercenaria*.

NICHOLAS J. GIARMAN
DANIEL X. FREEDMAN
Departments of Psychiatry and Pharmacology,
Yale University School of Medicine,
New Haven, Connecticut.
LUIS PICARD-AMI
Fairfield State Hospital,
Newtown, Connecticut.

[1] Giarman, N. J., and Day, S. M., *Biochem. Pharmacol.*, 1, 235 (1958)
[2] Giarman, N. J., Day, S. M., and Pepeu, G., *Fed. Proc.*, 18, 394 (1959).
[3] Amin, A. H., Crawford, T. B. B., and Gaddum, J. H., *J. Physiol.*, 126 (1954).
[4] Twarog, B. M., and Page, L. H., *Amer. J. Physiol.*, 175, 157 (1953).
[5] Paasonen, M. K., and Giarman, N. J., *Arch. Internat. Pharmacodyn.*, 114, 189 (1958).
[6] Paasonen, M. K., Maclean, P. D., and Giarman, N. J., *J. Neurochem.*, 1, 326 (1957).
[7] Costa, E., and Aprison, M. H., *J. Nerv. Men. Dis.*, 126, 284 (1958).
[8] Kitay, J. I., and Altschule, M. D., "The Pineal Gland" (Harvard University Press, Cambridge, Mass., 1954).
[9] Altschule, M. D., *N. Eng. J. Med.*, 257, 919 (1957).
[10] Farrell, G., Koletsky, S., and Lapham, L. W., *Fed. Proc.*, 18, 44 (1959).
[11] Lerner, A. B., Case, J. D., Takahashi, Y., Lee, T. H., and Mori, W., *J. Amer. Chem. Soc.*, 80, 2587 (1958).
[12] Wurtman, R. J., Altschule, M. D., and Holmgren, U., *Amer. J. Physiol.*, 197, 108 (1959).

HÆMATOLOGY

Evidence for a New Allele in the Kidd Blood Group System in Indians of Northern Mato Grosso, Brazil

A NEW phenotype in the Kidd blood group system, *Jk* (*a–b–*), has recently been recognized in a Filipina of Spanish and Chinese ancestry[1]. This phenotype is extremely rare in Whites and Negroes; its incidence in Asian people or their descendants has not as yet been determined. We recently had the opportunity to study the blood groups of a number of Brazilian Indians indigenous to the northern part of Mato Grosso in the region of the headwaters of the Upper Xingu River. Because of the peculiar geographical features defining this area, these Indians live in virtual isolation, and because of tribal customs, marriage is exclusively between first cousins. The present communication reports the frequency of the phenotype *Jk* (*a–b–*) and evidence for a new allele, *Jk*, in a sample of this population.

Venepuncture specimens were collected in sterile vacuum tubes containing acid–citrate–dextrose solution, and shipped by air to New York, where the testing was performed 3–5 weeks after the initial collection. It was possible to obtain 88 specimens from representatives of four linguistic groups. The names of these groups and the distribution of the phenotypes of the Kidd system are shown in Table 1. Because of the heretofore reported rarity of the phenotype *Jk* (*a–b–*), detailed re-testing was performed on the five specimens found to be *Jk* (*a–b–*). The cells were tested with three different anti-Jk^a sera, two anti-Jk^b sera, and with the serum of Mrs. Santos, the patient reported by Pinkerton *et al.*[1]. In all instances negative results were obtained.

Table 1. DISTRIBUTION OF PHENOTYPES OF THE KIDD BLOOD GROUP SYSTEM IN 88 INDIANS OF MATO GROSSO

Name of tribe	Number tested	Phenotypes			
		Jk ($a-b-$)	*Jk* ($a+b-$)	*Jk* ($a-b+$)	*Jk* ($a+b+$)
Carib	13	2	7	2	2
Arawak	19	0	4	7	8
Tupi	43	1	19	10	13
Trumai	13	2	4	6	1
Total	88	5	34	25	24

Calculations of gene frequencies based upon the hypothesis that only two alleles exist in the Kidd system yielded results that were internally inconsistent. The results were then recalculated on the assumption that three alleles exist, using Bernstein's method as described by Mourant[2]. The agreement between the observed and theoretical frequencies shown in Table 2 provides further evidence for the presence of a third gene, *Jk*, in the Kidd blood group system. It appears likely that this gene, though rare in Caucasians, is common in Asians and their descendants.

Table 2. PHENOTYPE AND GENE FREQUENCIES

	Phenotypes (per cent)				Genes (per cent)		
	Jk ($a-b-$)	*Jk* ($a+b-$)	*Jk* ($a-b+$)	*Jk* ($a+b+$)	*Jk*	Jk^a	Jk^b
Observed	5 68	33 64	28 41	27 27	0 2453	0 4185	0 3362
Expected	5 55	38 05	27 80	28 14			

This work was performed in part during tenure of one of us (R. T. S.) as Visiting Fulbright Lecturer, University of Bahia School of Medicine, Salvador, Bahia, Brazil.

We thank Dr. A. Cahan and Dr. F. H. Allen, jun., for the anti-sera supplied and Dr. L. C. Dunn for his critical comments. We acknowledge the co-operation of the Serviço de Proteção aos Indios, the Fundação Brazil Central, the Fulbright Commission and U.S. Information Service, U.S. Embassy, Rio de Janeiro.

RICHARD T. SILVER
Department of Medicine,
JANE M. HABER
Blood Bank,
AARON KELLNER
Department of Pathology,
New York Hospital—Cornell Medical Center.

[1] Pinkerton, F. J., Mermod, L. E., Liles, B. A., Jack, jun., J. A., and Noades, J., *Vox Sang.*, 4, 155 (1959).
[2] Mourant, A. E., "The Distribution of the Human Blood Groups", 216 (Blackwell Scientific Publications, Oxford, 1954).

Role of C'_4 in the Antiglobulin Reaction

WHEN human red cells are incubated with fresh serum containing a complement-binding blood-group antibody, they become agglutinable by an anti-'non-γ' globulin serum, that is, a serum reacting with human globulins other than γ-globulin[1-3]. In such cases the antiglobulin serum reacts with complement (C') rather than with the blood-group antibody[4].

The object of the present work was to identify more precisely the antigen and antibody concerned in this reaction: that is, the particular component of C' on one hand and the particular antiglobulin on the other.

In trying to identify the component of C' reacting with antiglobulin serum, two approaches were used. First, red cells sensitized with antibody were allowed to react with C' under conditions which permitted the formation of the complex $C'_{1,4}$ but were unfavourable to the formation of $C'_{1,4,2}$ [5,6]. Secondly, sensitized red cells were treated with some components of C' supplied from human serum and other components supplied from rabbit serum. In both sets of experiments the cells were tested with antiglobulin serum (either with anti-human globulin or anti-rabbit globulin), and with immuno-conglutinin serum (I—K) of the type described by Coombs and Coombs[7] as "I—K serum (auto-stimulation)".

In the first series of experiments, sensitized red cells (for example, $Le(a+)$ red cells incubated with inactivated anti-Le^a) were treated with de-ionized serum to which either calcium or calcium and magnesium had been added. Gandini[8] has recently published the results of similar experiments. Like Gandini we found that sensitized red cells treated at 0° C. with fresh serum containing calcium but not magnesium would react with antiglobulin serum, suggesting that the adsorption of C'_2 is not necessary for a positive antiglobulin reaction. We also carried out experiments at 37° C. and found that cells treated with de-ionized serum to which only calcium had been added reacted moderately strongly with an antiglobulin serum and weakly with an I—K serum (the positive reaction of the I—K serum could be explained by the presence of small amounts of magnesium in de-ionized serum[5]). Sensitized cells treated with serum to which calcium and magnesium had been added reacted strongly with I—K serum, but the reaction with an antiglobulin serum was also improved. This enhancement of the antiglobulin reaction suggested either that the adsorption of C'_2 enhances the adsorption of C'_4 or that C'_2 itself reacts with the antiglobulin serum. In an attempt to decide between these hypotheses, a second series of experiments was done.

For these experiments preparations containing predominantly C'_1 or C'_2 were made from human serum and rabbit serum by the method of Pillemer *et al.*[9]. Human serum containing only C'_4 was prepared by heating fresh serum to 56° C. for 30 min. and then treating it with zymosan. Rabbit serum was heated only to 52° C. for 30 min. because at higher temperatures C'_4 was destroyed; the serum was not treated with zymosan since this removes all complement activity[10].

Sensitized red cells incubated with human C'_1 alone were not agglutinated by an anti-human globulin serum; but if they were first incubated with human C'_1 or rabbit C'_1 and then incubated with human C'_4, they were agglutinated by anti-human globulin serum. Similarly, sensitized cells treated with human C'_1, then with rabbit C'_4 (and C'_3), were agglutinated by anti-rabbit globulin serum.

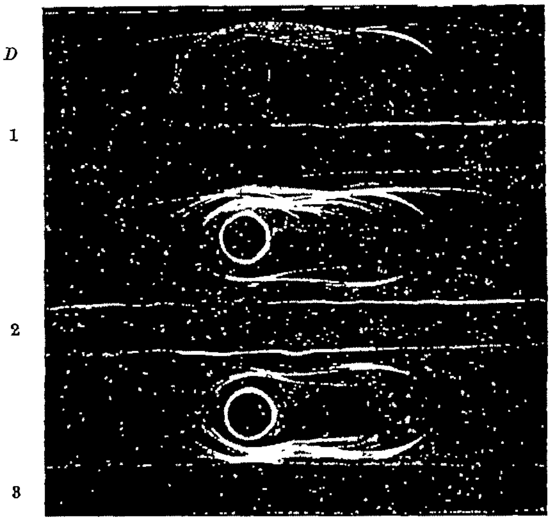


Fig. 1. Immuno-electrophoresis of normal human serum (placed in the circular cups and submitted to electrophoresis) versus anti-human globulin serum (in the longitudinal troughs 1, 2 and 3). The anti-human globulin serum was a specially selected one which only contained antibodies against α- and β-globulins (the line extending farthest to the left in the figures is due to β_2-globulin). 1, The untreated antiglobulin serum; 2, the same antiglobulin serum absorbed with 'complement-coated' cells, that is, sensitized red cells treated with human complement; 3, the same antiglobulin serum after absorption with sensitized red cells not treated with human complement; *D*, diagram of the reactions of the unabsorbed antiglobulin serum; the lines in the β_1-globulin region removed by absorption with 'complement-coated' cells are indicated by broken lines

In the case in which cells were first exposed to rabbit C'_1, then to heated, zymosan-treated, human serum, it seems clear that the only component of human complement adsorbed was C'_4, and since the cells were strongly agglutinated by anti-human globulin serum, C'_4 must be the chief and perhaps the only protein reacting with the antiglobulin serum. Nevertheless, stronger reactions with anti-human globulin serum were obtained when sensitized red cells were treated with rabbit C'_1 and C'_2 and human C'_4 than when they were treated with only rabbit C'_1 and human C'_4, so that again there is suggestive evidence that C'_2 enhances the adsorption of C'_4.

The conclusion that antiglobulin serum does not react directly with C'_1 is supported by the further observation that when sensitized red cells were incubated with fresh serum and then treated for 1 hr. at 37° C. with 0·01 M ethylenediamine tetra-acetic acid (treatment which is said[11] to remove virtually all C'_1 from the cells without removing C'_4), the cells still reacted strongly with antiglobulin serum.

That antiglobulin serum and I—K serum do not detect complement in the same state is known from the fact that the reactions of antiglobulin serum, but not I—K serum, are inhibited by the addition of whole serum to the reagent. A further difference may be shown by incubating sensitized cells with C' for varying periods, for after 4–5 hr. the cells no longer react with I—K serum but still react strongly with antiglobulin serum[10]; similar observations have been reported by Gandini[8]. Coombs *et al.*[12] and Gandini[8] have shown that C'_1, C'_4 and C'_2 are all needed for a positive I—K reaction. Incidentally, we have noted that in tests with an I—K serum it is common to observe that only a proportion of the cells are agglutinated, the appearance being that of a mixture of strongly agglutinated cells and unagglutinated cells; this may be due to the fact that the complex $C'_{1,4,2}$ decays rapidly at 37° C.[13] so that only a proportion of the cells are 'coated' with the active complex.

In order to identify the antibody in the antiglobulin serum reacting with C' adsorbed on to red cells, antiglobulin sera were examined by the technique of immuno-electrophoresis, before and after absorption with 'complement-coated' cells. Sheep red cells were sensitized with bovine antibody and then incubated with fresh human serum (previously absorbed with unsensitized sheep red cells). These 'complement-coated' cells, after being well washed, were used to absorb several different anti-human globulin sera. The sera were absorbed until they no longer agglutinated red cells which had adsorbed human C'. Such absorbed sera were found to have lost lines in the β_1 region (Fig. 1). This finding is consistent with the observation of Ellis and Gell[14], who immunized rabbits with an antigen–antibody precipitate which had been allowed to adsorb human C' and obtained a serum containing predominantly an anti-β globulin; and of Matuhasi and Usui[15], who obtained anti-β_1 and anti-α_2 following the injection of human C' adsorbed on to an antigen–antibody complex.

The conclusion of Gandini[8] that the antibody reacting with adsorbed complement is anti-α_2 may have been due to the fact that the particular preparation of α_2-globulin which he used is known to contain traces of other globulins (unpublished observations). We have found that a very pure preparation of 19*S* globulin, kindly prepared by Dr. R. A. Kekwick, containing only α_2- and γ-globulin fails completely to inhibit the reaction between antiglobulin serum and 'complement-coated' cells. On the other hand, we have succeeded in inhibiting the reaction by adding a fraction of serum containing predominantly β_1-globulin, obtained from starch-block electrophoresis.

It appears, then, that the so-called 'non-gamma globulin' Coombs reaction is a reaction between C'_4 adsorbed on to red cells and a corresponding anti-β_1 globulin.

G. C. JENKINS
MARGARET J. POLLEY
P. L. MOLLISON

Medical Research Council
Blood Transfusion Research Unit,
Postgraduate Medical School of London,
Ducane Road, London, W.12.

---

[1] Dacie, J. V., *Lancet*, ii, 954 (1951).
[2] Mollison, P. L., and Cutbush, Marie, *Lancet*, i, 1290 (1955).
[3] Cutbush, Marie, Crawford, Hal, and Mollison, P. L., *Brit. J. Hæmatol.*, 1, 410 (1955).
[4] Dacie, J. V., Crookston, J. H., and Christenson, W. N., *Brit. J. Hæmatol.*, 3, 77 (1957).
[5] Mayer, M. M., and Levine, L., *J. Immunol.*, 72, 516 (1954).
[6] Levine, L., Mayer, M., and Rapp, H. J., *J. Immunol*, 73, 435 (1954).
[7] Coombs, A. M., and Coombs, R. R. A., *J. Hygiene*, 51, 509 (1953).
[8] Gandini, E., "Bibliotheca Haematol.", Fasc. 10 (1959).
[9] Pillemer, L., Ecker, E. E., Oncley, J. L., and Cohn, E. J., *J. Exp. Med*, 74, 297 (1941).
[10] Mollison, P. L., and Polley, Margaret J., *J. Immunol.*, 3, 11 (1960).
[11] Becker, E. L., *Fed. Proc.*, 18, 557 (1959).
[12] Coombs, R. R. A., Blomfield, A. M., and Roberts, G. F., *J. Hygiene*, 48, 484 (1950).
[13] Mayer, M. M., Levine, L., Rapp, H. J, and Morncel, A. A. *J. Immunol.*, 73, 443 (1954).
[14] Ellis, H. A., and Gell, P. G. H., *Nature*, 181, 1667 (1958).
[15] Matuhasi, T., and Usui, M., *Med. and Biol.*, 46, 258 (1958).

Further Evidence for the Dual Nature of the Third Component of Complement

DURING the past two years there have been several reports of the complex nature of the third component of complement ($C'3$) based on its lysis of sensitized erythrocytes in the presence of the other components of complement[1–3], and Rapp *et al.*[4] have separated two factors from guinea pig serum which are both needed for the action that was previously associated with $C'3$. The existence of two such factors has also been suggested by the experiments described here.

Guinea pig serum heated to 56° for 20–30 min. fails to lyse sensitized erythrocytes that have already reacted with the first, second and fourth components of complement ($EAC'_{1,4,2}$) (see Table 1). This is not due to an anti-complementary action of heated serum, since it will not inhibit the lysis of $EAC'_{1,4,2}$ by whole guinea pig serum in the presence of 0·02 *M* versene. Classical methods of titrating $C'3$[5] using an $R3$ (whole serum from which $C'3$ has been removed by treatment with zymosan) indicated that only about 50 per cent of the $C'3$ in guinea pig serum is inactivated by heating, so that heated serum should be able to bring about the lysis of $EAC'_{1,4,2}$ unless some previously unknown heat-labile factor is also involved. Definite evidence for this factor was obtained by treating $EAC'_{1,4,2}$ (prepared according to the directions of Levine *et al.*[6]) for 15 min. at 37° with heated serum, centrifuging, resuspending the cells in $R3$, incubating for a further 15 min. at 37° and then determining the percentage hæmolysis. Table 1 shows that this leads to considerable hæmolysis, while treating $EAC'_{1,4,2}$ with the two reagents in the reverse order gives practically no hæmolysis.

Table 1. HÆMOLYSIS OF $EAC'_{1,4,2}$ BY GUINEA PIG SERUM REAGENTS

Reagent (in order of reaction with $EAC'_{1,4,2}$)	Percentage of hæmolysis of $EAC'_{1,4,2}$ prepared with. guinea pig serum	human serum
Heated serum + $R3$	43	37
$R3$ + heated serum	7	12
Heated serum alone	5	7
$R3$ alone	15	17
Serum + 0 02 *M* versene*	51	—
Serum + 0 02 *M* versene + heated serum*	52	—

* Reacted simultaneously with $EAC'_{1,4,2}$

Similar results are obtained by treating $EAC'_{1,4,2}$ prepared with human serum as a source of complement by the method of Leon[7] with the two reagents from guinea pig serum. However, the analogous reagents prepared from human serum will not lyse $EAC'_{1,4,2}$ prepared with either human or guinea pig serum. $R3$ from human serum can replace $R3$ from guinea pig serum, but heated human serum cannot substitute for heated guinea pig serum in these systems.

It is suggested that the term $C'3$ should be reserved for the component of complement that is adsorbed by zymosan and is comparatively heat-stable, while the new heat-labile factor not adsorbed by zymosan which reacts last in the known series of complement components should be called the fifth component of complement ($C'5$). Work on the identification of these components with Rapp's factors *a* and *b*[4] is proceeding.

Preliminary investigations of the kinetics of the reactions of $C'3$ with $EAC'_{1,4,2}$ and of $C'5$ with $EAC'_{1,4,2,3}$ suggest that the first reaction is a fast one and the complex $EAC'_{1,4,2,3}$ loses its reactivity with $C'5$ fairly rapidly at 37°, while the second reaction involving $C'5$ and leading to hæmolysis is a comparatively slow one. This is in apparent conflict with Rapp's demonstration of a short lag in the hæmolysis of $EAC'_{1,4,2}$ by versene-treated guinea pig serum[1] (containing $C'3$ and $C'5$), which suggests that the earlier step is rate limiting. This discrepancy would be resolved if the reaction of $C'5$ with the complex $EAC'_{1,4,2,3}$ could be shown[7] to be slower than the lytic reaction of the sensitized erythrocyte which has already reacted with all five components of complement.

The helpful and stimulating interest of Prof. A. Wormall is most gratefully acknowledged.

J. D. Hawkins

Department of Biochemistry,
Medical College of St. Bartholomew's Hospital,
London, E.C.1.

[1] Rapp, H. J., *Science*, 127, 234 (1958).

[2] Amiraian, K., Plescia, O. J., Cavallo, G., and Heidelberger, M., *Science*, 127, 239 (1958).

[3] Arday, F. E., Pillemer, L., and Lepow, I. H., *J. Immunol.*, 82, 458 (1959).

[4] Rapp, H. J., Simms, M. E., and Borsos, T., *Proc. Soc. Exp. Biol. Med.*, 100, 730 (1959).

[5] Bier, O. G., Leyton, G., Mayer, M. M., and Heidelberger, M., *J. Exp. Med.*, 81, 449 (1945).

[6] Levine, L., Mayer, M. M., and Rapp, H. J., *J. Immunol.*, 73, 435 (1954).

[7] Leon, M. A., *J. Exp. Med.*, 105, 403 (1957).

Hæmoglobin Content of the Larvæ of *Tendipes f.l. plumosus* L. from Various Levels of Bed Sediment

In previous work[1,2] it was shown that the amount of hæmoglobin in the larvæ of *Tendipes f.l. plumosus* varies according to the amount of dissolved oxygen present. However, the results obtained cannot be considered to be particularly reliable since at various seasons the larvæ are at various stages of development, and this may have some effect on the hæmoglobin content.

In order, therefore, to prove that the amount of hæmoglobin depends on the oxygen content of the environment, I tested for hæmoglobin content larvæ from various levels of bed sediment at the same period, taking into consideration the age of the larvæ. If the amount of dissolved oxygen is larger in larvæ from the surface layer, in which oxygen content is without doubt greater than in the deeper layers, then the amount of hæmoglobin should be less in larvæ from that layer than in larvæ from deeper layers.

Tendipes f.l. plumosus larvæ were collected for analysis from the bed of the Ordynacki pond in Dojlidy (a suburb of Białystok). Specimens were taken on the day when the pond had been emptied; thus it was possible to collect them and to calculate the exact depth of the strata from which they were taken. The larvæ were collected from two layers: from a 6-cm. surface layer and from a layer 10 cm. below it. The hæmoglobin content was determined by the method used in the previous studies[3]. The age of the larvæ was estimated by measuring the size of their heads[4].

Table 1. Hæmoglobin Content in the Larvæ of *Tendipes f.l. plumosus* L. from Different Layers of Sediment on the Bed of the Ordynacki Pond. Dry Mass (per cent)

Position No.	Surface layer (6 cm. deep)	Layer 10 cm. deeper
1	8·2	27·5
2	8·0	28·3
3	3·1	28·0
4	10·1	26·5
5	11·6	28·3
Average	8·2	26·7

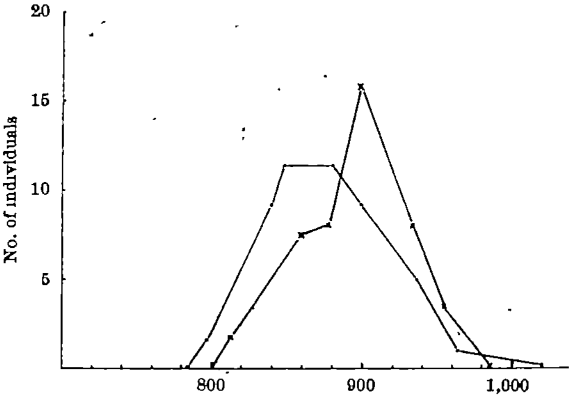


Fig. 1. Size of head of the larvæ of *Tendipes f.l. plumosus* L. .—.—.—, Surface layer (6 cm.); ×—×—, layer 10 cm. deeper

As a result of these studies it was found that the larvæ of *Tendipes f.l. plumosus* from the 6-cm. surface layer and those from the layer 10 cm. deeper were in the fourth stage of development (Fig. 1), despite the fact that the body measurements and weight of dry mass of one larva from the deeper layer are greater[5]. As will be seen from Table 1 there is a difference in the amount of hæmoglobin found in larvæ from the two layers of bed sediment. In the superficial layer the hæmoglobin content averaged 8·2 per cent of dry mass, whereas in the deeper layer of 10 cm. the hæmoglobin content of the larvæ varied, the average being 26·7 per cent. There is no doubt but that in the 6-cm. surface layer the oxygen content is much greater than that of the deeper layer. The fact that there is more hæmoglobin in the larvæ from the deeper layer is due to the smaller amount of oxygen there. It is characteristic that in that part of Rajgrodzkie Lake where there is least oxygen, not only is the hæmoglobin content highest and the weight of one of the larvæ heaviest but also that there is a greater concentration of larvæ found at that depth[6].

B. Czeczuga

Biology Laboratory,
Białystok Medical Academy,
Białystok.

[1] Czeczuga, B., *Bull. de L'Acad. Polon. Sci.*, 7, 363 (1959).

[2] Czeczuga, B., *Polskie Arch. Hydrobiol.* (in the press).

[3] Czeczuga, B., *Roczn. Akad. Med. w. Bialymstoku*, 4, 148 (1958)

[4] Konstantinow, A. S., *Wsiesojuzn. Nauczn.-Issled. Inst. Oziorn i Recz. Rybn. Choz. Trudy Sarat.otd.*, 5, 3 (1958) (in Russian).

[5] Czeczuga, B., *Bull. de L'Acad. Polon. Sci.*, 8, 105 (1960).

[6] Czeczuga, B., *Ekolgia Polska*, B, 5, 323 (1959).

RADIOBIOLOGY

Removal of Strontium from Milk

The importance of milk as a dietary source of calcium and other important nutrients makes it desirable to develop methods for use in removing radiostrontium from milk in the event that the concentration of the radioisotopes of strontium in this food should become a health hazard. Migicovsky[1] has

Table 1. EFFECT OF BONE COLUMN TREATMENT ON REMOVAL OF STRONTIUM-85 AND COMPOSITION OF MILK. (COLUMNS APPROXIMATELY 12–14 CM. × 1·8 CM.)

Bone	Amount bone (gm.) per quart milk	Calcium (m.equiv./l.)	Sodium (m.equiv./l.)	Potassium (m.equiv./l.)	Phosphorus (mgm. per cent)	Strontium-85 removed (per cent)
Control milk		55	24	39	88	
Anorganic bone treated with 4 *N* calcium chloride	25	51	21	37	89	57
Fat-free bone treated with 8 *N* potassium hydroxide	33	34	21	38	71	75
Fat-free bone treated with 4 *N* calcium chloride and 8 *N* potassium hydroxide	33	34	21	37	60	70

employed a synthetic resin in the mixed calcium, potassium, and sodium forms to remove substantial amounts of the radioisotopes of strontium and cæsium from contaminated milk. A large amount of resin to the volume of milk treated is required by this method.

Bone, owing to the fact that it contains as its mineral phase crystals of apatite, rapidly sequesters strontium ions from fluids *in vivo* and *in vitro*[2]. This property of bone has been utilized to develop a simple process for the removal of radiostrontium from milk. Various methods used in preparing bone for use have been observed markedly to affect the efficiency of the material in taking up strontium. The following have been found to be more effective than other forms of apatites: anorganic bone prepared by removal of proteins by extraction of bone with ethylene diamine[3]; fat-free bone prepared by extraction of lipids with a 50 per cent mixture of alcohol and ether; anorganic bone or fat-free bone treated with 4 *N* calcium chloride solution and the same materials treated with 4 *N* calcium chloride solution followed by 8 *N* potassium hydroxide solution. Excesses of each of the latter solutions were removed by washing the solids with water. Table 1 presents data demonstrating the efficiency of columns of pulverized modified bone (40–60 mesh) in the removal of strontium-85 added to milk. Analyses of milk before and after treatment are also given. Anorganic bone treatment produces the least alteration in milk composition and appears efficient in the removal of added strontium-85. Fat-free bone further modified, as indicated in Table 1, also has a marked ability to remove radiostrontium from milk but produces more alteration in the ionic composition of milk than anorganic bone.

10 ml. of 4 *N* calcium chloride solution will remove the bulk of the radiostrontium picked up by 10 grams of bone from milk. Potassium hydroxide does not improve the regeneration of anorganic bone column treated with calcium chloride, but it almost doubles the regeneration of a fat-free bone previously treated with calcium chloride.

The effect of treating fat-free bone with potassium hydroxide and/or calcium chloride on the efficiency of a column in removing strontium-85 added to a quart of milk is shown in Table 2. In each trial a constant flow-rate of 2 ml. per min. was maintained. As indicated a single column of modified fat-free bone can be regenerated repeatedly and is most efficient after combined treatment with calcium chloride and potassium hydroxide solutions. Anorganic bone can be repeatedly reactivated and re-used after calcium chloride treatment alone. The calcium content of milk when altered can be re-adjusted, if desired, by calcium additives. A taste panel has not reported changes in flavour of the treated milk. Greater efficiency in removal of radiostrontium by these materials should be obtained with longer columns.

Table 2. REMOVAL OF ADDED STRONTIUM-85 FROM MILK WITH A REGENERATED FAT-FREE BONE COLUMN (15 CM × 1 CM. DIMENSIONS)

Trial	Column* treatment	Percentage activity removed from milk (per quart)
1	8 *N* Potassium hydroxide	34
2	4 *N* Calcium chloride	23
3	4 *N* Calcium chloride 8 *N* Potassium hydroxide	47
4	4 *N* Calcium chloride 8 *N* Potassium hydroxide	45
5	4 *N* Calcium chloride	25
6	4 *N* Calcium chloride 8 *N* Potassium hydroxide	39

* 50 ml. of regenerating solution per trial.

It has been demonstrated in other experiments in which a gram of solid was mixed for 10 min. with 50 ml. of milk that approximately 50 per cent of the radiostrontium was removed by fat-free bone pre-treated with potassium hydroxide or by anorganic bone.

The techniques described indicate that a simple method for the commercial treatment of milk based upon these results is practical.

LEON SINGER
W. D. ARMSTRONG

Department of Physiological Chemistry,
The Medical School,
University of Minnesota.

[1] Migicovsky, B. B., *Nature*, 184, 374 (1959).
[2] Neuman, W. F., and Neuman, M. W., "The Chemical Dynamics of Bone Mineral" (Univ. Chicago Press, 1958).
[3] Williams, J. B., and Irvine, jun., J. W., *Science*, 119, 771 (1954).

Effect of Oxygen on the Radiosensitivity of Bacteriophage in the Presence of Sulphydryl Compounds

IONIZING radiation is generally more effective in killing cells if oxygen is present at the time of irradiation[1]. In view of the variety of the organisms in which the injury appears to be associated with the genetic apparatus[2], it is surprising that no oxygen effect should be found when bacteriophage[3] and transforming principle[4] are irradiated in an aqueous suspension containing nutrient broth or other material to protect them against indirect radiation effects.

The suggestion that a hydrogen donor may be responsible for the reduced sensitivity found under anoxia has been put forward on chemical grounds[5], and a similar conclusion has been reached from an analysis of the kinetics of the effects of oxygen and nitric oxide on the radiosensitivity of bacteria[6]; but direct evidence in support of the role of a hydrogen donor in the oxygen effect in a biological system has been lacking.

Two observations have directed attention to the sulphydryl compounds in this connexion. Cysteine[7] and cysteamine[8] gave added protection to *T*2 bacteriophage, which appeared to be already fully protected by nutrient broth. In an attempt to elucidate this effect, an investigation has been made into the effect of known concentrations of oxygen and cysteamine on the radiosensitivity of bacteriophage protected from indirect action. Similar experiments have been carried out with the *T*2 *E. coli B* complex formed by the adsorption of *T*2 to the host cell.

Wild-type *T*2 bacteriophage were irradiated in aqueous suspension, diluted in nutrient broth, plated in a layer of soft agar seeded with *E. coli B* and incubated at 37° C. It was found that thiourea was more effective than nutrient broth in protecting the phage against indirect effects of irradiation, and was convenient in that it did not froth when bubbled with a gas. Thiourea was without toxic effect even at high concentration, so long as it was adequately diluted before plating. The complexes were prepared from a logarithmic phase culture of *E. coli B* which was infected at a multiplicity of about 0·02 phage per bacterium in the presence of cyanide. Phage which had not adsorbed were inactivated with antiserum. The irradiations were carried out at 30,000 rads per min. with 8-MeV. β-rays at 2° C. As both cysteine and cysteamine oxidize at *p*H 7, care was taken to see that the oxidation to the disulphide form and the resulting depletion of oxygen did not influence the results of the experiment. Samples of the suspension were placed in an irradiation vessel which had a glass filter base. To control the amount of oxygen present, either oxygen or oxygen-free nitrogen was passed through the filter so that it bubbled through the suspension. Thus anoxia was ensured by the nitrogen stream, independently of the presence of the sulphydryl compound. When oxygen was bubbled through the suspension containing cysteamine, some oxidation occurred. At the end of the irradiation, after bubbling with oxygen for a total period of about 10 min., the amount of —SH remaining was found to be more than 80 per cent of the initial concentration, as estimated by the nitroprusside method[9]. Studies of the rate of equilibration of the dissolved gases in a similar bubbling vessel indicated that the concentration of oxygen fell by a factor of 100 in 40 sec. when nitrogen was bubbled through a suspension containing oxygen. It was estimated that at this rate of equilibration, the amount of oxygen consumed in the oxidation of the cysteamine would reduce the oxygen concentration by less than 10 per cent below the equilibrium value of 2 m*M*. Thus, during the period of the irradiation, the concentration both of cysteamine and oxygen was known to lie within certain limits.

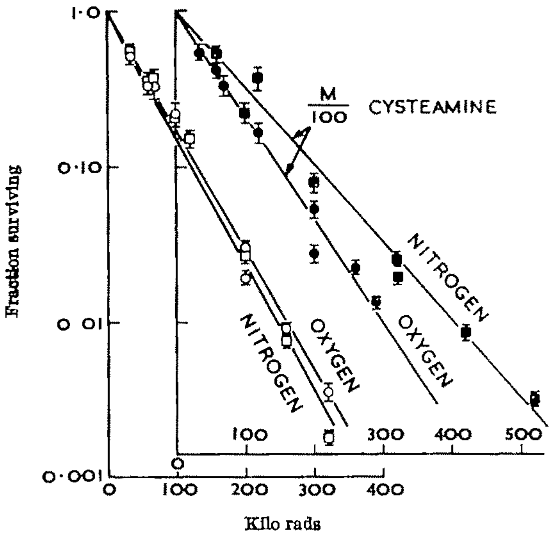


Fig. 1. Effects of 10 m*M* cysteamine and 2 m*M* oxygen on the inactivation of *T*2 phage suspended in buffer at *p*H 7 with 10 m*M* thiourea

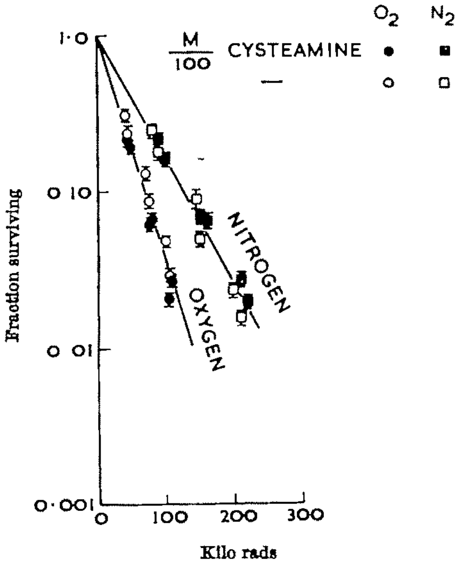


Fig. 2. Effects of 10 m*M* cysteamine and 2 m*M* oxygen on the inactivation of the *T*2–*E. coli B* mono-complex suspended in buffer at *p*H 7

The combined results of duplicate experiments are shown in Fig. 1. It is seen that the rate of inactivation of *T*2 bacteriophage protected by 10 m*M* thiourea was almost independent of the oxygen concentration. On adding cysteamine, there was a marked decrease in the inactivation rate under nitrogen, although most of the effect was abolished in oxygen. These results strongly suggest that oxygen competes very effectively for the radiation-induced injuries in the phage deoxyribonucleic acid which can be restored by the cysteamine. It seems unlikely that the protective effect of cysteamine is due to an improvement in the degree of anoxia to which the phage were subjected, as cysteamine was equally effective in sealed ampoules in the presence of sodium dithionite, which combines rapidly with oxygen at *p*H 7, while the dithionite by itself was without effect. The disulphide form cystamine was not active[8], but cysteine and cysteamine were about equally effective in causing anoxic protection.

It is of interest that after the host *E. coli B* has adsorbed *T*2 phage, the complex so formed is about twice as radiosensitive in oxygen as it is when anoxic[6,10]. As shown in Fig. 2, 10 m*M* cysteamine is without effect on the sensitivity of either the aerobic or anoxic complex. Metabolic steps are not involved in the development of the oxygen effect, since it occurs even if the adsorption takes place in the presence of cyanide.

It appears that an oxygen effect is observed when the phage deoxyribonucleic acid is in the presence of substances with labile hydrogen groups. With free phage, cysteamine or cysteine is effective, while in the case of the phage–bacterium complex, it may be that intra-cellular sulphydryl compounds or other hydrogen donors are involved. The degree of the injury sustained in an irradiation appears to depend upon competition between oxygen and the hydrogen donor[6], presumably for a carbon radical induced by radiation in the phage deoxyribonucleic acid. If this is true, the action of the hydrogen donor is to replace a hydrogen atom on the deoxyribonucleic acid which had been removed by ionization or by radical attack, thus restoring the deoxyribonucleic acid molecule to the active form. The oxygen effect observed with the free phage is smaller than that found with the complex. The explanation of this difference may lie in the difficulty which the sulphydryl compound (or oxygen) may experience in penetrating the phage head membrane and the tightly packed nucleic acid. If these substances are unable to diffuse freely over the surface of the deoxyribonucleic acid molecule, there will be reduced opportunity for reaction with a radiation-induced injury, so that a smaller oxygen effect might be expected. There is some evidence for this explanation in the finding that mature intracellular phage particles show no oxygen effect (unpublished work). If this is the correct explanation, then it is to be expected that transforming principle would show an oxygen effect in the presence of a sulphydryl compound and that the effect might be larger because of greater accessibility to the nucleic acid.

In summary, the reason why oxygen is without effect on the X-ray inactivation of bacteriophage in protective suspension lies in the absence of a suitable hydrogen donor such as a sulphydryl compound. A second factor is that some compounds may experience difficulty in penetrating into the compact structure of the phage head. The oxygen effect on the X-ray inactivation of the complex is presumably a reflexion of the competition between molecular oxygen and intra-cellular hydrogen donors, such as sulphydryl compounds, for the radicals induced by radiation in the phage nucleic acid.

I acknowledge valuable discussions with Dr. N. Symonds and Dr. H. Marcovich, and the assistance of Mrs. Elspeth van Durren. I am indebted to D. K. Bewley and G. Harding, who carried out the irradiation.

P. Howard-Flanders*

Medical Research Council
Experimental Radiopathology Research Unit,
Hammersmith Hospital,
London, W.12.

---

* Present address: Yale University School of Medicine, New Haven, Connecticut, U.S.A.

[1] Gray, L. H., *Rad. Research*, Supp., 1, 73 (1959).

[2] Gray, L. H., Ciba Found. Symp. Ionizing Radiations and Cell Metabolism, 225 (1956).

[3] Hewett, R. B., and Read, J., *Brit. J. Radiol.*, 23, 416 (1950).

[4] Ephrussi-Taylor, H., and Latarjet, R., *Biochim. Biophys. Acta*, 16, 183 (1955).

[5] Bacq, Z. M., and Alexander, P., "Fundamentals of Radiobiology", 312, 131 (Butterworth, London, 1955). Scholes, G., and Weiss, J., *Rad. Research*, Supp. 1, 177 (1959).

[6] Howard-Flanders, P., "Adv. Biol. and Med. Phys." 6, 553 (1958).

[7] Watson, J. D., *J. Bact.*, 63, 473 (1952).

[8] Marcovich, H., *Rad. Research*, 9, 149 (1958).

[9] Grunert, R. R., and Phillips, P. H., *Arch. Biochem.*, 30, 217 (1951).

[10] Van Dyke, J. G., *Biochem. Biophys., Res. Comm.*, 1, 54 (1959).

Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in Rats receiving an Acute Whole-Body Dose of X-Rays

It has recently been shown that ribonucleic and deoxyribonucleic acids injected in rats and mice can markedly influence the post-irradiation survival[1-3]; but the exact nature of the mechanism responsible for this beneficial effect is at present unknown. An attempt has been made to give a partial answer to this problem by studying the restorative effect of a ribonucleic acid extracted from yeast, as well as the products of a progressive degradation by controlled alkaline hydrolysis of the same substance, upon rats which had received a single whole-body dose of X-rays. The selected irradiation dose corresponded approximately to the *LD*85(30) for the control animals the death of which was due to acute damage caused to hæmatopoietic tissues. The 30-day survival of the treated animals was taken as a criterion of effectiveness.

The rats used in the experiments were 4 months old male albinos, of an inbred strain raised in the Institute, the body-weight of which varied from 140 to 150 gm. The animals were left un-fed overnight, then irradiated in groups of 4 contained in a 'Lucite' box which was revolved at 2·5 r.p.m. The X-ray unit was a G.E. Maxitron operated at 250 kVp. and 25 m.amp., equipped with a beryllium end-window and additional 0·25 mm. copper + 1 mm. aluminium filters. The half-value layer was 1·15 mm. copper. At a target distance of 80 cm., the delivery-rate averaged 40 r./min. as measured in air with a Victoreen Radocon dosimeter.

The trial solutions, adjusted to a *p*H of 6·5–7, were injected intraperitoneally at a constant volume of 2 ml. per animal. Their tonicity was determined by the freezing point depression method and equalized by the addition of appropriate amounts of sodium chloride with the tonicity of sodium chloride 150 m*M*. 2 ml. of this latter solution were injected into each animal of the control series. 24 hr. after the irradiation, the rats were given an unlimited standard diet. The subsequent mortality-rate and body-weight modification were checked at daily intervals during the 30-day period following the X-ray exposure. Dead animals were subjected to autopsy, and the survivors have been kept for a study of long-term effects.

In the first series of experiments, a dose of 100 mgm. of sodium ribonucleate, corresponding to 72 mgm. of pure ribonucleic acid, was injected within 15 min. of irradiation. Table 1 (rows *A* and *B*) shows the results observed at different X-ray levels between 450 to 550 r. It is clear that the treatment reduces the subsequent mortality-rate. Probit analysis[4] of the results allows the following regression equations to be calculated: $Y = -57{\cdot}05 + 23{\cdot}05 \log_{10}$ r. for the treated animals, and $Y = -41{\cdot}82 + 17{\cdot}72 \log_{10}$ r. for the controls, in which Y is the probit of the percentage of 30-day mortality and r. the X-ray dose in roentgens. There is no significant difference between the regression coefficients. The *LD*50(30) derived from the previous equations are respectively 492·3 r. (5 per cent fiducial limits 504 and 481·5) and 438·7 (5 per cent fiducial limits 451·2 and 427). They differ very significantly from one another ($P < 0{\cdot}001$). Calculation of the corresponding dose-reduction factor gives a value of 1·12. It is noteworthy that a dose-reduction factor of the same order of magnitude,

Table 1. Effects of Injection of Yeast Ribonucleic Acid on the 30-day Mortality of Rats

	X-ray dose (r.)	Number of rats: Per group	Number of rats: Total	Mortality at 30 days (per cent): Per group	Mortality at 30 days (per cent): Total
A. Control series* injected with 2 ml. of saline	550	20	20	100	100
	500	20, 20, 20 20, 20, 20 20, 24, 20	184	85, 80, 75 75, 70, 95 100, 70·8, 85	81·5
	450	10, 12, 20, 20	62	50, 75 70, 75	69·4
	400	20, 20	40	10, 25	17·5
B. Sodium ribonucleic acid (Merck)† injected at a dose of 100 mgm. in 2 ml. saline per animal within 15 min. of irradiation	550	20, 12, 12	44	85, 100, 95	90·9
	500	20, 20 20, 8	68	50, 45 65, 37·5	51·5
	450	20 20	40	25 15	20
C. Sodium ribonucleic acid (Merck)† injected at a dose of 100 mgm. in 2 ml. saline within 15 min. prior to irradiation	500	20 20 20	60	50 60 80	63·3
D. Ribonucleic acid (BDH)‡ injected at a dose of 80 mgm. in 2 ml. saline within 15 min. of irradiation	500	20 20	40	50 50	50

* At each level of irradiation (excepted, 550 r.), the control series include groups injected with saline solution either before or after irradiation. As statistical examination of their mortality after 30 days failed to reveal any difference between the pre- and post-treated groups, it was considered feasible to combine them in a single control group, valid for comparison with the ribonucleic acid pre- and post-injected animals.

† Obtained from Merck Co., Darmstadt, Germany, as the sodium salt of yeast ribonucleic acid. Following the method of Ogur and Rosen (ref. 6) the product has been found to contain 72 per cent of pure ribonucleic acid and 2 per cent of deoxyribonucleic acid. Traces of protein material have been detected.

‡ Ribonucleic acid from yeast, British Drug Houses, Ltd., England. It is converted into its sodium salt by addition of appropriate amount of sodium bicarbonate at 0° C. and injected at a dose corresponding to the ribonucleic acid content of the 'Merck' preparation Both these products, of different commercial origin, seem equally effective

1·17, has been reported for the protective effect of cysteamine on the hæmatopoietic tissues of the same strain of rats[5].

While demonstrating the restorative effects of ribonucleic acid, the above results do not by any means exclude the possibility that this product can also exert a protecting action. To elucidate this point 3 groups of 20 rats were first injected with a similar dose of 100 mgm. sodium ribonucleic acid, then irradiated with 500 r. 15 min. afterwards (Table 1 row *C*). Comparison of their 30-day mortality with those of animals injected after irradiation shows the post-irradiation treatment to be at least as effective as the pre-irradiation treatment. A χ^2 test, in the formula of which the Yates correction of continuity was incorporated[9], failed to reveal any significant difference between these two treatments (calculated $P > 0{\cdot}1$). Therefore, it seems very likely that ribonucleic acid, injected intraperitoneally, acts purely as a recovery factor, without any additional protective effects.

Further experiments were conducted to determine whether the effectiveness of ribonucleic acid is retained after partial degradation of the molecule into nucleotides by controlled alkaline hydrolysis. Two preparations were tested. The first, in which intermediate products were still abundant, was obtained under very mild conditions, while the second consisted of an almost pure mixture of mononucleotides. A comparative inspection of Tables 1 and 2 shows that both these hydrolysates are equally as effective as the native ribonucleic acid and leads to the conclusion that the recovery effect of this substance does not depend upon the integrity of its molecular structure.

Table 2. Decrease of the 30-day Mortality of Rats irradiated with 500 r. by Injection of 2 ml. of Alkaline Hydrolysate of Ribonucleic Acid*

Composition of hydrolysates† (per cent)		Moment of injection	Number of rats: Per group	Number of rats: Total	Mortality at 30 days (per cent): Per group	Mortality at 30 days (per cent): Total
I Oligonucleotides Mononucleotides Residual ribonucleic acid	70 28 0	Within 15 min. of irradiation	20 20	40	30 30	30
		Within 15 min. prior to irradiation	20 20	40	45 45	45
II Oligonucleotides Mononucleotides: Residual ribonucleic acid:	5·7 87·3 0	Within 15 min. of irradiation	20 20	40	50 50	50
III Control series				184		81·5

* Solutions were made up so that their content in nucleotides corresponded to a concentration of 50 mgm./ml. of non-depolymerized 'Merck' sodium ribonucleic acid

† Hydrolysate I was prepared by incubating 1 part of sodium ribonucleic acid 'Merck' with 8 parts of 0·33 *N* sodium hydroxide for 16 hr. at 24° C. Hydrolysate II was prepared according to the method of Davidson and Smellie (ref. 7). Further acidification by perchloric or trichloracetic acid did not give any precipitation in either solution, but caused a slight opalescence due to a trace of deoxyribonucleic acid. A non-mononucleotide fraction was, however, still present and was demonstrated by paper chromatography. The relative concentration of the non-mononucleotide material and the mononucleotide mixture was afterwards analysed by the method of Smith and Allen (ref. 8).

The precise action of ribonucleic acid and its biochemical bases are under investigation at the moment and a full account of this work will be published elsewhere.

J. Maisin
P. Dumont*
A. Dunjic†

Department of Radiobiology,
Cancer Institute,
University of Louvain,
Belgium.

* Research Fellow of the Institut interuniversitaire des Sciences Nucléaires.

† Research Fellow of the Department of Radiobiology, Cancer Institute.

[1] Detre, K. D., and Finch, S. C., *Science*, 128, 656 (1958).
[2] Panjevac, B., and Ristic, G., *Bull. Inst. Nucl. Sci. Boris Kidrich*, 8, 159 (1958).
[3] Maisin, J., Dunjic, A., Maldague, P., and Deckers-Passau, L., *C.R. Soc. Biol.*, 153, 379 (1959)
[4] Finney, D. J., "Probit Analysis" (Cambridge University Press, 1952)
[5] Dunjic, A., Maisin, H., and Maldague, P., *Arch. Intern. Physiol.*, 66, 22 (1958).
[6] Ogur, M., and Rosen, G., *Arch. Biochem.*, 25, 262 (1950).
[7] Davidson, J. N., and Smellie, R. M., *Biochem. J.*, 52, 594 (1952).
[8] Smith, K. C., and Allen, F. W., *J. Amer. Chem. Soc.*, 75, 2131 (1953).
[9] Siegel, S., "Nonparametric Statistics" (McGraw-Hill Book Co., Inc., New York, 1956).

BIOLOGY

The Redpoll in New Zealand: Interbreeding Sub-species

Since the opportunity of studying an animal population in which interbreeding and genetical mixing between two hitherto good and mainly allopatric sub-species is taking place must be relatively uncommon, it may be of interest to report on the discovery and preliminary investigation of a situation of this kind occurring in New Zealand.

The redpoll (F. Fringillidae : Aves) was introduced into various parts of New Zealand from about 1862 onwards[1]. The taxonomic status of the introduced birds was originally determined only to the species-level : *Carduelis flammea* (L.) (the present generally accepted nomenclature is used here, following Witherby *et al.*, 1938, "The Handbook of British Birds"). In 1953 Westerskov[2], on the basis of wing and bill measurements and details of plumage coloration of 36 skins collected in New Zealand and some adjacent islands, concluded that only one sub-species, *C.f. cabaret* (P. L. S. Mull.), was present. In the course, however, of an investigation of the ecology of the redpoll and other introduced fringillid species in Canterbury, New Zealand, it has been found necessary to modify Westerskov's conclusion. It appears that at least one other sub-species, notably *C.f. flammea* (L.), is present in the New Zealand populations.

The distinguishing features of the two sub-species *C.f. flammea* and *C.f. cabaret* are given in Table 1.

Table 1. DISTINGUISHING FEATURES OF THE SUB-SPECIES *C. f. flammea* AND *C. f. cabaret*

(After Westerskov, 1953, following Salomonsen, 1928, and Witherby *et al.*, 1938)

	Wing length (mm.)		Bill length (mm.)		General plumage colour	Wing-bar	Body-size
	M	F	M	F			
flammea	71–79	69–76	8–10	7·7–9·1	Paler	Conspicuous whitish	Slightly larger
cabaret	67–73	63–69	8–10	8–9·5	Darker	Inconspicuous buff	Slightly smaller

Observations made on approximately 170 living birds are summarized in the form of frequency-distribution curves for male and female wing-lengths, Fig. 1. The symbols *W* and *p* are given to show the occurrence, at various wing-lengths, of white wing-bar and pale plumage respectively (that is, the occurrence of *flammea*-type plumage characteristics). Reference to bill-length and body-size has been omitted, since nothing significant on these has been obtained in the present sample.

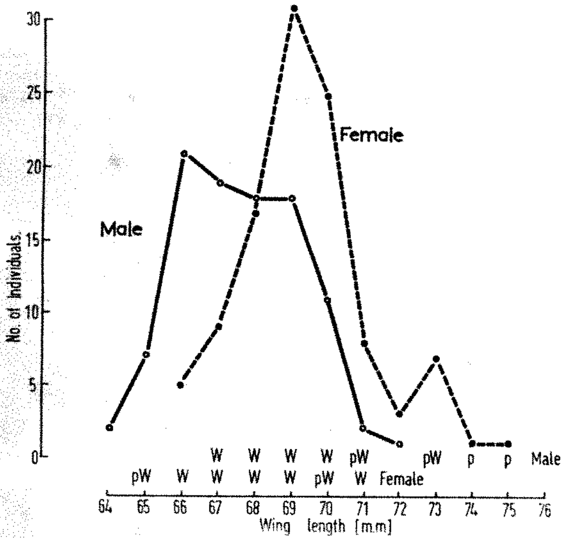


Fig. 1 Redpolls' wing-lengths – frequency distribution curves. *W*, Whitish wing-bar ; *p*, pale plumage

On comparison of Fig. 1 with Table 1, the following points will be noted : (1) The occurrence of individuals above the upper limits of the *cabaret* range of wing-lengths, for both sexes. (2) The absence of individuals in the higher portions of the *flammea* range. (3) The shift of the centres of gravity of the areas enclosed by the curves above the vicinity of the mean for *cabaret*. (4) The occurrence of *flammea*-type plumage characteristics (denoted by *W* and *p*) below the wing-length range for that sub-species.

From the conjunction of these features it seems apparent : (*a*) that the bulk of the population is composed of *cabaret*-type individuals ; (*b*) that a proportion of *flammea*-type individuals, perhaps 10–15 per cent of the population, is present ; (*c*) that the two types are interbreeding, resulting in the mixing of characteristics, for example, the occurrence of *W* and *p* with short wings, etc. (On several occasions, however, small groups of *flammea*-type individuals have been taken together. This suggests that there may still be some tendency to segregation.)

An explanation of the observed deviations from the typical *cabaret* characteristics, alternative to the assumption that one of the larger sub-species is present, may be mentioned in order to be dismissed. The alternative explanation is that the observed deviations from *cabaret* characteristics may be due to an evolutionary change within a pure *cabaret* population. It must be pointed out that this change must have been extremely rapid (the New Zealand populations have been isolated for less than a century) ; that selection pressure must have been low during this time of generally rapid expansion of the populations ; that the direction of the changes, increased wing-length and paler coloration, are the opposite of what would be expected, in an environment on the whole warmer and not less humid than the original, according to Bergmann's and Gloger's rules ; that the simultaneous evolution of several of the characteristics of another sub-species is in any event unlikely, much more so in the present case when the previously mentioned points are considered.

It may be noted that another of the introduced bird populations of New Zealand, that of the yellowhammer, *Emberiza citrinella* L., is now thought to be a mixed population of more than one sub-species, where previously it had been considered that only the British sub-species was present in New Zealand[3].

A number of points still await clarification. It is not yet certain, for example, that the large sub-species is actually *flammea*. The uncertainty arises out of the mixing of characteristics due to interbreeding. This sub-species seems much the most likely component of the present mixed population on the grounds of the observed characteristics (other possible sub-species are even larger than *flammea*—their absence cannot at present be asserted, of course, and in fact slight evidence has been obtained that a very few individuals of one or more or these larger sub-species may be present) and the fact that it is the only sub-species apart from *cabaret* which is found regularly and in appreciable numbers in Britain, the presumed place of origin of the New Zealand populations. (This last presumption is of course very much open to doubt.) It would be interesting, also, to ascertain what were the original proportions of pure *cabaret* and pure *flammea*, if that could be done. The present distribution of the various types will be investigated—this may yield information as to possible modification of the presumed previously existing geographical, behavioural and ecological segregating mechanisms between the two subspecies.

This investigation is continuing, and results will be reported and discussed in full elsewhere.

DAVID STENHOUSE

Agricultural Zoology Department,
Lincoln College,
University of New Zealand,
Christchurch.

[1] Thomson, G. M., "The Naturalization of Animals and Plants in New Zealand" (Cambridge University Press, 1922).

[2] Westerskov, K., *Notornis*, **5**, 189 (1953).

[3] Harrison, J. M., *Bull. Brit. Orn. Club*, **74**, 9 (1954); **75**, 1 (1955) (quoted in *Notornis*, **6** (6), 176 (1955)).

Yolk Formation in Oocytes of *Patella coerulea* L. and *Aplysia depilans* L. as observed in the Electron Microscope

ELECTRON microscope research on vitellogenesis has so far been mainly concerned with the identification of the precursors, or cellular constituents, from which the yolk formation begins[1-5]. The origin of the yolk and further stages in its formation in oocytes of *Patella coerulea* and *Aplysia depilans* are described here. Small fragments of the female gonads were fixed in a 1 per cent solution of osmium tetroxide at $pH = 7 \cdot 4$ for 1 hr. Other technical details are reported in a previous paper[6]. Preparations and observations were made at the Centre for Electron Microscopy at the University of Padua with a Siemens Elmiskop I*a* apparatus.

In the oocytes of *Patella coerulea*, at the beginning of vitellogenesis, it is possible to observe a reticulum of filaments about 200 Å. thick, which carry dark granulations about 300 Å. in diameter (Fig. 1). Some reticular cavities show a dark content, which gradually increases with the growth of the oocytes, and gives rise to well-formed proteic yolk globules showing an oval form (Fig. 2). Isolated or clustered granulations on their surface appear to enter the developing globules (Fig. 2). They are totally absent when the globules have reached their full development and only the filaments remain (Fig. 3). Previous experiments with ribonuclease showed that granulations are formed mostly by a ribonucleic complex[7].

In the oocyte of *Aplysia depilans*, vitellogenesis starts with the transformation of Golgi bodies or dictyosomes into small globules. They are surrounded, at a given stage, by a semi-lunar structure, which is formed by particles (Fig. 4) of about 950 Å. in diameter. Each particle shows a central clear zone and a peripheral zone which is composed of dark granulations with a diameter of about 300 Å. Many particles strictly adhere to the surface of the globules and it appears that granulations penetrate them (Fig. 4). When the globules are more developed, they show another semi-lunar structure, which is composed of a very dense reticulum (Fig. 5). Some of the biggest globules show some vacuoles (Fig. 5), the presence of which confirms a liquefaction process, which has been previously described[8-10]. Each globule then divides into very minute granules (Fig. 6), which find a place in the cavities (Fig. 7) of the surrounding reticulum. They finally aggregate to give origin to the definitive yolk (Fig. 7).

The electron microscope results give a fair explanation of previous optical microscope observations, which were made both in *Patella coerulea*[11] and in *Aplysia depilans*[8,9]. A very fine alveolar structure of the cytoplasm was observed in the former species along with variations in basophily, and a transformation of dictyosomes into yolk globules was described in the latter. This transformation appeared to be followed by a considerable growth of the globules, which divide to give rise to the smaller globules. Dictyosomes must thus be considered as true precursors in *Aplysia depilans*; no precursors in a strict

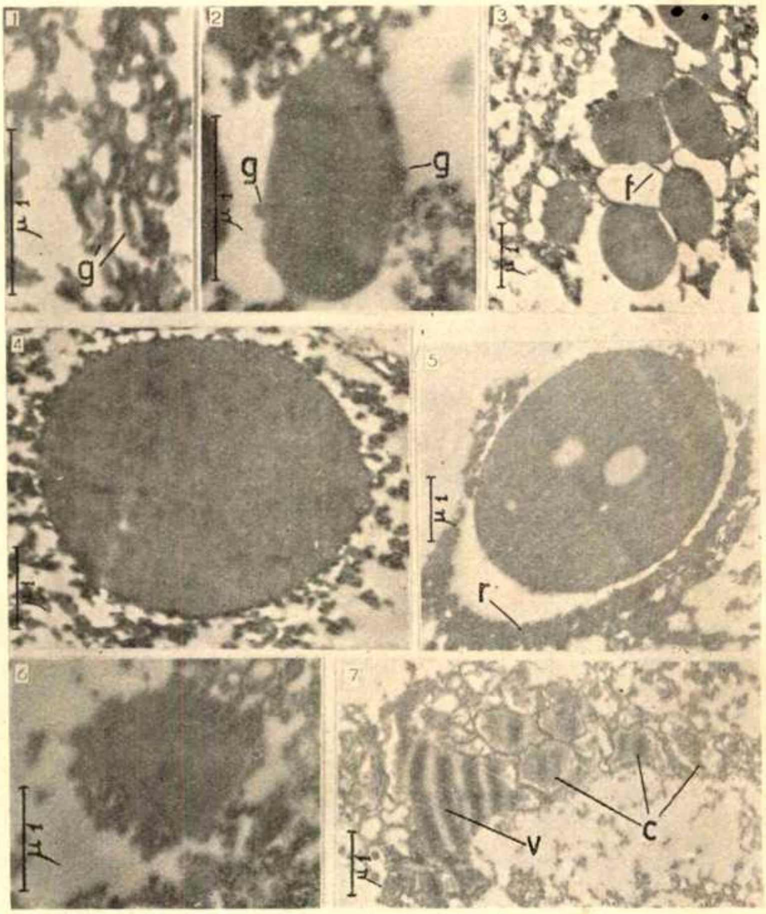


Fig. 1. Ergastoplasm in the oocyte of *Patella coerulea* with dark 300-Å. granulations (*g*). Fig. 2. Yolk globule of *Patella* oocyte with granulations (*g*) on its surface. Fig. 3. Yolk globules of *Patella* oocyte surrounded by filaments (*f*) without dark granulations. Fig. 4. Yolk globule of *Aplysia depilans* oocyte with particles on its surface. Fig. 5. Yolk globule of *Aplysia* oocyte with two vacuoles and a very dense semi-lunar network (*r*). Fig. 6. Yolk globule of *Aplysia* oocyte, which divides into very minute granules. Fig. 7. Cavities (*c*) in *Aplysia* oocyte with granules in aggregation and definitive yolk (*v*)

sense exist in *Patella coerulea*, where vitellogenesis takes place directly from the ergastoplasm.

This work was supported by Consiglio Nazionale delle Ricerche, Roma.

A. Bolognari

Istituto di Zoologia e di Anatomia comparata,
Università di Messina.

[1] Rebhun, L. I., *J. Biophys. Biochem. Cytol.*, **2**, 159 (1956).

[2] Kemp, N. E., *J. Biophys. Biochem. Cytol.*, **2**, 281 (1956).

[3] André, J., and Rouiller, R. C., *J. Biophys. Biochem. Cytol.*, **3**, 977 (1957).

[4] Yasuzumi, G., and Tanaka, H., *Exp. Cell Res.*, **12**, 681 (1957).

[5] Carasso, N., and Favard, P., *C.R. Acad. Sci., Paris*, **246**, 1594 (1958).

[6] Bolognari, A., *Boll. Zool.*, **25**, 155 (1958).

[7] Bolognari, A., and Calapaj, G. G., *Boll. Soc. Ital. Biol. Sper.*, **35**, 325 (1959).

[8] Bolognari, A., *Boll. Zool.*, **21**, 185 (1954).

[9] Bolognari, A., *Arch. Zool. Ital.*, **41**, 241 (1956).

[10] Bolognari, A., *Boll. Zool.*, **25**, 171 (1958).

[11] Ranzoli, F., *Caryologia*, **5**, 137 (1953).

Sex Difference in Accidental Mortality of Guppies exposed to Elevated Temperature

Mass mortalities of fish exposed to low[1–6] and high[7–10] temperatures in Nature have been reported; but no sex differences in such incidents appear to have been recorded. The omission of data on sex ratios may be due to the fact that their interpretation would generally be unsatisfactory since the sex ratios of the original populations would be unknown, and even slight differences in habits of the sexes might result in their exposure being significantly different. In the present instance, interpretation is easier because the exact number of adults of each sex before and after exposure is known.

Over a week-end the temperature of the laboratory in which about 2,000 guppies of unnamed strains being developed for experimental purposes were housed was accidentally raised. At the time the accident was discovered the temperatures in aquaria ranged up to 41° C. and about 150 adult and many young fish were dead. Some adult fish survived in 14 aquaria in which deaths occurred and in which there were adults of both sexes. The results of observations on fatalities and survival among adults in these aquaria are presented in Table 1. Generally, if both immature fish and adults were present the former were almost all dead if any adults were; and in one tank with several large females as well as smaller ones, the smaller ones died and the large ones all survived.

Table 1. Comparison of Survival of Adult Male and Female Guppies exposed to Elevated Temperature

	Male		Female	
	No.	Per cent	No.	Per cent
Surviving	10	32	47	81
Dead	21	68	11	19

The difference in the mortalities of adults of the two sexes has been examined using the chi-square test and found to be statistically significant ($P < 0{\cdot}002$ using the two-tailed test).

The observations here reported agree with the usually observed higher mortality of males[11] and with the laboratory observations of Gibson[12] on survival times of guppies at 37°, although they do not agree with her results at other temperatures. She found that the mean time to death of guppies at 37° was about 50 per cent higher for females than for males. At 34°, on the other hand, the time to death was greater for males (5,660 min.) than for females (3,400 min.) and at other temperatures (35°, 36° and 38°) she found no sex differential.

Before the mass mortality here reported, the sex ratio for adults in the aquaria was 54 males per 100 females; after the accident, 21 males per 100 females. (The original ratio cannot be interpreted as a 'natural' one for some aquaria contained mated groups that had been selected, and fish had been removed from others for experimental purposes.) The observations on this laboratory population suggest that elevations of temperature such as occur in small, shallow, unshaded ponds may bring about significant alterations of the proportions of the sexes.

John A. Freeman

Biology Department,
Winthrop College,
Rock Hill,
South Carolina.

[1] Agersborg, H. P. K., *Ecology*, **11**, 136 (1930).

[2] Dannevig, A., *Cons. Perm. Internat. Explor. Mer, J. Conseil.*, **5**, 194 (1930).

[3] Storey, M., and Gudger, E. W., *Ecology*, **17**, 640 (1936).

[4] Gunter, G., *Ecology*, **22**, 203 (1940).

[5] Gunter, G., *et al.*, *Science*, **105**, 256 (1947).

[6] Gunter, G., *Science*, **106**, 472 (1947).

[7] Huntsman, A. G., *J. Fisheries Res. Board Canada*, **5**, 485 (1942).

[8] Huntsman, A. G., *J. Fisheries Res. Board Canada*, **6**, 476 (1946).

[9] Mackenthun, K. M., *et al.*, *Trans. Amer. Fisheries Soc.*, **75**, 175 (1948).

[10] Bailey, R. M., *Ecology*, **36**, 526 (1955).

[11] MacArthur, J. W., and Baillie, W. H. T., *Quart. Rev. Biol.*, **7**, 313 (1932).

[12] Gibson, M. B., *Canad. J. Zool.*, **32**, 393 (1954).

Stereobalanus, a Genus New to the Old World

During a faunistic survey of all the lochs on the west coast of Scotland from Cape Wrath to the Solway, several pieces and some whole specimens of a golden yellow enteropneust were discovered in bottom samples taken with a 1/10 Van Veen grab (Fig. 1). The geographical location and bathymetric distribution of these specimens are given in Table 1.

In the first four localities the substratum consisted of a layer a few cm. thick of black glutinous mud overlying a stiff clay, but in Loch Glendhu it consisted of a mixture of small stones and mud. As the sampling intensity in all the lochs examined was fairly uniform, it is evident that the species is moderately common and widely distributed along the west coast

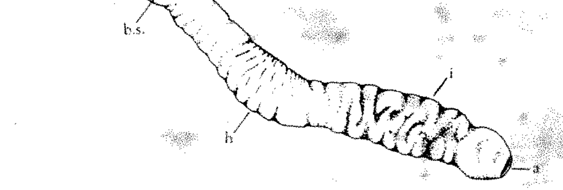


Fig. 1. *Stereobalanus* sp. Line drawing from photograph of live specimen. Overall length, about 8 cm. *a*, Anus; *b.s.*, common branchial slit; *h*, olive green hepatic region; *i*, sac-like intestinal region; *p.r.*, parabranchial ridges

Table 1. DISTRIBUTION OF SPECIMENS FROM WEST COAST LOCHS

Area	Position	Depth (fath.)	Date	No. of specimens
Loch Spelve (Mull)	56° 24·3′ N. 5° 43·5′ W.	8	5.6.57	1
Loch Spelve (Mull)	56° 24·1′ N. 5° 43·5′ W.	9	7.10.58	2
Loch Sunart (Glenmore Bay)	56° 40·8′ N. 5° 55·9′ W.	9	11.6.57	1
Loch Erisort (Lewis)	58° 7·4′ N. 6° 23′ W.	20	15.10.58	3
Loch Glendhu (Sutherland)	58° 15·4′ N. 4° 57′ W.	7	22.10.58	1

of Scotland and perhaps significant that it was not found in any of the samples taken south of Mull. A preliminary analysis of the associated fauna expressed as numbers per 1/10 m.^{2} is summarized in Table 2.

The pronounced radial arrangement of the longitudinal muscles and thick enveloping layer of circular muscles and reduced condition of the coelom in the proboscis, the absence in the mesosoma of complete dorsal and ventral mesenteries and collar pores, the very prominent dorso-lateral and ventro-lateral parabranchial ridges enveloping the branchial apertures, the rudimentary peripharyngeal cavities and the absence of any trace of œsophageal pores, justify the identification of this enteropneust as a species of the genus *Stereobalanus* Spengel.

The type material upon which this genus was established was first dredged off Cape Breton, Nova Scotia, in 1873, by the late Prof. W. C. McIntosh, and originally named *Balanoglossus canadensis* by Spengel[1]; afterwards, in a review of the nomenclature of certain of the Enteropneusta, Spengel established a new genus for this species and it became *Stereobalanus canadensis*[2]. It was later rediscovered by Reinhard[3] some 430 miles away from the type locality at the mouth of Sullivan's River, Frenchman's Bay, Maine, where it occurred in considerable numbers in a 'soft, fine mud' substratum together with *Corymorpha pendula*, *Nephthys caeca* and *Ctenodiscus crispatus*. It has also been found at San Diego, California (Bullock, T. H., and Rao, K. P., unpublished work).

The only other species of the genus recorded (*S. willeyi* Ritter) was found in San Pedro Channel, New Port, California, where fragments of specimens were discovered in very soft sandy mud taken from a depth of about 40 fm.[4].

Table 2. ANALYSIS OF THE ASSOCIATED FAUNA

Animal	Numbers per 1/10 m.^{2}			
	Spelve	Erisort	Glendhu	Sunart
Mysella bidentata (Montagu)	87	1	—	—
Other lamellibranchs	3	3	5	1
Loricata	—	—	7	—
Heterocirrus sp.	53	—	—	46
Pholoe minuta (Fabricius)	2	1	1	—
Eumenia crassa Oersted	3	—	1	—
Nephthys hystricis McIntosh	4	2	—	4
Notomastus latericeus M. Sars	1	—	2	1
Lumbriconereis hibernica McIntosh	2	4	4	—
Glycera sp.	—	2	4	—
Other polychaetes	10	20	25	6
Amphiura filiformis (O. F. Müller)	17	48	1	—
Amphiura chiajei Forbes	1	19	1	2
Other echinoderms	—	5	1	—
Ampelisca diadema (A. Costa)	1	1	2	—
Other amphipods	—	1	—	—
Cumacea	—	1	—	—

Although the specificity of the Scottish species cannot be determined without a more detailed comparative study, a preliminary examination of the general anatomy shows that it is more closely allied with *S. canadensis* than with *S. willeyi*.

Hitherto, the genus has been indigenous to the east and west coasts of North America. Its discovery in a comparable habitat in the Old World is therefore of considerable interest, and if it proves to be *S. canadensis* then it will provide yet another instance of the discontinuous distribution recorded for certain members of this phylum. It also makes an important addition to the number of Enteropneusta already recorded from the British Isles[5,6].

We are grateful to Prof. T. H. Bullock and Dr. K. P. Rao for a copy of their manuscript on this genus, and to Dr. J. S. Ryland for his assistance with the collection and preservation of the material and also for taking the photograph from which Fig. 1 was drawn.

C. BURDON-JONES

Marine Biology Station,
University College of North Wales,
Menai Bridge, Anglesey.

A. D. MCINTYRE

Scottish Home Department,
Marine Laboratory,
Victoria Road, Torry,
Aberdeen.

[1] Spengel, J. W., "Fauna u. Flora Neapel", 18 (1893).
[2] Spengel, J. W., *Zool. Jb.*, **15**, 209 (1901).
[3] Reinhard, E., *J. Wash. Acad. Sci.*, **32**, 309 (1942).
[4] Ritter W. E., and Davis, B. M., *Univ. Calif. Pub. Zool.*, 1, 171 (1904).
[5] Burdon-Jones, C., *Nature*, **165**, 636 (1950).
[6] Burdon-Jones, C., *Nature*, **172**, 342 (1953).

Effect of a Sewage Effluent Discharge on the Deposition of Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith)

DURING an ecological survey of the River Ivel[1], a chalk stream in Bedfordshire, it was observed that shells of the snail *Potamopyrgus jenkinsi* (Smith) were heavily encrusted with calcareous nodules upstream of a sewage effluent discharge whereas downstream of the discharge such shells were clean (Fig. 1). Above the sewage effluent, snails were more than 70 per cent heavier than those below the effluent (Table 1).

Table 1. A COMPARISON OF WEIGHTS OF SNAILS TAKEN FROM ABOVE AND BELOW THE SEWAGE EFFLUENT (AVERAGE OF 12 DETERMINATIONS)

Location	Width of shell aperture (mm.)	Dry weight (mgm.)	Calcium carbonate (mgm.)
Above effluent	1·50	2·98	2·44
Below effluent	1·46	1·73	1·42

Snails taken from below the discharge and placed in cages above it developed encrustations within three weeks. Warwick[2] referred to calcareous encrustations found on *P. jenkinsi* in a limestone district of Derbyshire but no demarcation of habitat effect was observed. Deposition also occurred on

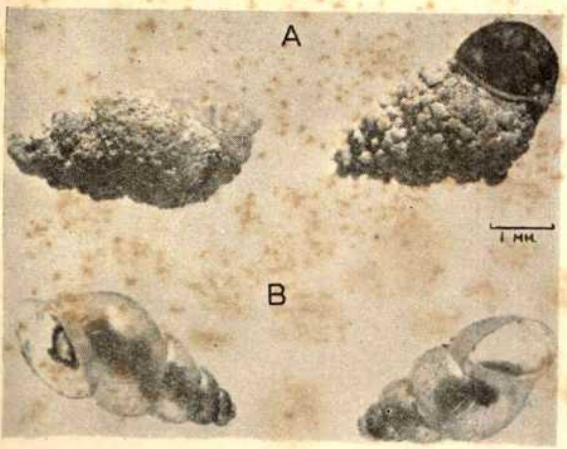


Fig. 1. *Potamopyrgus jenkinsi* shells from an unpolluted stretch of river showing calcareous encrustations (*A*) and from a polluted stretch (*B*)

glass slides immersed in the River Ivel upstream of the effluent. The *p*H value of the river water both above and below the effluent varied between 7·9 and 8·3 on the several occasions on which it was determined. Total hardness was about 290 p.p.m. as calcium carbonate. The algal flora on the snail shells was dominated by *Cocconeis* and '*Chantransia*' both upstream and downstream of the discharge. The effluent was of good quality (Table 2) and constituted between 5 and 10 per cent of the dry summer flow.

Table 2. ANALYSIS OF SEWAGE EFFLUENT

	Concentration (p.p.m.)	Number of samples
Organic carbon (as C)	22	3
Ammonia (as N)	1·7	2
Nitrite (as N)	0·1	2
Oxidized nitrogen (as N)	70	2
Phosphate (as P)	10·3	3
Synthetic detergent (as 'Manoxol O.T.')	5·2	4
Permanganate value	7	2
3 day B.O.D.	11	2
Suspended solids	10	2

Laboratory experiments were conducted in which glass slides were immersed in: (*a*) river water; (*b*) river water plus sewage effluent (5 per cent by volume); (*c*) river water plus synthetic sewage effluent containing no synthetic detergents[3] (5 per cent by volume); (*d*) river water plus sodium carboxymethyl cellulose (5 p.p.m.); and (*e*) river water plus sodium hexametaphosphate (1 p.p.m. as phosphorus) at *p*H 8·2 and 8·5.

Deposition occurred only on those slides immersed in river water without additives. The sample of sewage effluent used in the above experiments contained 52 p.p.m. total organic carbon, 4·5 p.p.m. synthetic anionic detergent (as 'Manoxol O.T.'), and 5·2 p.p.m. phosphate (as phosphorus). The synthetic sewage effluent contained 24 p.p.m. total organic carbon and 2·6 p.p.m. phosphate (as phosphorus).

It is evident that sewage effluents contain several constituents which prevent the deposition and aggregation of calcium carbonate under conditions similar to those prevailing in the River Ivel. Certain constituents of packaged detergents and soaps, such as condensed phosphates which sequester calcium and magnesium ions and act as dispersive agents, and organic soil suspenders such as sodium carboxymethyl cellulose[4] may be of importance. It seems likely, from experiments with sewage effluent prepared without synthetic detergents, that other agents inhibiting deposition are also present. Similar conclusions were drawn by Alekin and Moritschewa[5] from their observations on the Don and Volga. It would seem, from their work, that certain organic substances present in these waters are inhibitors of calcium carbonate deposition, particularly humus material of plant origin.

R. W. EDWARDS

Water Pollution Research Laboratory,
Stevenage, Herts.

J. HEYWOOD

Zoology Department,
The University,
Reading.

[1] Heywood, J., and Edwards, R. W. (in preparation).

[2] Warwick, T., *Proc. Malac. Soc. Lond.*, **30**, 71 (1953).

[3] Truesdale, G. A., Jones, K., and Vandyke, K. G., *Water and Waste Treatment J.*, **7**, 441 (1959).

[4] Schwartz, A. M., Perry, J. W., and Berch, J., "Surface-Active Agents and Detergents", **2** (Interscience Publishers Inc., New York, 1958).

[5] Alekin, O. A., and Moritschewa, N. P., *Doklady Akad. Nauk. S.S.S.R.*, **117**, 1030 (1957).

Occurrence of *Halimeda opuntia* var. *minor* on Jamaican Shores

I WISH to report the presence of *Halimeda opuntia* var. *minor* on Jamaican shores. The variety was confirmed by Miss Lena Pierce at the Institute of Jamaica.

It was found in water 1–2 ft. deep, at the eastern end of the barrier reef protecting the west harbour at Port Antonio, in the passage between the reef and Navy Island, on July 17, 1959.

It is not common, but several clusters are scattered around and easily distinguished from the more normal variety by the fine construction.

Although found on other Caribbean islands, this is the first time this variety has been discovered in Jamaica.

P. F. JAMES

Box 120,
Port Antonio,
Jamaica.

Living and Fossil Unicellular Algæ and Aplanospores

IN studies of peat deposits from south-western Australia, a number of small fossil algæ have been found with a morphology similar to certain living polyhedral unicellular species of the family Oocystaceae of the Chlorococcales. The classification of this family is artificial[1] and is based on the type of colony produced. Genera which have been placed in the family include *Tetraedron*, *Desmatractum*, *Octogoniella* and *Scotiella*[1–3]. Two of these, *Octogoniella* and *Desmatractum*, have a peculiar form characterized by two envelopes, separated by a more or less wide space containing an aqueous mucilage. The inner envelope is delicate, while the outer is composed of two conical halves joined together in the median plane.

Three distinct fossil algae, which match the forms described, have been found preserved in Western Australian peats of various ages between 4000 B.C. and the present. These are illustrated in Fig. 1, Nos. 2, 4 and 7. The principal difference between the

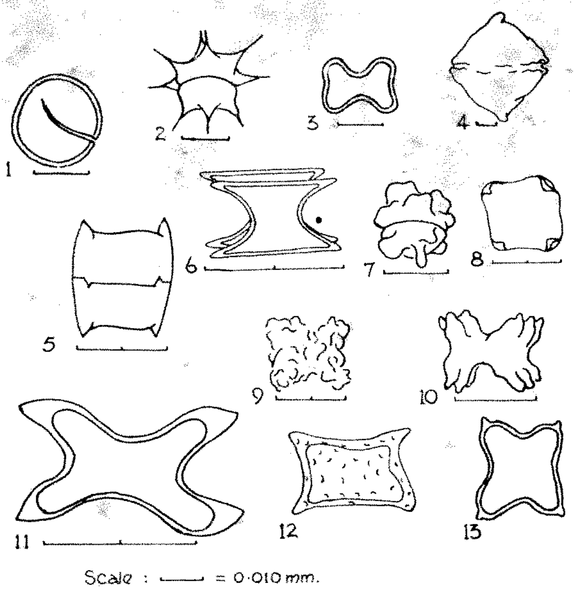


Fig. 1. Fossil algae of the Cyanophyceae: from a recent peat at Walpole (2 and 7) and Lake Muir (4). Fossil algal aplanospores: from a recent peat at Walpole (1, 5 and 11) and Lake Chittering (8). From a Lower Eocene glauconitic shale between 1,285 and 3,185 ft. in the Rottnest Bore (3, 9 and 10). From the Palæocene in the King's Park shale at 164 ft., Narrows Bore, No. 2 (6). Nos. 12 and 13 are living spores (refs. 2 and 3)

fossil forms and the living forms is the absence of the internal envelope of the protoplast, which is presumed to have been lost either after death of the organism, or during the processing of the peats for extraction of the microflora.

Fossil algal aplanospores have also been found preserved in peat sediments from a number of swamps and these are illustrated in Fig. 1, Nos. 1, 5, 8 and 11. Aplanospores are transported by the wind, as they have been found trapped with atmospheric pollen, in dried pinnules of tall *Schizaea* plants.

A palynological analysis of a peat profile from a swamp near Walpole, Western Australia, into which algal aplanospores are at present blown, suggested that a large number of the aplanospores were preserved under freshwater-lake conditions between 4700 B.C. and 600 B.C. Since then, with the rapid expansion of sedges and Hystrichosphaerideae, bog conditions have developed. Water in the bog has become more saline than in the lake and the number of preserved aplanospores diminished rapidly. The increased salinity is thought to favour germination of the aplanospores, after which they are no longer preserved.

Fossil aplanospores also occur in lower Tertiary glauconitic shales from the Perth Basin and these are illustrated in Fig. 1, Nos. 3, 6, 9, and 10. From finding these spores in sedimentary rocks, it is suggested that they may be of value as stratigraphic fossils and salinity indicators, while a detailed study of aplanospores from living families may enable a closer insight into the fossil history of the algae.

D. M. CHURCHILL

University of Western Australia,
Nedlands,
Perth.

---

[1] Smith, G. M., "Cryptogamic Botany", 1, "Algae and Fungi" (McGraw-Hill, New York, 1938).

[2] Fritsch, F. E., "The Structure and Reproduction of the Algae", 1 (Cambridge University Press, 1948).

[3] Prescott, G. W., "How to Know the Freshwater Algae" (W. M. C. Brown Co., Iowa, 1954).

Water-Soluble Methacrylates as Embedding Media for Preparation of Ultra-Thin Sections

AT present, the embedding of preparations for cutting of ultra-thin sections is most frequently carried out by the procedure originally described by Newman *et al.*[1] and later perfected by a number of other authors[2-4]. This method, however, suffers from the drawback that the embedding media used are, in their monomeric form, immiscible with water and usually good solvents of fats. The preparation must be dehydrated—usually with alcohol or other organic solvent—before embedding and this, together with the solving of fats, may lead to the alteration of biological structures and formation of artefacts.

These disadvantages might be expected to be avoided by using an embedding medium which is completely miscible with water in its monomeric form. This condition is met by a mixture of two monomers prepared by Wichterle and Lím[5]—glycol monomethacrylate and triethyleneglycol dimethacrylate. These compounds are prepared by a procedure based on re-esterification of methyl methacrylate with ethylene glycol and triethylene glycol, respectively.

Both monomers are clear, colourless liquids at room temperature of a viscosity somewhat higher than that of water, and stable indefinitely at 0–4° C. The triethyleneglycol dimethacrylate serves as a cross-linking agent and is added in a ratio of about 1 : 100. When an accelerator is added (for example, ammonium persulphate) the polymerization proceeds uniformly at about 40–50° C. or under the influence of ultraviolet radiation for about 12 hr. and results in a clear, transparent polymer of three-dimensional structure. It was noted that polymerization is greatly accelerated by the presence of even traces of different co-catalysts, for example; also by osmium oxides. This is a particular advantage especially in the case of preparations fixed with osmium tetroxide. The final properties of the polymer—particularly its hardness—can be controlled by adjusting the ratio of the two monomers and especially the water content of the mixture.

Embedding in glycolmethacrylate for cutting ultra-thin sections can be carried out by two procedures. Since an isotonic aqueous solution of the monomers does not appear to cause alteration of biological materials, the structure of the preparation may first be fixed in a mild manner by polymerization in an isotonic monomer solution. Mechanical fixation of the biological structure is assumed after this first step, although a relatively soft polymer is formed. Further hardening of the primary gel is then achieved by stepwise replacement of the water by monomer followed always by polymerization.

Although it is a little time-consuming, this procedure, according to our preliminary results, appears to be milder than the alternative method in which the preparation is passed through a series of aqueous monomer solutions of gradually increasing concentration in the same way as is usual with alcoholic solutions.

Preparations embedded by either procedure show a satisfactory hardness. A disadvantage is a certain swelling of the block in water which results in a decrease in hardness during cutting. We are at present trying to eliminate this drawback.

The sections which we have obtained so far were found to spread very well on the surface of aqueous ethanol containing lanthanum nitrate, and were easily picked up from the surface.

The technique for cutting ultrathin sections described here is being developed and further details will be published soon.

O. Wichterle

Institute of Macromolecular
Chemistry,

P. Bartl

Chemical Institute,
Czechoslovak Academy of Science,
Prague.

M. Rosenberg

Virological Institute,
Czechoslovak Academy of Science,
Bratislava.

[1] Newman, B., Borysko, E., and Swerdlow, M., *J. Res. Nat. Bur. Standards*, **43**, 183 (1949).

[2] Massey, B. W., *Stain Tech.*, **28**, 19 (1953).

[3] Moore, D. H., and Grimley, P. M., *J. Biophys. Biochem. Cytol.*, **3**, 255 (1957).

[4] Bachmeyer, M., and Schreil, W., *Naturwiss.*, **44**, 555 (1957).

[5] Wichterle, O., and Lím, D., *Nature*, **185**, 117 (1960).

A New Specimen of *Nipa* Fruit from Mohgaonkalan Cherts

The fruit *Nipa hindi* (Rode) Sahni was collected by Prof. K. P. Rode from Intertrappean beds of Mohgaonkalan, Chhindwara District, in 1933. So far it has been a holotype of *Nipa* from Deccan Intertrappeans of India.

A fresh specimen has been collected by me recently from the same locality. It differs from *Nipa hindi* (Rode) Sahni in size, shape, structure of internal seed, and the characters of the endocarp. However, the importance of the discovery of a new specimen is undoubtedly unique. Presence of *Nipa* fruit is very characteristic of the Eocene period; younger records are not yet known. Accordingly, on the discovery of Rode's only specimen of *Nipa hindi*, Prof. Sahni[1] had suggested an Eocene age for Intertrappeans at Mohgaonkalan. This new specimen falls in line and brings more support to Prof. Sahni's view on the age of the Deccan Traps of India. Hislop too had recorded this fruit in Deccan cherts in the publications by Carter[2], Hislop[3], and Hislop and Hunter[4]; but unfortunately his specimens are untraceable. Almost all the known records of *Nipa* show its existence roughly along the shore of the Nummulitic sea (Tethys), as indicated by Reid and Chandler[5], which probably extended from about north of Chhindwara.

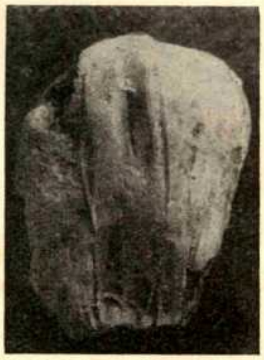


Fig. 1. *Nipa* fruit from Mohgaonkalan cherts. ×0·6

Fig. 1 shows a complete fossil fruit comparable to modern *Nipa fruticans*. The fruit is a single-seeded drupe, slightly flattened, obovoid, with six longitudinal ridges which meet at the apical distinct umbo. It measures 6·5 cm. in length and 5 cm. in breadth at its broadest distal part. The carpel wall is thick especially at the apex. The epicarp is thin and smooth, the sarcocarp is about 10 mm. thick, and the endocarp is about 0·8 mm. thick. The single seed inside is slightly flattened, and has a prominent sulcus with endocarpic ridge dipping into it. The sulcus with the endocarpic ridge extends from the base to the top of the seed.

Preservation of the material is satisfactory and structural details are under further investigation.

S. D. Chitaley

Government College of Science,
Nagpur.

[1] Sahni, B., and Rode, K. P., *Proc. Nat. Acad. Sci. India*, **7**, 3, 165 pl. 1 (1937).

[2] Carter, H. J., Geol. Papers on Western India, 2 volumes (Bombay, 1857).

[3] Hislop, S., *J. Bom. Asiat. Soc.*, **5**, 58–76, 148–150 (1853).

[4] Hislop, S., and Hunter, R., *Q. J. Geol. Soc.*, **10**, 470; **11**, 345 (1855).

[5] Reid, E. M., and Chandler, M. E. J., The London Clay Flora, British Mus. (Natural History) Cat. (1933).

Variation in *Phytophthora palmivora* (Butl.) Butl. on *Theobroma cacao* L. in West Africa

Diseases of *Theobroma cacao* L., particularly pod-rot, caused by *Phytophthora palmivora* (Butl.) Butl., have been described in all the cocoa-producing areas of West Africa. A large collection of isolates from most territories, however, has shown that the nature of the pathogen varies greatly in the region and that at least two types of the fungus exist.

The first type of isolate, referred to as the Ghanaian type, is the dominant fungal pathogen in the more westerly cocoa-growing countries of Ghana, Ivory Coast, and Sierra Leone. This type occurs occasionally in Nigeria, Southern Cameroons, Gabon and the Belgian Congo. The isolates are characterized by cultural and morphological features typical of *P. palmivora*, and also have rapid growth-rates when inoculated into healthy pods. Minor differences have been found between isolates within the group, but for the most part they are indistinguishable.

The isolates of the second, or Nigerian, group, which are the dominant pathogens in the more easterly countries of Nigeria, Southern Cameroons, Fernando Po, French Cameroons and probably Gabon, show marked differences from the Ghanaian type. Cultural and morphological characters are very dissimilar, especially in growth-rates on artificial media and in sporangial dimensions, and the rate of lesion development in pods is both appreciably slower and very variable. Current tests have shown that complementary strains for oospore production occur within the group. Mixed cultures of the two groups of isolates grown on oatmeal agar at 60° F. have been found to produce oospores. Dimensions of these spores corresponded to those described by Ashby[1] on growing cultures of the 'cocoa' and 'rubber' groups of the fungus together under similar conditions. No oospore production has been obtained by cross in any isolates from the westerly group of countries.

The occurrence of complementary isolates within a particular territory could result in genetic variation of the organism and possible changes in its pathogenicity. Varieties of *Theobroma cacao* now being bred for resistance and tolerance to black-pod disease will need more extensive testing in areas where the pathogen is variable than may be necessary in Ghana, where it appears to be uniform. The variability of the organism must also be recognized when conducting bio-assays of fungicides to be used in chemical control of the disease in the field.

Further investigations are proceeding, and a fuller account of the work will be published elsewhere.

P. D. TURNER

West African Cocoa Research Institute,
Tafo, Ghana.

[1] Ashby, S. F., *Kew Bull.*, 257 (1922).

ANATOMY

A Reconstruction of the Foot of the 'Abominable Snowman'

THE clearness of the tracks of the 'Snowman' shown in the photograph taken by Eric Shipton[1] (Fig. 1) has enabled me to make a reconstruction of its foot (Fig. 2). This has been used to produce imprints in snow which show a great similarity to the natural tracks (Figs. 1 and 3), suggesting that the model is accurate.

The plaster foot has the following anatomical peculiarities: (1) It is of great size: length 12½ in., fore breadth 7½ in., the width thus being 60 per cent of the length. The heel is 6½ in. broad—nearly as broad as the fore part of the sole. (2) The hallux is very thick and separated from other toes. (3) The second is the longest toe, and it is separated from the hallux and third toe; it is thinner than the hallux though more powerful than the other toes. (4) The third, fourth and fifth toes are small and united towards their bases, although the distal end of each toe gives a clear impression in the snow. The little toe is less bent than the others.

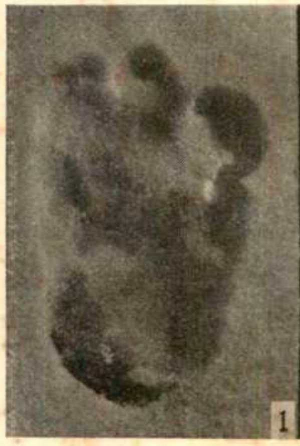
These features can be seen to a lesser degree in human and gorilla feet, and by comparing them certain inferences can be made.

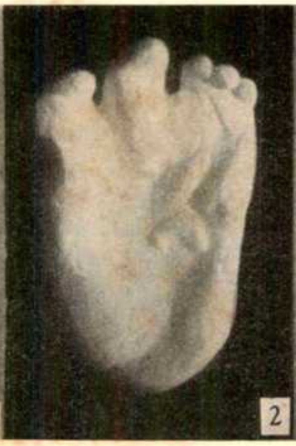
(1) The 'Snowman' foot is as long as that of a large gorilla but much broader. Sir Arthur Keith[2] emphasized the increase of the tarsal, and decrease of the digital, elements of the skeleton of the foot during the evolution of higher primates. In the foot of the gorilla, the tarsal elements account for 39 per cent of the length measured along the third digit; in the human foot, it accounts for 52 per cent. At the same time, describing the soft tissues of sole, Keith states: "we see the enormous increase of the heel in the gorilla; it is relatively and absolutely larger than the heel area of man". Fig. 4 shows this huge foot and it can be seen that it resembles the much larger heel of the Snowman. This may equally be regarded as a combination of the hominoid tendency towards increasing length and breadth of tarsal bones together with gorilloid tendency for a spread of the soft tissues. The great fore breadth (42·8 per cent of the length) is found also in the skeleton of the foot of the neanderthaloid from the Kiik Koba cave in the Crimea[3].

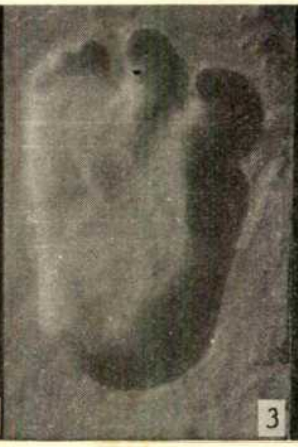
(2) The hallux of the 'Snowman' resembles that of the gorilla, except that it is straighter, longer and much more powerful. In conjunction with the depth of the impression made in the snow, this suggests that it carried much of the weight of the body. But at the same time the hallux has every appearance of being opposable, and could be used to grasp objects or in climbing. The first row of foot bones is shortest because of a very shortened metatarsal element, although the phalanges themselves are big. R. Neuhaus[4] and H. Virchow[5] call such cases in human foot (Fig. 5) "zurücktretende" hallux and they appear, as in the 'Snowman', to be due to an unusually short metatarsal bone.

(3) The unusually large size of the second toe of the 'Snowman' can be also compared with the human foot with "zurücktretende" hallux. This type of big toe can be accompanied with an elongated and thickened second toe (Fig. 5). H. Klaatsch[6] has described a similar case in an Australian aborigine, who possessed the same type of foot which was able to grasp much better than normal. This is the same combination of shortened first and elongated second axis both in the foot of the 'Snowman' and in an abnormal human foot.

These peculiarities can be explained functionally. The hallux is shortened and capable of grasping, but


1


2


3

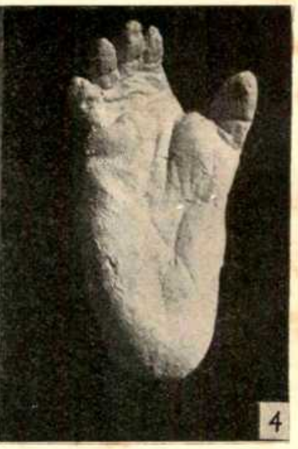
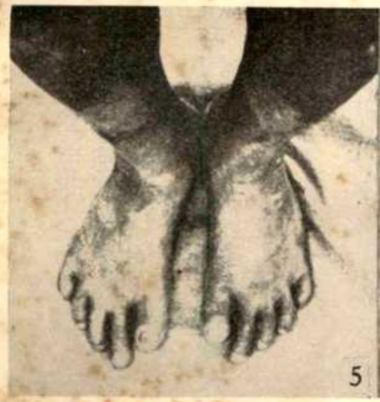
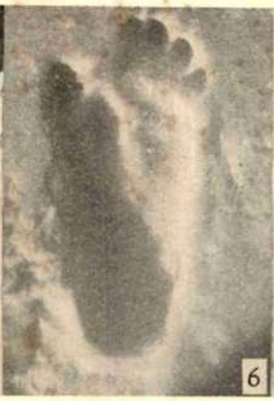
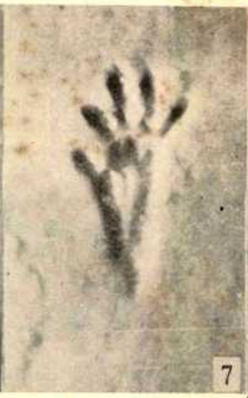

4

Fig. 1. The original track of the 'Snowman' (after Shipton). Copyright: The Mount Everest Foundation
Fig. 2. The reconstructed foot of the 'Snowman'
Fig. 3. Artificial track made with the reconstructed foot
Fig. 4. Plaster cast of a gorilla's foot







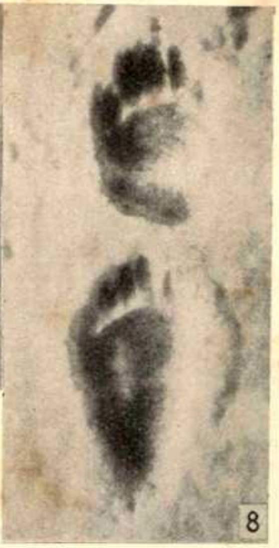


Fig. 5. The "zurücktretende" hallux in human feet (after Neuhaus)
Fig. 6. Artificial track of *Gorilla beringei*
Fig. 7. Artificial track of a langur
Fig. 8. Tracks of the fore and hind paws of the Himalayan black bear

less effective for use in walking upright. The second toe is therefore also involved in balancing and is elongated and thickened. This type of foot with its dual functions of grasping and balancing was probably characteristic of early prehominids in the first stages of the bipedal mode of life.

(4) The relative shortness of digits 3, 4 and 5 and their corresponding metatarsals are an obvious feature of the human foot. Also all three lateral toes of the 'Snowman' seem to show signs of partial syndactyly, but metatarsals 3–5 do not show any signs of the shortening which is observed in the human foot. The two distal phalanges of the little toe in the human foot are often fused together, and this condition may also explain the faintness of the impression made by the little toe of the foot of the 'Snowman', which we must suppose was held straighter than the others.

The impressions made by plaster casts of the feet of the mountain gorilla (Fig. 6), langur (Fig. 7) and the tracks from the preserved feet of black bear (Fig. 8) show that the footprint of the 'Snowman' is much like that of the gorilla and very different from the other two. Yet it has been suggested that Shipton's photograph was a footprint of either a bear or langur.

Other criticisms that the footprint of the 'Snowman' was deformed by the melting of the snow do not seem well founded, in view of the sharpness of the imprint and the similarity to the fresh artificial prints from the plaster model.

Hans Gross[7] mentions that good photographs of the tracks in the snow show even more details than do a plaster cast made from such tracks. But since heel and toes press more deeply into the snow than the sole, the arch of the foot is exaggerated and the impression is slightly shorter than the actual foot.

G. W. Gayer[8] stressed that the deepest impressions of human tracks are: the outer side of the back of the heel and on the inner side the big toe, and slightly less the outer side of the sole behind the little toe and the inner side behind the hallux. These details are well known from criminological studies and are very clearly seen in the tracks and plaster cast of the 'Snowman'.

In the original photograph it is also possible to see small heaps of snow thrown up by the back of the heel when it first touched the snow surface and was later pressed down by the flat of the heel, which is, according to Gayer, characteristic of the track of a bare human foot. This suggests that the track of the 'Snowman' was formed in the same way as a human one and that the 'Snowman' must walk in a human manner.

All the evidence therefore suggests that the so-called 'Snowman' is a very huge, heavily built bipedal primate, most probably of a similar type to the fossil *Gigantopithecus*.

W. Tschernezky

Zoology Department,
Queen Mary College,
Mile End Road,
London, E.1.

[1] Shipton, E., "Upon that Mountain" (London, 1956).
[2] Keith, Sir Arthur, *J. Bone and Joint Surg.*, **11**, No. 1 (1927).
[3] Bonch-Osmolowsky, G. A., "The Skeleton of the Foot and Shin of Fossil Man from Kiik Koba Cave" (Moscow–Leningrad, 1954) (in Russian).
[4] Neuhaus, R., "Deutsch Neu-Guinea", **1** (Berlin, 1911).
[5] Virchow, H., "Über Fuszskelette farbiger Rassen" (Berlin, 1917).
[6] Klaatsch, H., "Schlussbericht über meine Reise nach Australien in den Jahren 1904–1907", *Z. Ethnol.* (Berlin, 1907).
[7] Gross, Hans, "Criminal Investigation" (London, 1949).
[8] Gayer, G. W., "Foot Prints" (1909).

CYTOLOGY

Chromosomes of *Gyraulus circumstratius*, a Freshwater Snail

Polyploidy is relatively scarce in the animal kingdom, and is apparently almost entirely confined to those species in which reproduction is parthenogenetic, hermaphroditic or clonal[1]. Such animals usually do not have a heterogametous sex-determining mechanism to be disturbed by polyploidy. The hermaphroditic nature of freshwater pulmonate snails and their ability for self-fertilization[2] suggest the possibility that there might be a considerable degree of polyploidy among the large number of species of this group because a single accidental polyploid individual could give rise by self-fertilization to a polyploid strain, rather than producing only sterile triploids, if cross-fertilization were obligatory[3]. So far there has been little reliable evidence for polyploidy in aquatic pulmonate snails. (An earlier indication of polyploidy, based on the chromosome numbers reported for *Physa gyrina*[4], and *P. acuta* (=*integra*?)[5] $n = 6$ and 18, respectively, is due to erroneous observations concerning *P. gyrina*). Six specimens of this species from several localities in Colorado from which animals were taken for the earlier investigation were found to have haploid chromosome numbers of eighteen (J. B. Burch, unpublished work). The high chromosome number ($n = c.\ 59$) reported for the limpet *Ancylastrum costulatum* (=*Ancylus fluviatilus* Müller?) was not considered to be polyploid, but due to diphylogeny in freshwater snails[6].

During recent investigations of the chromosomes of freshwater snails we have had the opportunity to study *Gyraulus* (*Torquis*) *circumstriatus* (Tryon). Specimens were obtained from a mill pond on highway *M*–132, Section 5, Scio Township, Dexter, Washtenaw County, Michigan, U.S.A. Identifications were made by Dwight W. Taylor, U.S. Geological Survey. Duplicate shells have been deposited in the collections of the Museum of Zoology, University of Michigan (*UMMZ* 197464), and the United States National Museum (*USNM* 628895). The material examined consisted of ovotestes of ten specimens, all in active stages of gametogenesis. The tissues were sectioned and stained by Newton's crystal violet following fixation in Sanfelice, and acetic-orcein squashes were prepared following fixation in Newcomer's fluid[7]. Observations were made with a Tiyoda microscope using a ×90 (n.a. 1·25) oil immersion objective and ×10–30 oculars.

All specimens of *Gyraulus circumstriatus* were found to have thirty-six elements (presumably all bivalents) present during late prophase and metaphase of the first meiotic division of spermatogenesis (Fig. 1). So far as could be determined, the pairing behaviour of the bivalents appeared to be normal, and during diakinesis the paired chromosomes were held together by one or more chiasmata.

Exact counts on gonial metaphase cells could not be made, but they contained about seventy-two chromosomes. As seen in squash preparations gonial metaphase chromosomes are monocentric, with median, submedian, or subterminal primary constrictions. This is in contrast to the 'dot-like' mitotic chromosomes described from sectioned material of *Gyraulus hiemantium* and considered to be characteristic of aquatic pulmonate snails[8].

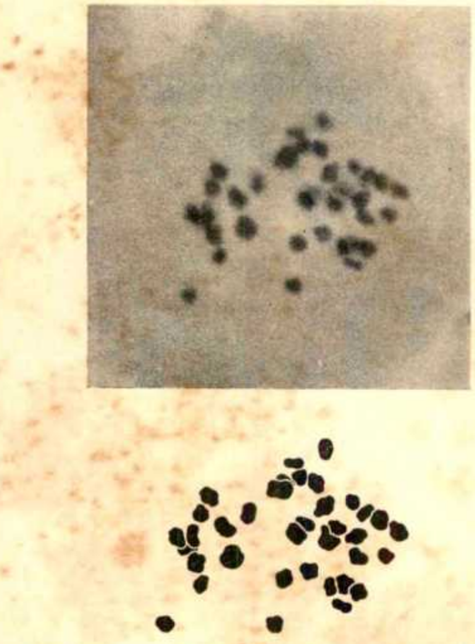


Fig. 1. Photograph and camera lucida drawing of prometaphase chromosomes of *Gyraulus circumstriatus* during the first meiotic division of spermatogenesis

Table 1. CHROMOSOME NUMBERS IN PLANORBID SNAILS

Species	Haploid No.	Diploid No.	Investigator
Anisus vortex	18	—	Le Calvez and Certain (ref. 6)
Gyraulus hiemantium	16	32	Inaba and Tanaka (ref. 8)
G. deflectus	18	36	Burch (ref. 9)
G. circumstriatus	36	*c.* 72	Burch (ref. 9)
Biomphalaria glabratus	18	—	Azevedo and Gonçalves (ref. 11)
olivaceus	18	—	Burch (ref. 9).
Helisoma subcrenatum	—	36	Bonham (ref. 10)
H. anceps	18	—	Burch (ref. 9)
H. trivolvis	18	36	Burch (ref. 9).
Planorbarius corneus	17	—	Azevedo and Gonçalves (ref. 11)
P. cornuta (= *corneus* ?)	18	—	Le Calvez and Certain (ref. 6)
Promenetus exacuous	18	—	Burch (ref. 9).

Chromosome numbers found in planorbid snails are shown in Table 1. It is interesting to note that with the exception of two species, *Gyraulus hiemantium* (Japan) and *Planorbarius corneus* (Portugal?), all species other than *Gyraulus circumstriatus* have a haploid chromosome number of eighteen. It should be emphasized also that this is the haploid number of the only closely related North American species studied, *Gyraulus deflectus*. These numbers, together with the hermaphroditic nature and ability for self-fertilization of planorbid snails, strongly suggest that *Gyraulus circumstriatus* is polyploid, that is, tetraploid. If this is true it is the first case of polyploidy to be found in pulmonate snails. The apparent rarity of polyploidy in snails indicates that this is not a major factor in the evolution of this group.

This investigation was supported (in part) by a research grant, *E*–952, from the National Institute of Allergy and Infectious Diseases, U.S. Public Health Service. Grateful acknowledgment is made to Linda L. Bush, Department of Biology, Western Michigan University, for technical assistance and to Henry van der Schalie, University of Michigan, for facilities and many kindnesses.

JOHN B. BURCH

Museum of Zoology,
University of Michigan,
Ann Arbor.

[1] Muller, H. J., *Amer. Nat.*, **59**, 663 (1925).

[2] Holzfuss, E., *Nachrichtsblatt deutsch. Malakozool. Gesellschaft* (1914). Colton, H. S., *Biol. Bull.*, **35**, 1 (1918). Crabb, E. D., *Trans. Amer. Micro. Soc.*, **47**, 1 (1928).

[3] White, M. J. D., "Animal Cytology and Evolution", 2nd ed. (Univ. Press, 1954).

[4] Mahoney, Rev. F. J., *Univ. Colorado Studies*, **26**, 3 (1940).

[5] Inaba, A., *J. Sci. Hiroshima Univ.*, **14**, 16 (1953).

[6] Le Calvez, J., and Certain, P., *C.R. Acad. Sci., Paris*, **231**, 16 (1950).

[7] Newton, W. C. F., *J. Linnean Soc.*, **47**, 316 (1926). Sanfelice, F., *Ann. Inst. Pasteur*, **32**, 8 (1918). La Cour, L., *Stain Tech.*, **16** (1941). Newcomer, E. H., *Science*, **118**, 3058 (1953).

[8] Inaba, A., and Tanaka, H., *J. Sci. Hiroshima Univ.*, **14**, 15 (1953). Inaba, A., *ibid.*, **14**, 16 (1953).

[9] Burch, J. B. (unpublished work).

[10] Bonham, K., *Growth*, **19**, 1 (1955).

[11] de Azevedo, J. F., and Gonçalves, M. M., *Anais Inst., Med. Trop.*, **13**, 4 (1956).

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, May 9

University of London (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 4 p.m.—Prof. Feodor Lynen (Munich): "Co-enzyme A and Fat Metabolism".*

University of London (at the Wright–Fleming Institute of Microbiology, St. Mary's Hospital Medical School, Norfolk Place, London, W.2), at 5 p.m.—Prof. A. Nenberger, F.R.S.: "The Digestion and Absorption of Protein in Normal Man and in some Pathogenic Conditions".* (Second of four Almroth Wright Lectures. Further Lectures on May 16 and 23.)

University College (in the Gustave Tuck Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. T. Kotarbinski (Polish Academy of Sciences, Warsaw): "Some Reflections on Praxiology. The Effectiveness of Human Actions".* (Further lectures on May 11 and 13.)

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Prof. J. M. Kay: "The Generation of Power". (First of three Cantor Lectures on "Energy".)

Tuesday, May 10

University of London (at the Institute of Obstetrics and Gynæcology, Hammersmith Hospital, London, W.12), at 2 p.m.—Prof. C. Scott Russell: "Pregnanediol".*

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

Royal Society of Arts, Commonwealth Section (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Sir Olaf Caroe: "The Pathans" (Sir George Birdwood Memorial Lecture).

Wednesday, May 11

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. Alwyn Williams: "The Stratigraphy and Brachiopod Faunas of the Caradocian Rocks of the Girvan District, South-West Ayrshire".

University of London (in the Wright–Fleming Institute Theatre, St Mary's Hospital Medical School, Norfolk Place, London, W.2), at 5 p.m.—Prof. G. W. Thorn (Harvard): "Current Concepts: Glucocorticoids and Gluconeogenesis".*

Institution of Electrical Engineers, Supply Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. G. Jancke: "The Development of the 400 kV. Network in Sweden".

University College (in the Physics Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. M. Nicolet (Institut Royal Météorologique de Belgique): "Solar Radiations and their Effects on the Upper Atmosphere".* (Further lecture on May 12.)

Challenger Society (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 5.45 p.m.—Annual General Meeting, followed by Dr. H. F. P. Herdman: "Modern Trends in Research Ship Design".

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 6 p.m.—Mr. C. M. Vignoles: "Petroleum People—Planning for To-morrow" (Presidential Address).

Society of Instrument Technology (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. A. E. Adams: "A Recording Stereocomparator".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. O. R. Frisch, F.R.S.: "Are the Laws of Nature Symmetrical?".

Thursday, May 12

Physical Society, Optical Group (at the National Physical Laboratory, Teddington, Middlesex), at 11.15 a.m.—Scientific Papers.

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. P. M. S. Blackett, F.R.S., Mr. J. A. Clegg and Mr. P. H. S. Stubbs: "An Analysis of Rock Magnetic Data"; Prof. W. H. McCrea, F.R.S.: "The Origin of the Solar System".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. J. H. Mason: "The Resistance of Sheet Insulation to Surface Discharges".

Royal Aeronautical Society, Astronautics and Guided Flight Section (at the Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1), at 6 p.m.—Mr. J. E. Allen: "On Reducing Costs of Space Research".

Friday, May 13

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. V. A. Ambartsumiam: "The Evolution of Stellar Systems" (George Darwin Memorial Lecture)

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant, Grade B (graduate, preferably possessing a degree which includes biological subjects and chemistry or physics) in the Natural Science Department, to teach biology to G.C.E. "A" level, human biology to G.C.E. "O" level, and elementary science—The Principal, Derby and District College of Technology, Kedleston Road, Derby (May 14).

Assistant Experimental Officer (graduate in chemistry, but those graduating in 1960 considered), for soil and plant analysis with sugar beet field experiments, at first near Lincoln and later near Bury St. Edmunds—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (May 14).

Lecturers and Assistant Lecturers (with research interests in inorganic chemistry, polymer chemistry or polymer physics) in Chemistry—The Registrar, Manchester College of Science and Technology, Manchester 1 (May 14).

Lecturers or Assistant Lecturers in Mathematics—The Registrar, The Manchester College of Science and Technology, Manchester 1 (May 14).

Research Assistant (qualified in biochemistry, physiology or zoology) to the Professor of Zoology—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8 (May 14).

Research Fellow in Electrophysiology in the Department of Experimental Psychiatry, to take part in research into the actions of drugs on the brain in experimental animals and eventually be responsible for the primate section of this programme—The Assistant Registrar, The Medical School, The University, Birmingham 15 (May 14).

Senior Lecturers in Metallurgy, Mathematics or Statistics, Pharmaceutical Microbiology, and Pharmacology; and Lecturers in Theoretical Chemistry, Mathematics and Pharmaceutics—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (May 14).

Assistant Lecturer in Organic Chemistry—The Secretary, The Queen's University, Belfast (May 16).

Assistants (3) (two in organic chemistry and one in inorganic chemistry) in the Department of Chemistry—The Secretary, The University, Aberdeen (May 20).

Tutorial Student in Mechanical Engineering—The Registrar, King's College (University of London), Strand, London, W.C.2 (May 20).

Assistant in the Department of Natural Philosophy—The Secretary, The University, Edinburgh (May 21).

Assistant (medical graduate, preferably with a B.Sc. degree in physiology) in the Department of Physiology—The Secretary, University College, Earlsfort Terrace, Dublin (May 21).

Demonstrator in Agricultural Microbiology in the Department of Agricultural Sciences, School of Agriculture, Sutton Bonington, near Loughborough—The Registrar, The University, Nottingham (May 21).

Assistant Lecturer (with a good honours degree and preferably holding the degree of B.Sc.) in Geography—The Registrar, The University, Nottingham (May 23).

Lecturer (with qualifications in pure mathematics) in Mathematics—The Secretary, The University, 36 North Bailey, Durham (May 23).

Shell Students (graduates in chemistry or engineering) in Chemical Engineering—The Registrar, King's College (University of London), Strand, London, W.C.2 (May 26)

Lecturer in Metallurgy—The Registrar, The University, Sheffield (May 28).

Lecturer (with a special interest in the philosophy of science) in Philosophy—The Registrar, The University, Hull (May 30).

Deputy (with experience of handling animals and preferably a zoological background) to the Director, Whipsnade Park, to assist the Director in the scientific and animal management work in the Park—The Secretary, Zoological Society of London, Regent's Park, London, N.W.1 (May 31).

Lecturer in Education; and a Lecturer in Geography in the Faculties of Arts and Economics, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 31).

Lecturer in Geology with special reference to aspects of Economic Geology and, in particular, to the Geology of Coal and Oil—The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (May 31).

Senior Lecturer in the Department of Anatomy at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, May 31).

Lecturer in the Department of Fuel Technology and Chemical Engineering—The Registrar, The University, Sheffield (June 1).

University Lecturer or Demonstrator (with qualifications in chemical or mechanical engineering, physical chemistry or physics) in the Department of Chemical Engineering—The Secretary of the Appointments Committee, Department of Chemical Engineering, Pembroke Street, Cambridge (June 1).

Lecturer (with a qualification in biochemistry and preferably a medical qualification) in Chemical Pathology—The Dean, St Thomas's Hospital Medical School, London, S.E.1 (June 4).

Senior Tutor/Demonstrator in Physics at the University of Sydney, Australia—Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 4).

Lecturer (preferably with a medical degree) in Chemical Pathology at the University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (June 6).

Chair of Physics—The Registrar, The University, Birmingham 15 (June 15).

Clinical Lecturer (registered veterinary surgeon, preferably with an interest in obstetrics, infertility and in reproductive diseases) in Veterinary Practice—The Registrar, Trinity College, Dublin (June 20).

Scientific Assistant (with a biological degree, the ability to write correct English and preferably some knowledge of foreign languages), for work which includes the abstracting and reviewing of biological literature—The Director, Commonwealth Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge (June 25).

LECTURER (with special qualifications or experience in inorganic chemistry) IN INORGANIC CHEMISTRY at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, June 30).

LINCOLN PROFESSOR OF CLASSICAL ARCHÆOLOGY AND ART—The Registrar, University Registry, Oxford (June 30).

RESEARCH STUDENTS (2) IN HISTORY OR ARCHÆOLOGY at the British Institute of History and Archæology in East Africa, Dar es Salaam—The Secretary, British Academy, Burlington House, Piccadilly, London, W.1 (October 31).

ASSISTANT, Grade B, TO TEACH BIOLOGY AND CHEMISTRY to G.C.E. Advanced Level with some general science—The Principal, Peterborough Technical College, Eastfield Road, Peterborough.

BIOCHEMIST (Basic grade)—The Secretary, St. Helier Hospital, Carshalton, Surrey.

CHAIR OF PHYSICS; and a CHAIR OF BIOLOGY in the Royal University of Malta—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

CHEMIST or BIOCHEMIST (with a good honours degree in chemistry or biochemistry and preferably with postgraduate experience) IN THE RADIOBIOCHEMISTRY DEPARTMENT, for biochemical research involving the use of radioactive isotopes and in particular carbon-14 and tritium—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 60/3.

INSTRUCTORS or ASSISTANT PROFESSORS (well qualified candidates) IN THE DEPARTMENT OF CHEMISTRY—Prof. C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver 8, B.C., Canada.

LECTURER IN MATHEMATICS—The Registrar, Bradford Institute of Technology, Bradford 7.

MICROBIOLOGIST, to participate in research dealing with the origin, constitution and utilization of fossil fuels—The Secretary, Research Council of Alberta, 87th Avenue and 114th Street, Edmonton, Alberta, Canada.

PHYSICAL METALLURGISTS or PHYSICISTS (with research experience) IN THE PHYSICAL METALLURGY DIVISION, Department of Mines and Technical Surveys, Canada, to work with a group carrying out fundamental investigations in metal physics—Dept. M.T.S., National Employment Service of the Government of Canada, 61 Green Street, London, W.1.

PHYSICIST (basic grade)—The Secretary, Royal Free Hospital, Gray's Inn Road, London, W.C.1.

PRINCIPAL LECTURER IN NUMERICAL ANALYSIS, a SENIOR LECTURER IN STATISTICS, and an ASSISTANT LECTURER (Grade B) IN THE DEPARTMENT OF MATHEMATICS—The Principal, Welsh College of Advanced Technology, Cathays Park, Cardiff.

RESEARCH ASSISTANT (with a physics, mathematics or engineering degree, and interested in heat transfer and particularly in computational work in that field), for an original investigation into the transient temperature distribution in the rotors of steam turbines—Dr. R. D. Hoyle, Mechanical Engineering Department, City and Guilds College, Exhibition Road, London, S.W.7.

SCIENTIFIC OFFICER (with an honours degree in chemistry) at Northern Outfall Works, Beckton, London, E.6, for control, development and research—Medical Officer of Health (D.1/A), County Hall, London, S.E.1.

SENIOR GEOLOGIST (with a Ph.D. degree in sedimentary geology and an interest in stratigraphy) WITH THE PETROLEUM AND NATURAL GAS BRANCH of the Department of Mineral Resources, Regina, Saskatchewan, Canada, to prepare reports for publication on strata considered to have petroleum possibilities—The Agent-General for Saskatchewan, 19 Chester Mews, London, S.W.1.

SENIOR LABORATORY TECHNICIAN, to be responsible for the new physics teaching laboratories and lecture demonstrations up to degree standard—The Secretary, King's College, Strand, London, W.C.2, quoting Ref. 3072.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Northampton College of Advanced Technology. Report of the Governing Body for the year 1958–1959. Pp. 23. Prizes and Certificates, Session 1958–1959. Pp. 24. (London: Northampton College of Advanced Technology, 1960.) [172

Annual Review of the British Electronic Engineering Association, 1959. Pp. 28. (London: British Electronic Engineering Association, 1960.) [172

Outrock Engineering Co., Ltd. Geological Laboratory and Field Equipment. Pp. iii+24. (London: Outrock Engineering Co., Ltd., 1960.) [172

Report on Defence 1960. Pp. 18. (Cmnd. 952) (London: H.M. Stationery Office, 1960.) 1*s.* net. [192

Ministry of Agriculture, Fisheries and Food. Bulletin No. 179: Identification of Seedlings of Common Weeds. By R. J. Chancellor. Pp. ii+72. (London: H.M. Stationery Office, 1959.) 4*s.* 6*d.* net. [192

Ministry of Agriculture, Fisheries and Food. Crop Protection Products Approved Scheme—Approved List 1959–60. Pp. 64. (London: Ministry of Agriculture, Fisheries and Food, 1960.) [192

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 1009, Vol. 252 (18 February 1960): On Adsorption at the Oil/Water Interface and the Calculation of Electrical Potentials in the Aqueous Surface Phase. 1: Neutral Molecules and a Simplified Treatment for Ions. By D. A. Haydon and F. H. Taylor. Pp. 225–248. 7*s.* 6*d.* No. 1010, Vol. 252 (18 February 1960): The Cauchy Problem for Elastic Waves in an Anisotropic Medium. By G. F. D. Duff. Pp. 249–273. 8*s.* No. 1011, Vol. 252 (18 February 1960): Atmospheric Waves Caused by Large Explosions. By J. N. Hunt, R. Palmer and Sir William Penney. Pp. 275–315. 13*s.* (London: Royal Society, 1960.) [192

B.C.I.R.A. Journal, Vol. 8, No. 1 (with which is incorporated the B.C.I.R.A. Bulletin and Foundry Abstracts). Pp. 162. Subscription rates: Sterling area £6 6*s.* 0*d.* per annum; Dollar area 20 dollars per annum. (Alvechurch, Birmingham: British Cast Iron Research Association, 1960.) [192

British Steel Castings Research Association. Data Sheets on Moulding Sands. Second, revised and enlarged edition. Pp. x+45. (Sheffield: British Steel Castings Research Association, 1960.) 30*s.* [192

Scientific Council for Africa South of the Sahara. Publication No. 37: Tenth Meeting of the Scientific Council, Kampala, 1959. Pp. 135. (London: Secretariat, C.C.T.A./C.S.A., Abbey House, Victoria Street, 1959.) [192

Research in Veterinary Science, Vol. 1, No. 1 (January 1960). (A Journal of the British Veterinary Association.) Pp. 93. Published quarterly. Annual subscription: 90*s.* post free. Single issues 25*s.* (Oxford: Blackwell Scientific Publications, 1960.) [192

Beyond Nihilism. By Prof. Michael Polanyi. (The Thirteenth Arthur Stanley Eddington Memorial Lecture, 16 February 1960.) Pp. iv+37. (Cambridge: At the University Press, 1960.) 3*s.* 6*d.* net. [192

British Universities Film Council. The Use of Film in Teaching and Research in British Universities 1959. (A Report of an investigation carried out in selected University Departments by a Sub-committee: G. E. H. Foxon, G. H. Bell, and C. J. Duncan.) Pp. 24. (Newcastle upon Tyne: C. J. Duncan, Hon. Secretary, British Universities Film Council, c/o The Medical School, King's College, 1960.) [192

Planning, Vol. 26, No. 439 (22 February 1960): The Market for Coal. Pp. 37–64. (London: Political and Economic Planning, 1960.) 3*s.* [192

Building Research Station Digest, No. 131 (February 1960): External Rendered Finishes. Pp. 4. (London: H.M. Stationery Office, 1960.) 4*d.* [192

Other Countries

United States Department of the Interior: Geological Survey. Water-Supply Paper 1308: Compilation of Records of Surface Waters of the United States through September 1950. Part 5: Hudson Bay and Upper Mississippi River Basins. Prepared under the direction of J. V. B. Wells. Pp. v+708+1 plate. Water-Supply Paper 1315–A: Compilation of Records of Surface Waters of the United States through September 1950. Part 11–B: Pacific Slope Basins in California, Central Valley. Prepared under the direction of J. V. B. Wells. Pp. v+458+1 plate. Water-Supply Paper 1503: Surface Water Supply of the United States, 1957. Part 2–A: South Atlantic Slope Basins, James River to Savannah River. Prepared under the direction of J. V. B. Wells. Pp. viii+323. 1.25 dollars. Water-Supply Paper 1507: Surface Water Supply of the United States, 1957. Part 4: St. Lawrence River Basin. Prepared under the direction of J. V. B. Wells. Pp. ix+379. 1.25 dollars. (Washington, D.C.: Government Printing Office, 1959.) [192

United States Department of the Interior: Geological Survey. Professional Paper 313–A: The Phosphoria, Park City and Shedhorn Formations in the Western Phosphate Field. By V. E. McKelvey and others. Pp. v+47+3 plates. 1 dollar. Professional Paper 316–C: Regional Geophysical Investigations of the Lisbon Valley Area, Utah and Colorado. By P. Edward Byerly and H. R. Joesting. Pp. iii+39–50+plates 6–9. Professional Paper 354–A: Intrenched Meanders of the North Fork of the Shenandoah River, Virginia. By John T. Hack and Robert S. Young. Pp. iii+10+1 plate. 20 cents. (Washington, D.C.: Government Printing Office, 1959.) [192

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 41, No. 2: Birds from Gabon and Moyen Congo. By Austin L. Rand, Herbert Friedmann and Melvin A. Traylor, Jr. Pp. ii+221–411. (Chicago: Chicago Natural History Museum, 1959.) 3.50 dollars. [192

Transactions of the American Philosophical Society, New Series. Vol. 50, Part 1: Contemporary Japan: The Individual and the Group. By Y. S. Matsumoto. Pp. 75. 2 dollars. Vol. 50, Part 2: Studies in Byzantine Astronomical Terminology. By Prof. O. Neugebauer. Pp. 45. 1.50 dollars. (Philadelphia: American Philosophical Society, 1960.) [192

Bulletin of the Florida State Museum, Biological Sciences. Vol. 5, No. 2: A Bilaterally Gynandromorphic *Hypodynerus*, and a Summary of Cytologic Origins of Such Mosaic Hymenoptera. Biology of Eumenine Wasps, VI. By Kenneth W. Cooper. Pp. 25–40. 35 cents. Vol. 5, No. 3: How Many Species of Birds have Existed. By Pierce Brodkorb. Pp. 41–58. 25 cents. (Gainesville, Fla.: Florida State Museum, 1959 and 1960.) [192

United States Department of the Interior: Fish and Wildlife Service. Fishery Bulletin No. 163: Contributions of Hudson and Connecticut Rivers to New York–New Jersey Shad Catch in 1956. By Kenneth J. Fischler. Pp. iv+161–174. (Washington, D.C.: Government Printer, 1959.) 20 cents. [192

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved Registered as a newspaper at the General Post Office

SCIENTIFIC RESEARCH IN THE OVERSEAS TERRITORIES OF THE BRITISH COMMONWEALTH

IN a recent book, "The End of Empire"[*], Mr. John Strachey argues cogently that Britain has a unique opportunity to lead the world in meeting the needs of the under-developed peoples and that, in doing so, in supplying both material means and technical skills, she can rise to a new level of national greatness. Mr. Strachey does not enter into any detail as to how this is to be done, and only passing reference is made to the Colombo Plan, the Colonial Development Corporation and the Colonial Development and Welfare Funds. Much stress is, however, laid on the replacement of the old conception of 'Colonial' by something wider, perhaps even wider than that of 'Commonwealth', though Mr. Strachey readily admits that the idea and the structure of the British Commonwealth offer possibilities of genuine advance.

From this point of view alone there is much to be said for the creation of the Overseas Research Council, though it is all the stranger that it should have been left for a question in the House of Commons to elicit the statement that the Colonial Research Council was dissolved in August 1959, and that its functions as an advisory and co-ordinating body now fall to the Overseas Research Council, which is responsible to the Minister for Science and operates in relation to overseas research generally. This was stated by Mr. Ian Macleod, Secretary of State for the Colonies, on March 10, and accordingly it would seem that "Colonial Research 1958–59"[†], which includes the report of the Colonial Research Council on Colonial research during the year 1958–59, along with the reports of the several specialist advisory bodies and one on research matters not covered by their reports, is the last to appear from the Colonial Research Council. Although, however, the covering letter submitting the report is dated November 4, 1959, no reference is made in any of these reports to the change, nor is any indication given as to the proposed future policy in regard to publication.

It would be difficult, however, to over-stress the importance of the work which has been briefly described in the reports collected under the general title "Colonial Research" during the past decade, and comments recently made by Dr. B. V. Bowden, principal of the Manchester College of Science and Technology, in two articles in *The Guardian* of March 9 and 10 dealing with his recent visit to Ghana, show how important it is both that such work should receive effective publicity and also that research work should be stimulated on an adequate scale in the university and technological institutions of the overseas territories before and after they achieve independent status. Dr. Bowden's articles show that the importance of research is as yet far from being understood in these emerging nations, or the contribution it can bring to the solution of their problems. The research schemes supported from Colonial Development and Welfare Funds and the research branch of the Overseas Civil Service may well increase rather than decrease in importance during the next decade.

The schemes noted in the present report—71 new schemes and 63 supplementary—involve grants totalling £798,974 and bring the total allotted to Colonial Development and Welfare Research Schemes since 1940 to £19,493,932; actual disbursements now total nearly £14·7 million. Much the largest research schemes approved during the year ended March 31, 1959, are those for the Tropical Section of the Road Research Laboratory (£121,568), the Colonial Pesticides Research Unit, Arusha, East Africa (£71,188) and the maintenance of the Anti-Locust Research Centre, 1958–59 (£65,657); £31,405 was for trachoma research, 1958–60; £23,372 for the Desert Locust Survey; £39,524 for the Tropical Metabolism Research Unit, Jamaica; £22,728 for agricultural research in Swaziland; some £31,000 for the West African Building Research Unit; £19,440 for the Colonial Microbiological Research Institute, Trinidad; £20,226 for the Seismic Research Unit in the Imperial College of Tropical Agriculture, Trinidad; £15,825 for the establishment of a cocoa research station in the British Solomon Islands Protectorate; and £15,000 for sorghum breeding research in East Africa. While no other research grants exceeded £15,000, these examples sufficiently indicate the vital importance of continued support from the United Kingdom, both in respect of the nature of the schemes and the financial resources of the territories concerned, even when due regard is had to the assistance already given by the Colonial governments from their own resources.

It is obvious from these figures that the research schemes represent a relatively minor proportion of the assistance already being given to the lesser developed countries from British Government funds. The White Paper "Assistance from the United Kingdom for Overseas Development"[*] put the total at £138 millions in the current year alone, an increase of £57 million on 1957–58, and although the former sum represents about 1·25 per cent of the national income of the United Kingdom, the White Paper urges the need to continue and if possible increase this effort. It may well be that the proportion going to research schemes is the one that, apart from educational assistance, most urgently needs increasing and, as already suggested, the need may become even more urgent as the Colonial territories achieve independence. About 33 per cent of the gross allocation of Colonial Development and Welfare Research Funds has been for agricultural, animal health and forestry schemes, 17 per cent for medical research, 9 per cent for fisheries research, 10 per cent for tsetse and trypanosomiasis research, 8 per cent for social science and economic research, 9 per cent for pesticides research, 5 per cent for research sponsored by the Colonial Products Council and 3 per cent for anti-locust research. Frequently such research involves the co-operation of research institutions and organizations working in several territories, and it may not be easy for a newly independent territory always to appreciate the significance of such work or the factors determining its success. A similar observation might be made of some of the work described in the section of "Colonial Research" which deals with research matters not covered by the reports of the specialist advising bodies. Building and housing research, for example, largely relies on the work of the Tropical Building Section of the Building Research Station of the Department of Scientific and Industrial Research in Britain. The Geodetic and Topographical Surveys and the Geological Surveys as well as meteorological research also depend largely on assistance from the United Kingdom, and although in East Africa there is a flourishing Industrial Research Organization, elsewhere the Crown Agents' Engineering Advisory Service assists and advises overseas officers on a wide range of technical matters; reference is also made particularly to advice given overseas by the Water Pollution Research Laboratory.

---

[*] The End of Empire. By John Strachey. Pp. 351. (London: Victor Gollancz, Ltd., 1959.) 30*s.* net.

[†] Colonial Office. Colonial Research 1958–1959: Reports of the Colonial Research Council; Committee for Colonial Agricultural, Animal Health and Forestry Research; Colonial Economic Research Committee; Colonial Fisheries Advisory Committee; Colonial Medical Research Committee; Colonial Pesticides Research Committee; Colonial Products Council; Colonial Road Research Committee; Colonial Social Sciences Research Council; Tsetse Fly and Trypanosomiasis Committee; Director, Anti-Locust Research Centre; and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. Pp. 419. (Cmnd. 938.) (London: H.M. Stationery Office, 1959.)

[*] "Assistance from the United Kingdom for Overseas Development." Cmnd. 974. Pp. 19. (H.M.S.O., 1960.) 1*s.* net.

In much of this work man-power is an important factor. Twenty-five new appointments brought the total complement of the Research Branch of the Overseas Civil Service to 207 in March 1959. There was also a Research Fellow studying nematode damage on East Africa crops, who completed his investigations during the year, and a second continuing work on human trypanosomiasis at the West African Institute for Trypanosomiasis Research; two further Research Fellowships were awarded for work at the University College of the West Indies as well as two research studentships in medicine and one in soil science for training for research appointments overseas.

Measured against the tasks still to be undertaken, let alone completed, this man-power seems slender even when allowance is made for the substantial contribution made by British universities and the staffs responsible to the several research councils such as the Council for Scientific and Industrial Research, the Medical Research Council and the Agricultural Research Council. The question of man-power is undoubtedly one of the most important which the Overseas Research Council will have to face, and it should be able to count on the full support of the Advisory Council for Scientific Policy, perhaps the more especially since the recent inquiry into scientific and engineering man-power in Great Britain conducted for that Council by its Committee on Scientific Man-power made no estimates of the demand for such man-power overseas. The proceedings of the Commonwealth Education Conference again show how important it is that the overseas need should receive full attention in planning the expansion of university and of technological education.

In this context the new Overseas Research Council will require to work in close association with the Scientific Council for Africa South of the Sahara and with the Commission for Technical Co-operation in Africa South of the Sahara. The recently published report of the tenth meeting of the Scientific Council* gives no indication of the resources at the disposal of either the Council or the Commission; but, quite apart from the extent to which many problems in Africa depend on international co-operation for their solution, it is obvious that every effort should be made to avoid duplication of effort, and to use the limited resources of scientific and technical man-power as wisely as possible and where the maximum advantage to the general benefit can be obtained. Reference is already being made to the increasing difficulty in co-ordinating agricultural research projects, for example, owing to the speed of developments in Africa, and only international action can hope to solve the problems raised by the destruction of natural resources in Africa.

There are indeed signs that co-operation is developing. An Inter-African Conference on hydrology is to be held at Nairobi in January 1961, and the Inter-African Pedological Service, which was expected to be fully staffed by the autumn of 1959, reports progress with the pedological map of Africa except in West Africa. The Inter-African Soils Bureau is directing its activities more towards liaison between technical organizations working in Africa and is seeking to play a more dynamic part. Inter-African Conferences on Soils and on Forestry have already been held, and the Food and Agriculture Organization of the United Nations intends to set up in Africa a regional forestry commission as in other continents. Other examples are to be seen in the Inter-African Bureau for Epizootic Diseases, the function of which in examining requests for technical aid in the field of animal diseases is likely to develop in future, the Inter-African Conferences on Housing and Urbanization and on Labour, of which two and six, respectively, have already been held, and the Inter-African Committee on Maps and Surveys.

One note of caution should be sounded in respect of any developments depending on the Scientific Council for Africa South of the Sahara. Among the participants are the Union of South Africa, which indeed supplies the present chairman in the person of

---

* Scientific Council for Africa South of the Sahara. Publication No. 37: Tenth Meeting of the Science Council, Kampala, 1959. Pp. 135. (London: Secretariat, C.C.T.A./C.S.A., Abbey House, Victoria Street, 1959.)

Dr. P. S. du Toit, and Dr. S. M. Naudé as an ordinary member. Recent events in South Africa and the general policy of the South African Government must make it more than doubtful whether the continued support of that Government can be expected, and even whether its membership of the Council will continue to be acceptable to other countries. The ultimate effect of the South African Government's policies towards the universities and eventually to scientific research is likely to stultify the value of much of its contribution.

The picture of co-operation provided in "Colonial Research 1958–59" is much more reassuring. Much the longest of the reports of the ten specialist advisory bodies is that of the Committee for Agricultural, Animal Health and Forestry Research, which occupies more than 170 pages out of a total of 419. Besides stressing the importance of the work being done by the Commonwealth Institute of Entomology, the Commonwealth Institute of Biological Control, the Commonwealth Mycological Institute and the Department of Statistics at the Rothamsted Experimental Station, this report deals at length with the work of various regional organizations such as the East Africa Agriculture and Forestry Research Organization, the East Africa Veterinary Research Organization and the West African Cocoa Research Institute. The much shorter reports of the Colonial Fisheries Advisory Committee and the Colonial Social Science Research Council are likewise much concerned with the work of regional bodies. But the report of the Colonial Pesticides Research Committee, by and large, depends on the work of such co-operative ventures as the Colonial Pesticides Research Unit at Porton, the Agricultural Research Council's Unit of Experimental Agronomy at Oxford, the Silwood Park Field Station of the Imperial College of Science and Technology, the Colonial Pesticides Research Unit, East Africa, and the West African Fungicides Team.

The bulk of the work of the Tsetse Fly and Trypanosomiasis Committee is carried out through the East African Trypanosomiasis Research Organization and the West African Institute for Trypanosomiasis Research, while that of the Anti-Locust Research Centre on locust research and control is peculiarly dependent on political factors which may retard or favour international co-operation. This year's report refers to a notable tendency to expand and strengthen international co-operation both in locust control and in these lines of research which provide a basis for practical anti-locust measures. The Director refers appreciatively both to the help given by the Food and Agriculture Organization, the United Nations Educational, Scientific and Cultural Organization and the World Medical Organization, and to progress made in research on problems of locust biology.

In such conditions it is impossible for scientific and technical research on problems of the Colonial or Overseas Territories to disregard entirely the political situation, at least so far as it affects the conditions in which scientific and technical work is pursued. It would indeed be wrong if scientists and technologists failed to make representations when particular policies threaten the conditions in which creative work, effective co-operation between scientists and technologists of different nationalities or races, or the free interchange of scientific and technical knowledge, are possible. "Colonial Research 1958–59" provides an impressive picture of the effort which is already being made in Great Britain to serve the Overseas Territories, whether dependent or independent. But there is no room for complacency; expansion is an urgent need. It is the more important, therefore, that the political conditions which determine its efficiency and effectiveness should be clearly understood, and that government policies should be such as to encourage and not hinder or frustrate the essential co-operation and the creative work which have so much to bring to the welfare and development of the less advanced peoples.

MODERN PHILOSOPHY OF SCIENCE

Modern Philosophy of Science

Selected Essays. By Hans Reichenbach. Translated and edited by Maria Reichenbach. Pp. ix+214. (London: Routledge and Kegan Paul, Ltd.; New York: Humanities Press, 1959.) 28*s*. net.

THIS book contains eight articles by the late Prof. Hans Reichenbach, only one of which has previously appeared in English. Five are translated from earlier appearances in German, and two, concerned with the ethical problem, are compiled from MS. notes left by the author. The translation and editing have been carried out by the author's widow, Mrs. Maria Reichenbach, and there is a short foreword by Prof. R. Carnap. A valuable feature of the book is a complete bibliography of Reichenbach's writings which is appended.

Reichenbach was one of the founders of the logical-empiricist school of philosophy which came into being mainly through the philosophical implications of the theory of relativity, and throughout his life he remained one of its ablest and clearest expositors. Anything from his pen is worth reading. Nevertheless, it is doubtful whether the present volume was a well-advised venture. Much of the material has been incorporated in better form in work published by Reichenbach during his lifetime, and some of the remainder—particularly the first essay, which replies to some early objections to relativity—is no longer of vital interest. The immediate philosophical reaction to the relativity theory was the charge that it violated certain fundamental philosophical principles and therefore could not be true. This is now generally acknowledged to have been due to a misunderstanding. It is clear that, so far as such principles are concerned, the theory could be true: the important question now is whether it is true. The criticisms which Reichenbach set out to answer in 1921 have long ceased to trouble anyone.

The essay on "The Freedom of the Will", together with a short note on "The Explication of Ethical Utterances", constitute the part of the book not previously published. This was well worth issuing, for it presents in more detailed form ideas already adumbrated in "The Rise of Scientific Philosophy", published in 1951. The thesis maintained is that while determinism excludes complete freedom of the will, probabilistic causality does not, and a "non-cognitive theory of ethics" is advanced of which the essence is "the recognition of the non-logical relation between knowledge and action". This is consistent with the author's general philosophy of science, of which "The Rise of Scientific Philosophy" gives an admirable account. Owing to the much more speculative nature of the subject, however, it is scarcely likely to carry the same conviction as the epistemological discussions which are more directly related to the actual content of modern physical theory.

HERBERT DINGLE

SOCIOLOGY: THE NEW HOPE

The Sociological Imagination

By C. Wright Mills. Pp. vii+234. (London and New York: Oxford University Press, 1959.) 36*s*. net.

THIS book has, in effect, three themes: (1) a sociological account of the present state of the social sciences themselves, and particularly of the state of sociology in the United States; (2) recommendations concerning what the social sciences should be like, and finally, (3) reflexions on our times. The three themes are, of course, closely interwoven, for the account of current sociology is largely a condemnation which calls for a specification of a better way, while the diagnosis of how the ills came about requires a discussion of the wider social factors responsible for them.

At the root of sociology and the social sciences lies a great hope and a promise—of a kind of collective self-knowledge. If there is one thing which ought to be obvious (though there are still people to whom it is not) it is that society constrains us, that our lives, thoughts and aims are, at the very least, conditioned by a social framework we never made or chose, and in a way we often do not understand. Sometimes, and for those fortunate enough to be in a congenial environment, this is no source of sorrow: but when the insight is combined with a partial rejection or failure of current values and institutions, it leads to a hope of control through knowledge. This hope, as Prof. Mills reminds us, was at the origin of sociology, and it still powerfully animates him—if not all his colleagues.

If there is one country where this hope might be thought to have better expectations of fulfilment than elsewhere, it is the United States, where sociology is a recognized and extensive profession, where it is neither muzzled (as it is behind the Iron Curtain), nor ignored as the dubious fad of a marginal minority. In fact, the picture in the United States is not at all rosy, despite the number of sociologists and the recognition they receive. Prof. Mills provides an explanation, and he does it brilliantly.

A good deal of the output of the flourishing American sociological profession consists, using Mills's terms, of "Grand Theory" or of "Abstracted Empiricism". "Grand Theory", not to put too fine a point on it, is simply pretentious verbiage of a kind which has to be read to be believed. Prof. Mills charitably says that it does contain some ideas, and heroically extracts them for us. The respectable mice rescued from under the mountains of rubbish are insights—valid so far as they go and well suited for any systematic treatment of societies—such as that social life consists of the interaction of individuals with reasonably stable reciprocal expectations, with shared values which had been inculcated by a common background, and so forth . . . (but not for very long, for this is nearly all there is in it).

"Abstracted Empiricism" consists of the proliferation of ritualized, standardized surveys, usually by means of questionnaires, in which the collection of dubiously valuable or even reliable data is guided by little thought or concern with genuine questions. The blindness of such "Abstracted Empiricism" complements the emptiness of "Grand Theory".

Prof. Mills gives us a convincing account of how these fashions came to be dominant. Their roots are various: the emulation of a false image of natural science, an image which was mistaken anyway, and which in any case, even if it were valid, could not be easily re-applied to social matters; the shift of the practical impulse from, roughly speaking, helping the poor to helping sales promotion and the manipulation of personnel; the safe political innocuousness of the new practices; the (probably inevitable) bureaucratic ethos inherent in the administration of foundations, expensive and large-scale research, etc. (Natural scientists are fortunate in that the traditions of their subject were well established before our present era. One shudders to think what might have happened had the foundations existed in the early days of the Royal Society.)

Prof. Mills attempts to do more than describe and analyse the current ills, he also hopes to remedy them. His recommendations to sociologists are sound and perceptive. So are his reflexions on our times and the part that thought and valuation can play in the modern world. I only fear that he may implicitly —in trying to stem the tide—be too optimistic, that the general social factors on the other side are too strong. I hope I am wrong.

But this is not a book which will stand or fall by either the soundness or the success of its positive recommendations. It is already fully justified by the admirable account offered of an important if unattractive phenomenon, and one which is playing a very significant part in American life. This was, so to speak, a necessary book. Somebody had to write it, and we can all be thoroughly grateful that the somebody was Prof. C. Wright Mills.

E. GELLNER

DAIRYING IN GREAT BRITAIN

The United Kingdom Dairy Industry

Edited by Prof. E. L. Crossley. (Prepared under the auspices of the XV International Dairy Congress on behalf of the United Kingdom Dairy Association.) Pp. viii+142+16 plates. (London: United Kingdom Dairy Association, 1959.)

THIS book was written to mark the fifteenth International Dairy Congress held in London during the summer of 1959; it provides a valuable picture of the state of the dairy industry in the late fifties. Prof. E. L. Crossley, helped by a list of distinguished contributors, has distilled 142 remarkably uncluttered pages of useful information. He begins by setting dairying in relation to other branches of agriculture and reminds us that milk and dairy products worth no less than £350 million are produced annually on British farms. This forms about one-third of the total agricultural output and represents almost twice as much milk as was produced for sale in 1935, or is produced at the present time in such major dairying countries as Denmark, the Netherlands and New Zealand. Further, the annual increase in milk production has also been considerably more rapid than in most other dairying countries.

From the economic structure of the industry we pass to milk production on the farm and the astonishing changes which have taken place since 1935 in the national herd, in milk recording, in artificial insemination, in the feeding and management of cows and in the design and use of cowsheds and milking machines. Nor are the advisory services, the necessary milk regulations and the means of controlling milk quality overlooked.

About two-thirds of the book is devoted to dairying in its narrower sense, to milk collection, transport and reception, to pasteurization, sterilization and bottling of milk, with all the machinery these involve to-day, to some essentially British aspects of milk distribution and to the control of milk quality at every stage. Naturally we find also an account of the development of a highly efficient dairy technology from the traditional farm-house manufacture of cream, butter and cheese.

The book concludes with chapters describing the training of young people for the dairy industry and outlining the work now in progress at the main centres of research. For readers who find here a new or wider interest in dairying—and they will certainly number more than the overseas Congress visitors at whom the book was modestly aimed—there is a useful list of general information. This provides a ready means of following any topic in greater detail. There is also an abundance of good illustrations ranging appropriately from attractive coloured drawings of the breeds of dairy cattle to most appetizing pictures in beautiful colour of the industry's greatest triumph, British territorial cheeses at their best.

C. C. Balch

CENTRAL AFRICAN SAVANNAHS

Les Savanes de l'Afrique Centrale

Essai sur la Physionomie, la Structure et le Dynamisme des Formations Végétales Ligneuses des Régions Sèches de la République Centrafricaine. Par Roger Sillans. (Encyclopédie Biologique, Tome 55.) Pp. xv+424+2 planches. (Paris: Éditions Paul Lechevalier, 1959.) 16,000 francs.

In spite of the wider geographical implications of the title, this book relates directly only to the territory of Oubangui-Chari, which with the Cameroons and Moyen Congo to its west, and the Sudan to its east, is, from its central position in tropical Africa, of more than usual importance for considering questions of plant-geography. Based on a doctoral thesis by R. Sillans, it is primarily a record of personal observation and study of the savannahs of that part of Africa, and more especially of their woody vegetation.

The contents of this book follow an arrangement not unusual in studies such as these, with descriptions of climate, geography, geology and soils, and a general account of the ecological classification of the vegetation of Oubangui-Chari, followed by a discussion of the methods employed by the author and some of the terms used. After this preliminary matter there is a much more detailed account of the savannah vegetation, together with a floristic list of the known woody species.

The territory shows a range of vegetation from lowland rain-forest to woodland and savannah, spread over a rather uniform topography, and accompanied by gradual climatic changes. As the author suggests, there are no natural frontiers to the territory. In all, some 3,600 species occur, among which are a number of endemics of which the author gives a list. This, however, needs some revision: for example, *Cola gigantea* is not endemic, and the remarkable Bignoniaceous genus *Tisserantodendron* occurs also in the Cameroons. The author also attempts to give a biological spectrum of the flora.

That part of the work of most general interest deals with the author's conclusions about how the vegetation has evolved. He maintains that the original covering of forest or woodland has been and is still being destroyed by means of clearing for the purpose of subsequent cultivation. Repeated through the centuries, this clearing, accompanied by partial or complete felling and by firing of the resultant débris, has entailed modifications in vegetation, species, soil and, perhaps, climate. The forest is replaced by tall grassland with more or less scattered trees, which may itself develop into savannah-woodland and ultimately, perhaps, again into forest. The savannahs of Oubangui-Chari in fact represent, according to the author, various stages in seral regeneration following cultivation.

Now, according to Sillans, the original regression of the forest is in no way due to bush-fires; not until cultivation has resulted in the establishment of grassland can they enter. He considers that their destructive effect has been over-estimated, and that they do not normally prevent a gradual re-development of savannah woodland into forest. No evidence of real adaptation of plants to a permanent régime of fires is regarded by him as proved; but there is an interesting account of nanism and the 'suffruticose' habit being induced in a species of *Bridelia* through repeated cutting in connexion with cultivation.

The problems of the age and origin of bush-fires and their effect on the savannah vegetation of tropical Africa are still most disputed; in fact Prof. J.-L. Trochain, in a preface to the book, combats some of M. Sillans's views. The ultimate solutions are, however, brought nearer by the important evidence presented in this work. I am, however, appalled by its price of 16,000 francs.

J. P. M. Brenan

UNSTEADY SUPERSONIC FLOW

The Potential Theory of Unsteady Supersonic Flow

By Prof. John W. Miles. (Cambridge Monographs on Mechanics and Applied Mathematics.) Pp. xii+220. (Cambridge: At the University Press, 1959.) 45*s*. net.

The aerodynamic theory of unsteady flows is mainly concerned with questions of the following type: If a wing or body, moving forward with constant speed, has a prescribed transverse motion about its rectilinear mean path, what are the resulting forces and moments? During the golden age of the linearized theory of compressible flow (1945–55 approximately), when it was permissible to assume that wings were thin, Mach numbers moderate, and disturbances small, a considerable store of answers to such questions was established. Prof. Miles was very much in the forefront of the attack on these problems, and the appearance of his authoritative book on the subject is to be welcomed.

The book deals mainly with the supersonic theory, in which the existence of domains of influence and dependence makes it possible to solve explicitly a number of linearized problems. The opening chapter is a careful study of the restrictions appropriate to various approximate governing equations, of which that corresponding to the sound equation in still air is the most important: various xt-transformations (x is the streamwise co-ordinate, t the time) of this equation are then considered. Basing his presentation not on the traditional method of retarded-potential doublets but on the more compact method of integral transforms, Prof. Miles makes short work of each of the following problems: two-dimensional wings, the rectangular wing of semi-infinite span, wings with 'supersonic' edges, and the extension of Evvard's method to wings with straight, subsonic side-edges. For the delta wing with subsonic edges, further approximations are necessary. There is a detailed account of methods for wings of slender planform and slender bodies, and the book ends with a genuflexion towards non-linear problems.

Despite the formidable economy of his presentation, the author cannot treat all the ramifications of his subject in a book of modest size, but there are ample references to papers on those (mainly secondary) questions which are not included. The book maintains the high standard of the Cambridge Monographs on Mechanics and Applied Mathematics.

L. E. FRAENKEL

MONKEYS AND DISEASE

Diseases of Laboratory Primates

By Prof. Theodore C. Ruch. Pp. xxvi+600. (Philadelphia and London: W. B. Saunders Company, 1959.) 52*s*. 6*d*.

THIS volume is the first of four parts of a projected "Handbook of Primates", and treats in monographic form the spontaneous diseases of laboratory primates. The main topics reviewed are the diseases caused by parasitic agents and, to a lesser extent, nutritional disorders, both of which have an important bearing on the management of a monkey colony. In addition to this information, which is of immediate practical value, the author also describes the nature of conditions such as cardiovascular and dental diseases and suggests that monkeys may be suitable animals for research into these problems.

Three of the more important conditions—enteric diseases, respiratory tract infections and tuberculosis—which are responsible for the high mortality frequently observed in monkeys, are dealt with at length. The chapters on these subjects will be of particular interest to those who are responsible for the management of large colonies of monkeys now maintained in many countries for the production and testing of poliomyelitis vaccine.

In the course of reading this book, attention is directed to the numerous pathogenic agents which have been accidentally transmitted to man. Of these the most serious is *B*-virus (*Herpesvirus simiae*), which has caused a number of fatal cases of ascending myelitis. Since this virus, and other pathogenic agents, are localized in the mouths of infected animals, the author rightly points out that procedures should be designed to preclude, so far as possible, the occurrence of monkey bites. It would have been of value to those who have not seen this condition in monkeys if photographs showing *B*-virus lesions in infected animals had been included.

The compilation of this volume is clearly the result of much painstaking work involving an extensive review of literature and, in addition to providing factual material, Prof. Ruch has succeeded in presenting the subject-matter on each topic in a most readable form. This will be a very useful reference book and its publication fills an important gap in scientific literature.

C. R. COID

THE MEASUREMENT OF INFORMATION

Information Theory and Statistics

By Prof. Solomon Kullback. (Wiley Publications in Mathematical Statistics.) Pp. xvii+395. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 100*s*. net.

THIS book provides a treatise upon the general statistical theory of information, as complete, thorough and up to date as any single book to-day. It deals with the various measures of information and information-rate, not restricted to their place within the theory of communication (as are so many recent texts), but as part of the general theory of statistics and probability. It covers and relates the work of Fisher, Shannon, Chernoff, Kolmogorov, of Good, Woodward, Barnard and many others well known within the field.

The author's reputation here needs no comment from me. In this book he aims at unification—conceptual, notational and methodological—of scattered work by West Europeans, Americans and Russians too. He covers not only the specialized applications of information theory to communication problems but treats the whole field of statistical hypothesis testing as it arises also in the design of experiments and in observation theory, in the theory of stochastic processes, in parameter estimation and in other processes of statistical inference. In the first half of the book the various logarithmic measures of information are developed and their properties studied, in terms of measure theory; it is the second half which is concerned with a wide range of applications to statistical inference.

The book is essentially mathematical in treatment and in its purpose. It comes at an opportune time for many people in the physical sciences; for biologists, for telecommunication engineers (detection, coding problems, etc.); again, for psycho-physics (behaviour models and artefacts) and many other fields. Modern techniques of statistical inference are making an ever-increasing contribution and the relevance of information theory merits careful attention and revaluation at this present time.

The many worked and unworked examples form a particularly valuable feature of the book; it is well provided, too, with a glossary of mathematical terms and with a comprehensive bibliography of several hundred references.

COLIN CHERRY

Rice

By D. H. Grist. Third edition. (Tropical Agriculture Series.) Pp. xxiii+466+72 photographs. (London: Longmans, Green and Co., Ltd., 1959.) 48*s*. net.

D. H. GRIST'S valuable book "Rice" is now in its third edition. It has been strengthened by the inclusion of two authoritative chapters, one on the genetics of rice and the other on improvement by selection and breeding. These were contributed by D. Rhind, who has had the satisfaction of seeing in West Africa progeny of seed he bred in Burma. Grist also has spent much of his life in the study of this crop and is to be congratulated both on the original compilation and on the no less important revision. In Chapter 12, Grist quotes the work of Pearsall and Mortimer (*J. Ecol.*, 27, 483; 1939) and of Pearsall (*Emp. J. Exp. Agric.*, 18, 289; 1950) which, he points out, provided an entirely new approach to the chemistry of water-logged soils. The Japanese quickly followed up these ideas, leading to more efficient use of their hard-pressed paddy fields. It is hoped that it will be possible for Grist to enlarge this chapter in the next edition of this book so as to include an account of this recent work.

H. GREENE

1959 Supplement to British Veterinary Codex 1953

Pp. xviii+134. (London: Pharmaceutical Press, 1959.) 35*s*.

THE appearance of this Supplement to the British Veterinary Codex is an expression of the policy of the Codex Committee to provide an interim volume before proceeding to a full new edition. It is a sound policy, and a necessary one, if the Codex is to attempt to keep abreast of new developments in the field of pharmacology. The drugs and vaccines described in the Supplement are already familiar by their having been some time in veterinary use, and it becomes a welcome reference book on actions and dosage. The period since the first appearance of the British Veterinary Codex in 1953 has been one of intensive research in pharmacology, and it is, indeed, during this period that a specific discipline of veterinary pharmacology has emerged. Curiously enough, despite these exciting new developments, the teachers of veterinary pharmacology in Britain are only now beginning to turn to the problem of producing a text-book in their subject to which the student or practitioner can refer. In this situation the Codex is particularly valuable.

P. JEWELL

Brompton Hospital Reports

Vol. 27, 1958. (A collection of Papers by Members of the Staffs of the Hospitals for Diseases of the Chest (Brompton Hospital and London Chest Hospital); and of the Institute of Diseases of the Chest.) Pp. x+277. (London: Lloyd-Luke (Medical Books), Ltd., 1959.) 15*s*. net.

FOR those who wish to follow the progress of knowledge of diseases of the chest this volume collects, in the handy and attractive form well known to readers of the earlier volumes in this series, twenty-one papers, all of which have been previously published in the journals named in the preface.

The volume opens with an appreciation of the fine work of Maurice Myers, who joined the staff of the Brompton Hospital Sanatorium in 1932 and spent the rest of his professional life there, being deputy medical superintendent for the greater part of this time. For him, as this memoir of his life says, the treatment of pulmonary tuberculosis was an art, and his death in December 1958 deprived us of the services of a man of long and wide experience.

It is impossible, in a brief notice, to discuss in detail the contents of the papers here reproduced. Three of them deal with the treatment of pulmonary tuberculosis by extraperiosteal plombage, thoracoplasty and streptomycin, isoniazid and sodium *p*-aminosalicylate. Two papers report respectively on the treatment of pleural effusions by antibacterial therapy and on the proteins in serum and the pleural fluid, while two discuss studies of tuberculin sensitivity in tissue cultures and in the middle-aged and the elderly. There are five papers on heart conditions, one on multiple brochostenoses due to sarcoidosis, one on pleural neoplasms and one on the surgery of œsophageal lesions. The volume concludes with four papers on bronchiectasis, bronchodilator drugs and bronchograms, and two on pulmonary mycoses in Britain and the occurrence of *Aspergillus fumigatus*. The list of papers published by the staff during August 1957–July 1958, and the author and subject indexes to volumes 1–27, summarize the great work that this hospital has been doing.

G. LAPAGE

Genetyka

By Edmund Malinowski. Pp. 582+14 plates. (Warszawa: Państwowe Wydawnictwo Naukowe, 1958.) Cena zl. 42.

THIS text-book on genetics by one of Poland's leading authorities on the subject follows the familiar lines of such books published in Western Europe in pre-war times. The reader is introduced to the principles of evolution through references to Darwin; the story of Mendel's discovery, and the rediscovery of Mendel, is retold and the now classical studies of the early Mendelians are described. The role of the chromosomes in heredity and in evolution is explained, and brief references are made to some of the more recent genetical studies such as those on biochemical mutants in micro-organisms and the Watson–Crick views on the structure of deoxyribonucleic acid.

The chapter on evolution contains a brief section on Lamarck and the inheritance of acquired characters; experiments of MacDougall, Harrison and others are shown to be susceptible of explanation as selection effects and the cautious conclusion is reached that there is no evidence so far that can be accepted as definite proof of the inheritance of acquired characters. There is no mention of the work of T. D. Lysenko and his school.

In the final chapter on the application of genetics in agriculture we are told that the main achievements in breeding improved wheat varieties for Polish conditions have been based on some original crosses between the English wheat Squarehead and the Polish Pulawka. Mention is made of the production of hybrid maize and hybrid onions in the United States and of the artificial production of polyploid races of various crop plants in Sweden and elsewhere. In this connexion we are told of some tetraploids of serradella (*Ornithopus sativus*), produced by Polish workers, which exceed the original diploid strains in fodder yield by as much as 100 per cent.

P. S. HUDSON

EXISTENCE OF NET ELECTRIC CHARGES ON STARS

By Prof. V. A. BAILEY
School of Physics, University of Sydney

I

It has been found possible to account for the known orders of magnitude of five different astronomical phenomena and the directions relating to three of them by means of the single hypothesis that a star like the Sun of mass M_s gm. carries a net negative charge, $-Q_s$, which is given by the formula:

$$Q_s = \beta_s G^{\frac{1}{2}} M_s \text{ e.s.u.} \qquad (1)$$

where G is the constant of gravitation and β_s is a pure number of the order of 0·03.

Thus, for the Sun we have:

$$Q_s = 1{\cdot}5 \times 10^{18} \text{ e.s.u.} \qquad (2)$$

The same hypothesis leads to simple qualitative or semi-quantitative explanations of at least the thirteen other phenomena considered later.

The first five phenomena are as follow: (1) the magnetization of the Earth; (2) the outer Van Allen belt of radiation; (3) the maximum energy of about 5×10^{18} eV. found for a primary cosmic ray particle; (4) the Sun's north polar magnetic field vector H_p; (5) the approximate equality of the ratio P/U for the Sun to the mean value of this ratio for Blackett's[1] group of five magnetic stars, where P is the magnetic moment and U is the angular momentum of a star.

The phenomena 1–4 arise as follows from the presence of the solar charge $-1{\cdot}5 \times 10^{18}$.

The velocity of translation of the Sun relative to the Earth is $v_s = -29{\cdot}8$ km./sec. and consequently its charge, $-Q_s$, sets up in a non-rotating frame of reference accompanying the Earth a magnetic field H_r which is perpendicular to the ecliptic, directed from north to south and has near the Earth the intensity $6{\cdot}9 \times 10^{-3}$ gauss.

The magnitude and direction of H_r are approximately those required by J. S. Chatterjee[2] for the initial field, of unknown source, which saturates the highly permeable magnetic material of a 20-km. shell near the top of the Earth's crust and thus imparts to the Earth its observed magnetization. For Chatterjee requires a "field of the order of 0·1 to 0·01 gauss".

Moreover, the field H_r not only magnetizes the Earth but also neutralizes the resulting external terrestrial field in a narrow and approximately toroidal region which lies nearly in the Earth's equatorial plane and has a radius equal to about 3·7 earth radii. The magnetic field in and near this region is such that it could act as a 'magnetic bottle' which is partly accessible to energetic charged particles from much further out. These results account very well for the existence of the outer Van Allen belt which has a maximum density at about 3·6 Earth radii.

The Sun's charge also produces an electric field which has the potential $V = -3{\cdot}0 \times 10^{17}$ volts at the Earth's orbit. This field causes free protons and other nuclei in distant space to approach the Sun and move in orbits round it. Those nuclei which lose little energy on the way to the Earth's orbit will then reach this orbit with an energy of $3{\cdot}0 \times 10^{17}Z$ eV., where Ze is the charge on the nuclei concerned. For an iron nucleus this energy amounts to 8×10^{18} eV. Also the orbits of all the nuclei will be oriented at random. These results account very well for the observed maximum energy 5×10^{18} eV. of a primary cosmic ray particle and for the isotropy of cosmic rays.

The rotation of the negatively charged Sun imparts to it a magnetic moment which is directed from north to south. This in turn produces a north polar magnetic field vector H_p which would have the magnitude $-0{\cdot}75$ gauss if the Sun's charge were distributed in the same way as the mass and if the mass and angular velocity were distributed as in Chapman's[3] model A. A uniform distribution of Q_s throughout the Sun would yield the value $-8{\cdot}5$ gauss. These results agree in order of magnitude and direction with the observations of Hale and Langer who, according to a report by H. W. Babcock[4], found a mean value of -4 gauss. They also agree with the most recent observations of H. D. Babcock[5]. The presumably temporary reversal of the direction of H_p, during six years, which was observed by the Babcocks suggests that our estimated value of H_p corresponds to the constant component of the Sun's magnetic field, and that there exist also an oscillating component which varies with the solar cycle and a component due to local turbulence.

The fact (5) would arise from the hypothetical stellar charges specified by formula (1) if the Sun and the average of Blackett's five stars had axially symmetrical distributions of the angular velocity ω, the charge density σ and the mass density ρ such that at a point (r, θ) the quantities $\omega\sigma$ and $\omega\rho$ are each functions of θ and r/a alone, where a is the diameter of the star. The latter assumption is the reasonable one that magnetic stars are homologous rotating bodies.

It would be a remarkable coincidence if these five phenomena were all explained correctly in their orders of magnitude and their related directions by means of a single hypothesis which is entirely false, even if the last phenomenon calls for a supplementary assumption of homology in magnetic stars.

For, even if we make the moderate assumption that the probability of a false theoretical value A, of a physical quantity, agreeing in order of magnitude with the observed value B is less than 0·1, the probability of five such agreements and of three chance agreements of direction would be less than $1/10^4 \times 2^3$, that is, less than 1 in 80,000.

If to these eight agreements we add the thirteen other different phenomena which are qualitatively or semi-quantitatively explained below by means of the same 'false' hypothesis, the resulting coincidence would be truly extraordinary.

My hypothesis implies the existence of strong electric fields (but less than 10^9 V./cm.) in the Sun's atmosphere. In combination with the magnetic fields which exist there they could lead to relativistic electrons trapped in the corona. Three consequences of this situation are: (a) the phenomena cited by Kellogg and Ney[6] in support of their new theory of the corona; (b) the high temperatures in the corona; (c) the acceleration and ejection of fast magnetized and negatively charged clouds of ionized hydrogen, of the same general character as Bostick's plasmoids and rings, which are generated along with flares near strongly magnetized regions like sunspot groups.

These fast clouds could serve to explain the solar radio phenomena associated with flares observed by Wild *et al.*[7] and interpreted by them and by McLean[8] as indicating the early ejection of a fast stream of electrons with a mean velocity of about $\frac{1}{3}$ c, and the subsequent ejection of a cloud of relativistic electrons at velocities of about 1,000 km./sec., that is, $c/300$. They estimate that the fast stream contains not less than 3×10^{33} electrons.

If we assumed that this stream diverges less than π steradians it would follow that at least 7×10^{25} electrons are intercepted by a sphere around the Earth of radius equal to that of the outer Van Allen belt. Consequently the intercepted electrons would tend to become trapped in the Van Allen belt and so to lower the Earth's potential by more than $4 \cdot 5 \times 10^{9}$ V. This would lead to a large transient increase in the intensity of the cosmic rays and also allow the entry into the Earth's upper atmosphere of a large flux of low-energy nuclei. The latter flux could be held responsible for the remarkable early and sudden increase of the electron density below 90 km. in the dark ionosphere following the great solar event of February 23, 1956; a similar flux has been suggested by D. K. Bailey[9], but his flux is assigned to a different origin. Both the transient increase of cosmic rays and the sudden increase of lower ionospheric ionization could occur within 10–30 min after the strong solar flare commenced, as was observed to be the case. When the fast electrons stop arriving, the Earth's potential would commence to rise, by admission of nuclei, until it and the cosmic-ray intensity return to their normal values. The arrival of the slow magnetic clouds, after the lapse of 1–3 days, could then give rise to other effects, including magnetic storms and temporary decreases of cosmic ray intensity.

The value 0·03 for β_s is consistent with the fact that current theories of stellar constitution are good approximations for the Sun and (presumably) for Blackett's average of five stars. For even if we adopt Chapman's model *A* with $\beta_s^2 = 9 \times 10^{-4}$ the forces of electrostatic repulsion are only about one-thousandth of the corresponding forces of gravitational attraction.

If a star possessed a charge such that β_s approached or exceeded the value 1 and this charge became located mainly near the surface of the star, the forces of electrostatic repulsion alone would make its outer parts unstable and so lead to their expulsion. This suggests one possible explanation of novæ and supernovæ. A necessary accompaniment of such an explosion of a rotating star is the ejection of magnetized clouds and relativistic electrons; this alone would explain the existence of the mysterious spectra of certain novæ and also the polarized light and strong radio noise emitted by the Crab Nebula.

The emission of strong radio noise from large regions around some galaxies, such as the Galactic Halo, may be explained by regarding each of these regions as the atmosphere of the negatively charged and rotationally magnetized galaxy concerned. For such an atmosphere would necessarily contain trapped electrons with relativistic energies.

Lastly, we may expect that when two such charged and magnetized galaxies enter into collision they would set up strong electromagnetic disturbances in each other's atmospheres and so generate the intense radio noise which has been observed in such collisions.

A discussion of possible sources of the stellar net charges, some possible difficulties which may be raised by my hypothesis and some possible tests of it will be given in Part 2.

2

Possible sources of the stellar charge $-Q_s$, certain criticisms which may be raised against these hypotheses and possible tests of them will now be discussed.

A possible source of $-Q_s$ is provided by one of the following alternative hypotheses H_1 and H_2.

H_1: The thermonuclear processes in the interior of a star like the Sun generate certain particles, provisionally named 'astrons', each possessing a small mass m_a and a positive electric charge e_a many times smaller than the electronic charge e and able to penetrate matter as easily as a neutrino can. Under this hypothesis the star acquires a negative charge $-Q_s$ which is ultimately limited by the flow of nuclei into the star and the flow of electrons out of it.

H_2: As suggested in an earlier publication[10], the four-dimensional space-time universe U_4 is a hyper-surface in a five-dimensional universe U_5 and the laws of conservation of energy, momentum and electric charge hold true exactly in U_5 and only approximately in U_4. Consequently, there can exist streams of electrically charged particles from U_5 into U_4 or vice versa. Also the geometrical character of this hypothesis requires that these streams depend on the local metric of U_4, that is, on the local physical conditions in U_4; thus the streams inside a star would be different from those outside it. The streams from or into U_5 could then give a net negative charge to the star; they could also maintain this charge constant under any possible drains due to the emission of electrons into space and the attraction of nuclei from space.

This hypothesis H_2 may appeal more to theoretical physicists, for it can also serve to unify the theories of the gravitational, electromagnetic and quantum fields and one theory of cosmology[10]. The present application of H_2 to the interior of a star suggests that a correct theory of nuclear forces would be one that could be unified with the other four theories in a five-dimensional mathematical form. This suggestion receives some support from Rayski's[11] recent publication entitled "A Six-dimensional Interpretation of Electrodynamics and Nuclear Interactions".

The first hypothesis H_1 is more easily linked with current views about the thermonuclear processes inside stars like the Sun. For this can be done simply by adopting two supplementary hypotheses, namely (h_1) that astrons are neutrinos and (h_2) that a proton carries the same charge e as a positron and an electron carries the charge $-e$. From these hypotheses and the two known nuclear processes:

$$n^0 \rightarrow p^+ + \beta^- + \bar{\nu} \text{ (antineutrino)}$$
$$p^+ \rightarrow n^0 + \beta^+ + \nu \text{ (neutrino)}$$

it can be deduced that a neutrino carries the small positive charge e_a, and a neutron and an antineutrino each carries the negative charge $-e_a$. These hypotheses and deductions are also consistent with the current assumption that the principal thermonuclear process in the Sun is the proton-proton chain reaction in which two β^+ particles and two neutrinos (ν) are released for every four protons involved. Moreover, they are consistent with the remarkable fact that the neutron behaves like a spinning negative charge.

By means of certain arguments based on current views about the flux of neutrinos out of the Sun, 5×10^{38} per sec., and the mean energy of each, 0·25 MeV., it may be inferred that a necessary condition for most of the neutrinos to escape from the charged Sun is that $e_a \ll 4 \times 10^{-16}e$. Also an argument suggested by Dr. M. J. Buckingham, based on the same value of the neutrino flux, 5×10^{38}, and on the age of the Sun, 5×10^{9} years, leads to the conclusion that $e_a > 4 \times 10^{-19}e$. It is remarkable that the net positive charge $e_h = 2 \times 10^{-18}e$ assumed by Lyttleton and Bondi[12] to be carried by a hydrogen atom lies between these limits to the value of e_a and is only five times as large as the lower (and nearer) limit. This fact and their use of the charge e_h to explain galactic recession suggest that some elaboration of my hypothesis of negative stellar charges could also serve to explain this recession. For example, the additional assumption that the Population II stars in the galaxy have charges Q_s such that $\beta_s > 1$ and are so related in number to the Population I stars that the average value of β_s for the galaxy is about 2·2 could allow the forces of mutual repulsion between my negatively charged galaxies to set up the same velocities of recession as those set up by the excess positive charge in the universe of Lyttleton and Bondi.

The hypothesis H_1 may possibly form part of the hypothesis H_2 when the latter has been developed mathematically and otherwise.

It may be argued that the main hypothesis is untenable because : (*a*) interstellar space appears to be too highly conducting and (*b*) the negatively charged star would quickly lose its charge by the emission of free electrons. This argument is nullified by the hypothesis H_2 under which there exist streams of charged particles from or into U_s which can replace any lost negative charge by an equal amount of fresh charge. But even under the hypothesis H_1 this argument has little force until, (*a*) it can take full account of the evidence that now exists that interstellar space contains coherent magnetic clouds of ionized hydrogen and that in the Solar system such clouds are continually flowing away from the Sun (see Parker[13]), and (*b*) it can be proved that a highly magnetized sphere of hot condensed hydrogen like the Sun cannot under any conceivable distribution of its negative charge $-Q_s$ retain for long the charge which is left by the emission of my positively charged neutrinos.

Another possible criticism is that my theory does not account for the existence of an extended spectrum of cosmic ray energies. This criticism is met by pointing out that not only do the attracted nuclei start from points at different distances from the Sun but also different nuclei encounter different obstacles on their way to the Earth's orbit, such as the magnetic clouds mentioned above, and so lose different amounts of energy through these encounters. The latter process would become more effective if, as is probable, most of these magnetic clouds were negatively charged by electrons trapped in their fields.

A fourth objection which may be raised against the theory is that during some six years the general magnetic field of the Sun was opposite to that set up by the negative charge $-Q_s$. This is met by Blackett's suggestion that a slow electromagnetic oscillation may be superimposed on the unidirectional general field and by the possibility that the observed effects of the latter may sometimes be obscured by those due to the irregular fields arising from turbulence.

Another possible criticism is that the theory is contradicted by the apparent transient generation of low-energy cosmic-ray particles in the Sun following certain flares. This criticism is met by referring to the discussion in Part 1, in which it is shown how the very fast solar stream of electrons, inferred from the radio observations of Wild *et al.* at times of strong solar flares, can transiently lower the electric potential of the Earth and so transiently increase the intensity of the flow of low-energy primary cosmic-ray particles into the Earth's atmosphere.

Lastly, it may be argued that the electric fields in the Sun's atmosphere set up by its charge should be revealed by the presence of large Stark effects in some of the spectral lines. This argument is not conclusive, because the Stark effects which have been observed are usually attributed to atomic electric fields which can be greater than the solar fields, and also because about 43 per cent of the lines in the spectrum of the Sun are as yet unidentified and may therefore arise in part from large Stark effects.

A more complete account of this work is in the course of publication in the *Journal and Proceedings of the Royal Society of New South Wales*. In that account three possible experiments are described, and two predictions are made which may serve to test the theory or parts of it.

One of these experiments is to determine, by means of satellite-borne magnetometers, the Earth's equatorial magnetic field and its direction at distances up to at least ten Earth radii. Another experiment is to determine whether Bostick's plasmoids (or rings) carry net negative charges by firing them into or through Faraday cages.

One of the predictions is that, during the next ten years, the value of the Sun's north polar magnetic field will return to the mean value and direction, -4 gauss, which were found by Hale and Langer.

I wish to acknowledge the valuable help which has been given to this work by the expert advice and criticisms of numerous colleagues and friends, in particular those of Profs. S. T. Butler, H. Messel and C. N. Watson-Munro, and Drs. M. J. Buckingham, R. G. Giovanelli, R. E. B. Makinson, H. D. Rathgeber and J. L. Pawsey, and Messrs. A. F. A. Harper, J. P. Wild and H. Wood.

Note added in proof. If the formula (1) is also applied to the planet Jupiter, which resembles the Sun in its chemical constitution and in emitting strong, elliptically polarized radio noise, the polar magnetic field resulting from a uniform distribution of Q_s and from the planet's rotation has an intensity of about 5 gauss. This approximates to the value 7 gauss derived by A. G. Smith and T. D. Carr (*Astrophys. J.*, 130, 641 (1959)) from observations of Jupiter's radio noise.

[1] Blackett, P. M. S., *Phil. Mag*, 40, 125 (1949).
[2] Chatterjee, J. S , *J Atm. Terr. Phys.*, 8, 238 (1956)
[3] Chapman, S., *Mon. Not Roy. Astro. Soc.*, 108, 236 (1948).
[4] Babcock, H. W., *Mon. Not. Roy. Astro. Soc.*, 113, 361 (1953).
[5] Babcock, H. D., *Astrophys. J*, 130, 364 (1959).
[6] Kellogg, P. J., and Ney, E. P., *Nature*, 183, 1297 (1959).
[7] Wild, J. P , Sheridan, K. V., and Neylan, A. A., *Aust. J. Phys.*, 12, 369 (1959).
[8] McLean, D. J., *Aust. J. Phys.*, 12, 404 (1959).
[9] Bailey, D. K., *Proc. Inst. Rad. Eng.*, I.G.Y. Issue, 47, 255 (Feb. 1959).
[10] Bailey, V. A , *Nature*, 184, 537 (1959).
[11] Rayski, J., Joint Inst. Nuclear Res., *P*-379, Dubna (1959).
[12] Lyttleton, R. A., and Bondi, H , *Proc Roy. Soc.*, A, 252, 313 (1959).
[13] Parker, E N., *Proc. Inst. Rad. Eng.*, I.G.Y. Issue, 47, 239 (Feb. 1959).

PADDY SOILS AND RICE PRODUCTION

By Dr. H. GREENE

Rothamsted Experimental Station, Harpenden, Herts

DURING 1954, an annotated bibliography[1] of rice soils and fertilizers was compiled by G. V. Jacks and M. Kathleen Milne. This has more than 900 entries, but does not include some valuable papers on paddy soils in Japan that were presented at the fourth session of the International Rice Commission, held in Tokyo during 1954. Much of the following summary is based on three of these papers: a historical review[2] by Harada *et al.*; a study of the chemistry of paddy soils[3] by Shioiri and Tanada; and a study of soils and fertilizer use[4] by Mitsui.

Paddy fields of Japan are mostly located on well-drained alluvial soils of Recent origin. Their subsoil remains continuously oxidized to a considerable depth: below this there may be a gley horizon due to a permanent water-table. Irrigation during the summer sets up reducing conditions in the topsoil which becomes bluish grey to a depth of 25 cm. or so. When the crop ripens the fields are allowed to dry and the whole furrow slice becomes oxidized. When irrigation is resumed in the spring vigorous growth of algae and duckweed occurs. These take up carbon dioxide during the day, allowing the surface water to become alkaline by the afternoon, and give off carbon dioxide at night so that the surface water is weakly acid by the early morning. Oxygen produced during the day and diffusing atmospheric oxygen reach the soil surface, which remains brown to a depth of a few millimetres. Below this a very thin (0·5 mm.) layer of hydrated ferric oxide may sometimes be found. This is an embryonic upper iron pan formed by oxidation of ferrous compounds diffusing upwards from the bluish grey reduced layer. The diffusion of iron seems to be accompanied by localized and perhaps progressive bleaching of the bluish grey layer. In this layer reduction of nitrate, sulphate and ferric ions takes place and a consequent lessening of acidity. A lower more substantial pan containing iron and manganese oxides may be formed by downward diffusion at the junction of the reduced layer and the oxidized subsoil. Similar iron pans have been observed in north-west England by Crompton[5]. If concentrated nitrogenous fertilizers are applied at the surface, nitrate formed in the surface layer is leached downwards; denitrification occurs in the reduced layer and is accompanied by loss of gaseous nitrogen or nitrous oxide, this loss being more serious than that due to deep percolation. The soil of an irrigated field can be represented as in Fig. 1.

Yields are increased by 10 per cent or more if paddy fields can be dried off between successive crops. When air-dried paddy soil is flooded, anaerobic micro-organisms regain the ascendancy and ammonium nitrogen is produced in greater amount than from continuously wet soil. The increase, amounting perhaps to 20 kgm. nitrogen per hectare, is readily taken up by the rice plant. Air-drying prior to flooding also increases the availability of phosphate. Aoki[6] concluded that the effective part of the phosphoric acid in paddy soils appears to be present as iron compounds, their solubility being increased by conditions of reduction. Similar conclusions are drawn by Paul and De Long[7], Islam and Elahi[8] and by Gasser and Bloomfield[9], who found that phosphate associated with iron is mobilized by anaerobically fermenting organic material. Ponnamperuna *et al.*[10] consider that the rice plant benefits from the increased availability of iron but may suffer from an excess of reduced substances.

Ammonium sulphate should be worked into the soil before the first flooding or, surprisingly, it can be mixed with peat or peaty soil to form egg-size balls which can be thrust into the flooded soil. This latter method is specially recommended for 'degraded' paddy soils in which damage from hydrogen sulphide is feared. It has recently been stated[11] that urea is preferred to ammonium sulphate as nitrogenous fertilizer for 'degraded' paddy soils as well as for acid soils of Japan. In lowland paddy soil the sulphate of chemical fertilizers is readily reduced to sulphide which, if soluble, inhibits respiration of plant roots and so prevents selective uptake of potassium and uptake of phosphate and other plant nutrients. This physiological disorder involving root-rot is known in Japan as *akiochi* or 'fall-down'. According to the observations of Sethi[12], Crafts and Broyer[13], van Raalte[14], Vlamis and Davis[15], rice thrives in waterlogged soil because its young roots supply oxygen to the otherwise reduced soil: if iron is present in solution, the young roots acquire a yellowish brown coating of ferric hydroxide gel which apparently protects the roots against moderate amounts of hydrogen sulphide. The oxidative action of the roots ceases or grows less at flowering, this decline possibly being associated with differential response to potash of young and older rice plants noted by de Geus[16].

The 'degraded' soils which occupy about 17 per cent of the lowland rice area of Japan are described as follows: (1) the furrow slice is grey and shows little evidence of 'active' iron (as estimated by Truog's method using sodium sulphide and oxalic acid); (2) the plough sole layer is usually bleached; (3) below the plough sole there is a layer where ferric and occasionally manganic oxides accumulate; (4) in mid-summer the furrow slice emits hydrogen sulphide

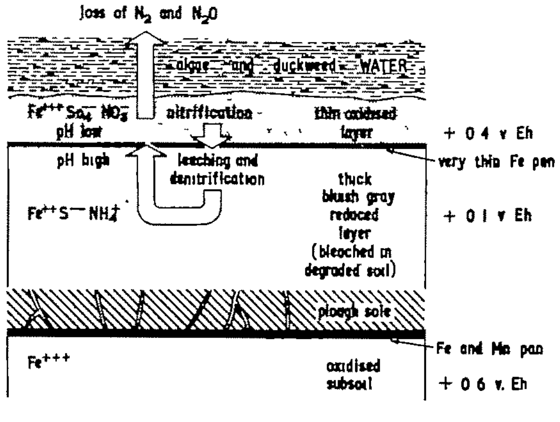


Fig. 1

gas ; (5) roots of rice are whitish and lack the coating of ferric oxides which would protect them from damage by hydrogen sulphide. This description corresponds closely to that given by Koenigs[17] for a 'sawah' profile in Java : de Gee[18] has determined the oxidation potential of the 'sawah' profile. His results are shown in Fig. 1. According to Mitsui[4], the 'degraded' paddy soil occurs on siliceous materials such as are derived from acid igneous rocks or sandstone. It may be supposed that these materials occur mainly as low-lying alluvial deposits, that they contained little iron at the time of deposition and were readily leached.

Observations of Bloomfield[19,20] suggest that leaching and precipitation of iron oxide in poorly drained soils commonly involve formation of soluble complexes of ferrous iron by the action of decomposing plant remains. The complexes are sufficiently stable to be transported by percolating water, but if brought into contact with ferric oxide they are sorbed and the ferrous iron is readily re-oxidized. Following up these ideas, Jeffery[21] has added excess water to oxidized soil plus organic matter and has observed : (*A*) a rapid fall in redox potential, which is followed by (*B*) a fairly rapid recovery ; and by (*C*) a slow decline such as is given by soil plus water in the absence of added organic matter. He ascribes stage *B* to oxidation by ferric oxide originally present in the soil. This recovery leads to a desirable situation *C* in which both ferric and ferrous ions are present. For stage *C* Jeffery derives an equation relating *Eh* and *p*H. The observations lead to a more precise understanding of the balance of oxidation-reduction at different seasons and at different parts of the soil profile. In a second paper[22], Jeffery develops an equation in an attempt to define optimum conditions for rice growth and thus the suitability of any given soil for paddy. Shioiri and Tanada[3] found in a laboratory test a marked fall in redox potential on adding excess water to samples from the furrow slice of paddy soil, whereas samples of upland soil showed little change. Paddy soil that had been treated with organic fertilizer produced abundant hydrogen sulphide when water-logged, whereas corresponding upland soil did not. The upland soil presumably had a greater reserve of ferric oxide. Accordingly, heavy applications of upland soil are used with some success to improve degraded paddy soils.

These studies, arising from the pioneering work of Prof. W. H. Pearsall (see review of Grist's book on p. 507 of this issue), are of more than academic interest : they should contribute to increased production of this crop, which is vitally important to so many millions of patient, hard-working people. Much is already being done. In Japan, soil survey (Endo[2]) has been directed to mapping different kinds of low-yielding land, including *akiochi* (degraded) paddy fields, acid soil, low-yielding volcanic soil, saline soil, poorly drained soil. Improvement is then sought by appropriate means, for example, by adding iron-rich materials to degraded soils and by appropriate use of fertilizers as described above ; by addition of calcareous materials to acid soils ; by improvement of drainage. D. H. Grist[23] rightly considers that improved water control is the best way of raising rice yields. The following may be included among the encouraging results obtained by use of fertilizers. Richardson[24], describing 81 field experiments on paddy fields in China, recorded the following responses to 60 kgm. per hectare applications reckoned as nitrogen, phosphate and potash : mean yield, 2,805 kgm. per hectare ; responses—nitrogen, +620 ; phosphate, +290 ; potash, +40 kgm. per hectare rough rice, that is, threshed grain. On the advice of Stewart[25], very numerous experiments with fertilizers have been carried out on farmers' fields in India. Yates, Finney and Panse[26] recorded, for 2,445 experiments in Bihar, India, a profitable response of 280 lb. threshed grain/acre to 20 lb. nitrogen per acre ; phosphate was profitable only on responsive soils. Numerous additional experiments during the period 1953–56 indicate[27] that a dressing of 20 lb. nitrogen/acre plus 20 lb. phosphate per acre would generally be the most profitable for paddy in India. In the north and north-east, the dressing of nitrogen can be increased to 40 lb. with or without application of phosphate ; in certain areas distant from the coast, the dressing of phosphate can be raised to 30 or 35 lb. phosphate per acre. Potash at 20 lb./acre gave a profitable return in some areas, including two centres in Bihar. Ashby[28] found from 173 completed experiments on farmers' wet paddy fields in Kelantan, Federation of Malaya, an economic response to 200 lb./acre of placed fertilizer supplying nitrogen, 23·5 ; phosphate, 20 ; potash, 25 lb./acre. In Zanzibar, Tidbury[29] found the most profitable dressing to be 2 cwt./acre ammonium sulphate plus 3 cwt./acre of superphosphate. It is worth mentioning these results that derive only in part from a more accurate appreciation of wet soils. The possibilities are more encouraging than might appear from the earlier investigations. Important observations on response to phosphate applied to wet paddy fields of British Guiana were made by Gasser[30]. Factorial experiments carried out on three kinds of soil gave results as shown in Table 1, while analysis of straw and threshed grain from these experiments gave percentage contents of phosphate shown in Table 2.

Table 1

Site	Soil	Threshed grain (lb./acre) With phosphate	Threshed grain (lb./acre) Without phosphate
Cane Grove	toxic aluminium	2,977	409
Mahaicony Abary	pegassy clay	2,740	1.769
Botanic Gardens	fertile frontland clay	4,126	4,102

Table 2

Site	Straw		Threshed grain	
	With phosphate	Without phosphate	With phosphate	Without phosphate
Cane Grove	0·036	0·036	0·159	0·117
Mahaicony Abary	0·049	0·038	0·244	0·160
Botanic Gardens	0·107	0·105	0·298	0·299

In comparison with the other low-lying soils, the higher fertility of the frontland clay (derived from marine alluvium) in the Botanic Gardens, British Guiana, is clearly shown in the satisfactory phosphate content of grain from plants which had not received phosphatic fertilizer. The soils increase in acidity and in content of exchangeable aluminium in the order : Botanic Gardens < Mahaicony Abary ≪ Cane Grove. The Cane Grove soil, considered to be formed by sedimentation in brackish water, is like the gyttja soils studied by Wiklander and co-workers[31–33] in Sweden, and is related also to soils of mangrove swamps studied by Tomlinson[34,35] and by Hart[36] in Sierra Leone and to the 'gelam' soils of Malaya (Coulter, ref. 37). Such soils occur widely and I have suggested[38] that sulphur, readily leached from humid uplands in the form of sulphate, may be arrested in reduced form in lowland deposits together with elements forming insoluble sulphides. When air gains access to such deposits (for example, when water-levels fall because rain has been less heavy than usual) oxidation rapidly occurs, with formation of sulphuric acid in sufficiently high concentration to react with clay to form aluminium sulphate.

Of course, much has yet to be learned about these poorly drained or water-logged soils, which differ so sharply from upland soils that ordinary methods of analysis may be misleading or fail to yield significant results. At present it seems permissible to distinguish, as three corners of a triangular diagram, well-drained paddy soils, which are fertile; *akiochi* or degraded paddy soils which are infertile for lack of iron; paddy soils related to gyttja which are infertile owing to excess of aluminium. The preceding brief account refers to mainly mineral soils: some corresponding features are shown by peaty soils, for example, the pegassy soils of British Guiana seem related to gyttja. This subject will be more conveniently discussed on some later occasion. Current work (Bloomfield, C., private communication) indicates that decomposing plant remains mobilize not only iron but also many other elements of importance in plant nutrition.

[1] Jacks, G. V., and Milne, M. Kathleen, "An Annotated Bibliography of Rice Soils and Fertilizers". FAO and the Commonwealth Bureau of Soil Science. Pp. 180 (1954).

[2] Harada, T., *et al.*, "Advance in Investigation of Soil and Fertilizer in Japan". Ministry of Agriculture and Forestry, Japanese Government. Pp. 86. (Nippo Printing Co., Tokyo, 1954.)

[3] Shioiri, M., and Tanada, T., "The Chemistry of Paddy Soils in Japan". Ministry of Agriculture and Forestry, Japanese Government. Pp. 45. (Dainippon Printing Co., Tokyo, 1954.)

[4] Mitsui, S., "Inorganic Nutrition Fertilization and Soil Amelioration for Lowland Rice". Pp. 107. (Yokendo, Ltd., Tokyo, 1955.)

[5] Crompton, E., Rep. Sixth Congr. Inter. Soc. Soil Sci., Paris, Vol. E, 155 (1956).

[6] Aoki, M., *J. Sci. Soil Japan*, **15**, 182 (1941), quoted in ref. 3.

[7] Paul, H., and DeLong, W. A., *Sci. Agric.*, **29**, 187 (1949).

[8] Islam, M. A., and Elahi, M. A., *J. Agric. Sci.*, **45**, 1 (1954).

[9] Gasser, J. K. R., and Bloomfield, C., *J. Soil Sci.*, **6**, 219 (1955).

[10] Ponnamperuma, F., Bradfield, R., and Peech, M., Trans. Sixth Int. Congr. Soil Sci., *C*, 503 (1956).

[11] Ministry of Agriculture and Forestry, Japan, Int. Rice Comm. Newsletter 7, 14 (1958).

[12] Sethi, R. L., India Dep. Agric. Mem., Bot. Series, **18**, 57 (1930).

[13] Crafts, A. S., and Broyer, T. C., *Amer. J. Bot.*, **25**, 529 (1938).

[14] van Raalte, M. H., *Ann. Bot. Gardens Buitenzorg*, **50**, 90 (1940), quoted in ref. 3.

[15] Vlamis, J., and Davis, A. R., *Plant Physiol.*, **19**, 33 (1944).

[16] de Geus, J. G., "Means of Increasing Rice Production" (Centre d'étude de l'azote, Geneva, 1954).

[17] Koenigs, F. F. R., Trans. Fourth Int. Congr. Soil Sci., **1**, 297 (1950).

[18] de Gee, J. C., Trans. Fourth Int. Congr. Soil Sci., **1**, 300 (1950).

[19] Bloomfield, C., *J. Soil Sci.*, **2**, 196 (1951).

[20] Bloomfield, C., *J. Sci. Food Agric*, **11**, 641 (1955).

[21–22] Jeffery, J. W. O., *J. Soil Sci.* (in the press).

[23] Grist, D. H., "Rice" (see p. 507 of this issue).

[24] Richardson, H. L., Trans. Int. Soc. Soil Sci., Comm. II and IV, **1**, 222 (1952).

[25] Stewart, A. B., Report on Soil Fertility Investigations in India with special reference to Manuring, 160 (Army Press, Delhi, 1947).

[26] Yates, F., Finney, D. J., and Panse, V. G., Indian Council Agric Res., Research Series No. 1, 20 (1953).

[27] Prem Nath, "Fertilizer Trials on Paddy", Indian Council Agric. Res., Research Report Series No. 1 (1959).

[28] Ashby, H. K., *Malayan Agric. J.*, **35**, 191 (1952).

[29] Tidbury, G. E, *Trop. Agric.* (Trin.), **33**, 113 (1956).

[30] Gasser, J. K. R, Brit. Guiana Dept. Agric. Rep., pp. 232 (Mimeo, 1956).

[31] Wiklander, L., and Hallgren, G., *Ann. Roy. Agric. Coll. Sweden*, **16** 811 (1949).

[32] Wiklander, L., *et al*, *Ann. Roy. Agric. Coll. Sweden*, **17**, 24 (1950).

[33] Wiklander, L, Hallgren, C., and Johnsson, E, *Ann. Roy. Agric. Coll. Sweden*, **17**, 425 (1950).

[34] Tomlinson, T. E., *Emp. J. Exp. Agric*, **25**, 108 (1957).

[35] Tomlinson, T. E., *Trop. Agric.* (Trin.), **34**, 41 (1957).

[36] Hart, M. G. R., *Plant and Soil*, **11**, 215 (1959).

[37] Coulter, J. K, *Malayan Agric. J.*, **35**, 22 (1952).

[38] Greene, H, Trans. Fifth Int. Congr. Soil Sci, **1**, 146 (1954).

THE CENTO INSTITUTE OF NUCLEAR SCIENCE IN TEHRAN

By H. A. C. McKAY
Director

TO meet the great world-wide interest in nuclear science and its applications, it has often been suggested that regional centres should be created. Each centre would provide training and research facilities for a group of neighbouring countries. The first of such centres to be established is the CENTO (Central Treaty Organization) Institute of Nuclear Science, formerly the Baghdad Pact Nuclear Centre, which now serves the three countries of the CENTO region, Iran, Pakistan and Turkey. The Institute is concerned exclusively with the peaceful uses of nuclear science, and forms one of the quite extensive economic activities of the Central Treaty Organization.

The original Nuclear Centre in Baghdad was formally opened on March 31, 1957 (see *Nature*, 179, 936; 1957) and trained about sixty Middle East scientists in nuclear techniques, before the Iraqi revolution brought operations to a close. A decision to re-establish the Centre in Tehran was taken jointly by the CENTO countries in January 1959, and on June 23, 1959, H.I.M. the Shahenshah of Iran performed the opening ceremony in the presence of a distinguished audience. Two training courses have since been held in Tehran. The re-naming of the Baghdad Pact necessitated the re-naming of the Centre, and the present name was adopted in November 1959.

All the CENTO countries contribute to the running of the Institute. Its scientific policy is in the hands of a Scientific Council consisting of a leading scientist from each of the four countries; the United States sends an observer. The Scientific Council reports to the Economic Committee of CENTO, and in general administrative matters the Director of the Institute maintains liaison with the Deputy Secretary General for Economic Affairs of CENTO. The British representative on the Scientific Council is Sir John Cockcroft, and the Institute owes him a great debt for his continued efforts on its behalf.

Finance and staff are provided by all the CENTO countries. Iran has provided accommodation in the new and modern Faculty of Science building in the University of Tehran. The United Kingdom has provided the initial stock of equipment, worth about £20,000, most of which was flown out by charter plane.

The link between the Institute and scientific establishments in the United Kingdom is vital to its operation. Much of the value of the Institute is due to its serving as a channel for British knowledge and experience in the nuclear field to reach the CENTO region. The United Kingdom Atomic Energy Authority has provided the Director and five other scientists out of the Institute's total complement of twelve scientific staff. The British staff have been carefully chosen so that between them they cover the basic fields of nuclear physics, electronics, radiochemistry and health physics; the number could not be cut without affecting vital services. The present Director is a radiochemist from the Atomic Energy Research Establishment at Harwell, and his predecessor, W. J. Whitehouse, was a nuclear physicist from the same Establishment. The personal connexions with Harwell are such that advice and help are readily obtained from that source.

While the British staff cover the fundamental physical and chemical aspects of nuclear science, staff from the region are often specialists in one or other of the biological sciences. They are thus able to co-operate with the British staff in the development of applications of interest to the region, especially in agriculture. Attached to the Institute there is also a CENTO Senior Research Fellow, Dr. C. J. Banks, an entomologist from Rothamsted Experimental Station, who is applying radioisotopes in his particular field. The region staff have in many cases had a period of training in the United Kingdom before joining the Institute.

At present the Institute is engaged primarily in work with radioisotopes, which offers the best starting-point for the region in nuclear science. Its main activities fall under two heads: training courses and research projects.

The first training course in Tehran lasted nearly two months, from mid-September to mid-November 1959. It was attended by thirteen students from Iran, Pakistan and Turkey, all having at least a university science degree, and two being professors at their own institutions. (The Institute actually has space and equipment for twenty students working in pairs.) The course was comparable with those given at Harwell, Oak Ridge in the United States and elsewhere, though perhaps rather fuller, and taking rather less for granted as regards familiarity with modern laboratory techniques.

Ten of the students are staying on at the Institute for the rest of the academic year for advanced training or research, largely in fields of their own or their home institution's choosing. It is something of an experiment to operate in this way. A criticism of the courses given earlier in Baghdad was that they were too short; in the time available, the students could not digest their new knowledge sufficiently to be able to use it immediately on their return home. (The same criticism would apply, perhaps even more strongly, to most radioisotope courses elsewhere.) Merely to extend the courses did not seem very satisfactory, because the essential ground was already covered. However, by keeping the students on project work for several months, it is hoped to provide a sufficient assimilation period in the right atmosphere. It is hoped, too, that the students will catch something of the research spirit from the experienced scientists at the Institute.

The projects now in progress include water-flow studies by radioactive labelling and tritium counting; testing of cement and of archæological specimens by beta-ray back-scattering; solvent extraction and ion exchange work in solution chemistry; synthesis of labelled carbon-14 compounds; observation of cytological changes in plants grown under the influence of phosphate labelled with phosphorus-32; and a study of the food reserves of certain insects. There is also quite a large project on the study of the migration of wheat pests (*Aelia* and *Eurygaster* species) by radioactive labelling of the insects. This was initiated by W. T. Spragg, chief chemist, at the Centre in Baghdad, and pilot-scale field-trials were carried out last spring in Anatolia and near Tehran, under CENTO auspices. A further trial is planned this year.

When the students return to their home establishments, the Institute intends to continue to follow the progress of their researches, and to send its staff on consultative visits. Being in the region, it can offer much closer support than could a training centre in Europe or the United States.

The second course at the Institute in Tehran was a special radioisotope course for agriculturists, running from mid-January to mid-March. Eleven students from the region attended, of the same general calibre as those on the first course. The course contained less nuclear physics and radiochemistry than the first (general) course, and concluded with a series of lectures and experiments dealing specifically with biological topics.

Although the main emphasis at the Institute is on radioisotope work, with some bias towards agricultural applications, it is prepared to help in any field of nuclear science, in accordance with the needs of the CENTO region countries. The staff, between them, are of quite wide experience, and can moreover draw on the very large resources of Harwell. Assistance has already been given in testing uranium- and thorium-prospecting equipment, and some of the students are receiving preliminary training for reactor and gamma-irradiation work. Moreover, the Institute has been promised facilities on the 5-MW. swimming-pool reactor, on which construction work is just starting at the University of Tehran Nuclear Centre a few miles from the Institute. The University of Tehran also possesses a 3·5-MeV. Van de Graaff machine, a mass spectrometer, and a beta-ray spectrometer, which it is proposed to erect at its Nuclear Centre.

In the medical field, the Institute is giving all the encouragement it can to the establishment of a radioisotope clinic in Tehran. Until this exists, medical students at the Institute can get very little direct practical experience in their own particular field, although they can still obtain a great deal of benefit from the instruction given in general nuclear techniques. Most of the equipment necessary for such a clinic is already in Tehran, and there are medical men keen to use it, so it is to be hoped that work will start in the fairly near future. It may also be noted that the United Kingdom has recently presented a 1,000-curie radiocæsium therapy unit to the Faculty of Medicine of the University of Shiraz.

Certain lessons have been learned in setting up and operating the Institute, which may be of interest to those planning a similar venture. As regards equipment, it is important for the Institute to be well stocked with instruments of general use, such as ovens, thermostats, *p*H meters and incubators; it is usually too late to think of ordering such items for specific researches after the students arrive. A quick supply channel for chemicals, radioisotopes and other small items is vital, and Tehran's position on trunk air routes was a factor in the choice of location. Rapid clearance of radioisotopes through the Customs has been arranged with the Iranian authorities. The Institute has found it necessary to instal its own electrical generator to ensure a constant supply, and steps are being taken in co-operation with the University of Tehran to put into operation a liquid-nitrogen plant.

As regards staff, the CENTO region countries have understandable difficulties in releasing good scientists to work at the Institute. Partly this is because trained scientists are in great demand in their home countries, and partly because of financial difficulties; the latter will, it is hoped, be surmounted. Technicians and junior laboratory staff are also hard to find, and there is a great need to train people for such jobs, as well as to overcome the social attitudes that tend to deflect people from them. The Institute offers training especially in electronics under D. R. Cockbaine, chief electronics engineer, and it is to be hoped that the CENTO countries will take full advantage of the opportunity; electronics servicing is an essential part of a nuclear science programme.

On the financial and administrative side, the Institute has a fair degree of autonomy within the broad lines of policy laid down for it. The finances are largely centralized in a single budget, from which all expenses are paid according to the Institute's own rules (which are based on those of the CENTO Secretariat); this avoids the complications of having to deal with the separate regulations of four different Governments.

Certain aspects of the Institute's work presuppose co-operation with a national atomic energy authority. Any operation involving possible release of radioactivity outside the Institute itself may come in this category. The Institute's insect-labelling project is the most important immediate example, and waste disposal is another which will arise in the future (for the present all radioactive waste is stored). Relations have therefore been established with the Atomic Energy Commissions of the three countries of the region.

The immediate success of the Institute encourages the hope that it will become established as a scientific centre of high reputation in the Middle East. Its character may change somewhat, as the atomic energy programmes of Iran, Pakistan and Turkey get under way, and they begin to conduct their own radioisotope courses. (For Iran and Turkey especially, these will have the advantage of being in their own languages.) The future trend at the Institute may then be towards more specialized training and towards research projects. The benefits should be felt in many fields, owing to the wide ramifications of nuclear science.

OBITUARIES

Prof. E. P. Stebbing

Prof. E. P. Stebbing, whose death at the age of ninety occurred on March 21, must have surpassed the now almost legendary Sir William Schlich, whose pupil he was, both in the number of years he presided over a forestry school, and in the number of forestry students who passed through his hands. His influence on forestry was far greater in the educational field than in any other, despite his special interest and numerous writings on forest entomology and soil erosion.

Interest in entomology showed early when he was still under training for the Indian Forest Service at the Royal Indian Engineering College at Coopers Hill. In 1900 he had the distinction of being the first forest officer in India to be appointed to a scientific research post, that of forest entomologist, having served in an executive capacity as assistant and deputy conservator during his first seven years. The post of forest entomologist had only been sanctioned for two years, and was not renewed; but it so happened that the post of superintendent of the Indian Museum at Calcutta was vacant, and Stebbing was given an officiating appointment. When the Forest Research Institute was established at Dehra Dun in 1906 he was the obvious man to deal with entomology, and he worked there as Imperial forest zoologist until his return to Britain in 1910.

During his time in India and Burma he did a remarkable amount of pioneer work, the results being published as *Forest Bulletins* (8) and *Leaflets* (5), and *Indian Forest Records* (3) and *Memoirs* (5), dealing with insects injurious to many of the chief timber species, namely, teak, *Shorea robusta*, *Acacia arabica* and the conifers, as well as with the lac insect. His best-known entomological work is his "Indian Forest Insects of Economic Importance: Coleoptera" (1914). Stebbing's biological work was of a higher standard than his contributions to taxonomy, which obviously did not interest him so much; but in those days he could scarcely have avoided it since so few of the insects with which he was concerned had been named and described.

In 1910 he was appointed lecturer in forestry in the University of Edinburgh, and nine years later became the first professor of forestry there. He had thus completed more than forty years when he retired in 1951 (*Nature*, 167, 670; 1951).

Stebbing travelled widely, having visited Macedonia (as transport officer during the First World War) and the U.S.S.R., and afterwards many of the British and French Colonies, especially in West Africa. The country of his choice was patently France, and annually from 1921 he took groups of students there for part of their training. He had many friends in the Département des Eaux et Forêts, and just before he retired he was doubly honoured by having the Croix de Chevalier de la Légion d'Honneur conferred on him, and one of the famous ancient oaks in the Forêt de Tronçais named after him.

On the topic of erosion, Stebbing was strongly of the opinion that the administrators were inexcusably slow in taking—or enforcing when necessary—soil conservation measures, by preventing further denudation of vegetation, restricting excessive grazing, and undertaking constructive works. From his writing and speeches on this subject, he might have been considered somewhat of an alarmist, especially as to the rate of the 'advance of the desert' everywhere, though with special reference to the Sahara.

His most enduring publication will undoubtedly be his historical book on the "Forests of India" (1926). It is truly monumental in size, approaching 1,900 pages in three volumes covering the subject in great detail from its beginnings in the 1850's down to 1925. For the third volume covering the period 1900–25, he was able to use freely memoranda prepared for him by a large number of serving officers, but in doing so he drew on his own experience and added his personal views, thereby making the story much more alive and interesting than it would otherwise have been. He re-visited India and Burma in connexion with this work and was engaged on the preparation of a further volume to bring the history up to 1940 at the time of his death—I recently took over from him the task of completing and publishing it (extending it to the end of the British regime in 1947).

As a teacher, Stebbing had very definite ideas of what was best for his students, and kept as firm a rein on the curriculum as he did on his horse. He always rejected any suggestion of loading up his undergraduate course with more basic science, considering that practical forestry had not yet advanced enough for it to be of any value: his course was accordingly more weighted on the technological side than elsewhere—which might not have been expected in view of his own early specialization. Possibly he was inclined to overstress the model of advanced European practice, rather curiously adding an overdose of engineering and surveying appropriate to India and Burma in the old days.

No account of Stebbing's life would be complete without reference to his personality. Small and spare, he was exceptionally 'tough' both on foot and as a horseman, and remained so until an unusually advanced age. Stories of his walking performances still persist in India, while his equestrian ride from his home in Kent (Romden Castle) to London in 1935 when he was sixty-five was no isolated feat.

During much of his time at Edinburgh, Stebbing had the largest number of students among the four university schools of forestry in the United Kingdom. Many of them had been sent from overseas, and these and many others are serving or have served in the forest services of Britain and all countries of the Commonwealth; in fact, cases could be quoted where the large majority of the officers of the Forest Department were his men. One can safely prophesy that his record will never be repeated, and he will long be remembered in all forestry circles.

H. G. CHAMPION

Prof. E. J. Kraus

DR. EZRA JACOB KRAUS died at Corvallis, Oregon, on February 28 at the age of seventy-four. He was distinguished throughout the United States both for his massive contribution to scientific horticulture and for his flair for friendship with young botanists. He graduated from Michigan State University in 1907 and spent the first eleven years of his academic career in Oregon State College. In 1919 he went from Oregon to the University of Wisconsin; after a few years there he accepted an invitation to a chair in the botany department in the University of Chicago, where he stayed until his retirement in 1949.

The scientific work for which Kraus is remembered is his analysis of the balance of carbohydrate and nitrogen in plants in relation to fruiting. He demonstrated that many crop plants did not bear fruit unless a balance was maintained between these two classes of compounds. Some of his disciples greatly over-simplified his ideas by talking loosely about a carbohydrate–nitrogen ratio (or even a C/N ratio); but Kraus himself always realized that the relation between chemical composition and fruiting was a subtle and complex one, and he was impatient of these facile simplifications. Kraus's ability to diagnose why crops failed to bear fruit was quite astonishing. He showed (for example) how low yields in the apple orchards in the Hood River valley were due to over-manuring coupled with early pruning. A score of other examples could be cited, where fruit growers were able to improve their yields by controlling the balance of carbohydrate and nitrogen by means of simple horticultural practices: manuring, pruning, ringing and the like.

In Chicago he turned his attention to the anatomical effects of plant growth hormones, and (during the War, when he was attached to the U.S. Department of Agriculture) to the use of hormone-like chemicals for weed control; in both these fields he did important work.

But in the memories of hundreds of students Kraus will survive as a man rather than as a research worker. His influence on the graduate students who passed through his hands was enormous. It was conveyed through a quiet approach, a slightly cynical modesty, a bubbling sense of humour, and above all an impression that the priority which Kraus put first in his life was to spend time with young men, to talk to them, to travel with them, to pass on to them his enthusiasm for scientific horticulture. He was a capital 'debunker': indeed his interest in applied science and his suspicion of pure science sometimes led him to distrust research which seemed too sophisticated, and the succession of young men who had the privilege of his friendship remember with zest his mocking pragmatism.

Kraus disliked administration and committees, and he retired early (partly on account of illness) to spend the rest of his life doing the work he loved in the place he loved. From 1949 until his death, as a visiting professor of horticulture at Oregon State College, he devoted his time to horticulture, especially to the production of new varieties of chrysanthemums, and to cultivating his friends. He died after a long and painful succession of illnesses.

Kraus received wide recognition for his distinction in American botany. He was president of the Botanical Society of America in 1933 and of the American Society of Plant Physiologists in 1928, and he won many medals and prizes for his horticultural work. Much of his work is inevitably out of date: but his influence on a generation of botanists will endure.

E. ASHBY

Sir Leonard Woolley

CHARLES LEONARD WOOLLEY, who died on February 20, nearly eighty years old, was perhaps the most internationally famous archæologist of his generation. This reputation was built upon far more than the fact that he best represented the ordinary man's notion of an archæologist, namely, a digger-up of the lore, but especially the treasures, of antiquity. Certainly this was his life's work, and certainly his successes in it were outstanding. He was constantly in the field (in Egypt, Syria, above all in Iraq), he never belonged to any institution, he never undertook to teach students (except by practical example to his assistants), and he scarcely attempted academic literature in his subject.

Yet even among those few who could have worked so widely and so hard as he, many would have fallen short for want of certain talents which Woolley possessed. First, by some scarcely explicable gift, he could find the most rewarding spot to work, whether it was the choice of Atshanah (the ancient

Alalakh) in 1937 among the multitude of settlement-mounds in its area, or the divining, season after season, at Ur of the most significant quarter to unearth in the great city. There he conducted, beginning from 1926, his most famous operation, revealing the royal tombs of Sumerian rulers who had held sway over the city in a period of unequalled splendour, about 2,500 B.C. as now believed, unhappily just before writing, already in use, had learned to record history.

In this great discovery also was best exercised the next in order of Woolley's talents, namely, a fine appreciation of materials in the ground, how they should each be reached, traced, or penetrated, how objects sighted should be protected from impacts of tools or of the atmosphere, how they should be lifted, and how first-aid should be given for their protection, transport, and even their ultimate reconditioning. Many almost deceptively 'well-preserved' exhibits in museums are now substantially as they left Woolley's hands, not restored or falsified, but skilfully extricated by him and remoulded to the shapes which they had lost by decay and pressure of earth. Much of his work of this kind was brilliantly improvised in days which, although not long past, were before the very recent development of preservation laboratories and techniques in museums.

Woolley had, moreover, a notable facility of exposition, which worked in two ways: an attractive lecturer and writer for general audiences, he was also —more important for one whose discoveries could well speak for themselves—a judicious author of excavation reports, that difficult marginal literature which, always bulky, is worthless if it strives for effect, repulsive and unreadable if too painfully 'scientific'. Woolley's many publications were highly successful in these two kinds; his popular works are both interesting and well founded upon his discoveries (whereas his few attempts at more general themes are not very valuable), and his large volumes of excavation reports have the virtues of well-arranged matter, ample pictures and plans, and careful description based upon his industrious recording in the field. Such descriptive parts can nearly always be read with interest and ready understanding. Some have, indeed, criticized his observation as not being of the exactitude demanded by the most recent methods, and it is true that Woolley could be intuitive in his perception of archæological levels and his mental reconstructions of buildings and fragments. But such criticisms seem not to make enough allowance for the character of most Near Eastern sites, and the pell-mell of dwellings and artefacts of different ages, often jumbled together, which they usually exhibit.

Woolley's lively mind and exploring intelligence, if they sometimes led him beyond his evidence, were of more service in suggesting many true and fruitful consequences of his discoveries. These, as great and varied as have fallen to any modern digger, are his principal bequest and his enduring memorial.

C. J. GADD

Dr. Eric Boehm

DR. ERIC BOEHM, who died suddenly at Cardiff on December 28, was a well-known and respected figure in industrial chemical and pharmaceutical circles. Born in Breslau, Silesia, sixty-one years ago, he served a pharmaceutical apprenticeship in the town of Schreiberhau and later studied at the University of Berlin, graduating in 1922. He followed this with postgraduate training which, in 1925, resulted in the award of a Ph.D. He later studied bacteriology at the Robert Koch Institute in Berlin. The pre-war political situation in Berlin forced him and his family to leave Germany for Great Britain.

As a research worker he had become associated with Prof. Sabaletschka after the latter had introduced the now well-known esters of *p*-hydroxy-benzoic acid. Their association resulted in establishing these compounds under the trade names of 'Nipa Esters' as extremely useful, reliable and non-toxic preservatives for pharmaceutical and medicinal products and for foodstuffs. In 1938 these two workers showed that esters of gallic acid showed very promising anti-oxidant activities; this led to the widespread use of propyl gallate as an anti-oxidant for animal fats to prevent or retard rancidity. Its proved non-toxicity was recognized in 1948 when the United States officially approved its incorporation in fats for human consumption, to be followed by similar recognition in Britain and elsewhere.

In 1942, Boehm showed that certain mono-aryl and mono-alkyl ethers of ethylene glycol possess bactericidal activity. Interest centred chiefly around the phenyl ether of ethylene glycol ('Phenoxetol'), which was investigated bacteriologically and clinically by Berry, Gough *et al.* It showed unusual activity against *Ps. pyocyanea* and during the War, in the early days of penicillin, when topical application to wounds was, of necessity, used, a combination of 'Phenoxetol' with penicillin widened the antibacterial spectrum of the latter and also prevented its decomposition in the wound.

Dr. Boehm was that rare combination of an able scientist and capable business administrator. He also combined rare intellectual qualities with integrity, charm and kindness, as those who had the privilege of knowing him can testify.

H. BERRY

Prof. H. Stansfield

PROF. HERBERT STANSFIELD, whose death occurred on March 14, was appointed to the chair of physics and electrical engineering at University College, Southampton, in 1912. Previously he was a lecturer in physics in the Victoria University, Manchester. In 1919 he was transferred, with other Departments of the College, from the old Hartley Building to the new site at Highfield.

Research undertaken at Southampton by various members of his staff, under his direction, was started in the late 'twenties. His main interest was in optics, particularly with modifications to the Michelson interferometer experiments on the velocity of light. One summer he co-operated with the Royal Navy on sound recordings of gunfire. Setting up his apparatus in an area where no reports were expected, many yards of photographic paper recordings from an Eindhoven string galvanometer were processed and examined, and the nil report confirmed.

Past students will remember Prof. Stansfield's very characteristic action in stroking his fountain pen on his beard in order to charge some piece of electrostatic equipment in lecture demonstrations. Another characteristic was his exceptionally dry skin. He would touch 200-V. terminals with his fingers and then to be quite sure he would moisten them and repeat the action and remark, "Yes, I am sure they are alive"!

He retired in 1932 at the age of sixty, and the opportunity was then taken to separate the Department of Electrical Engineering at Southampton from Physics, and join it with the Departments of Civil and also Mechanical Engineering in the Engineering Faculty. C. E. CHESTER

Mr. W. H. Searle, B.E.M.

WILLIAM SEARLE, who was for sixty-three years fisherman collector on the staff of the Marine Biological Association of the United Kingdom, died at Plymouth on April 6, at the age of eighty-four. 'Bill', as he was affectionately known by all, must live in the memory of a great number of biologists, from all over the world, who visited the Plymouth laboratory either as research workers or students. It can be truly said that he played a very important part in the development of marine biology through his remarkable knowledge of the fauna and flora and its local distribution as far afield as Salcombe. He was able to produce almost any organism when required, though their specific names were not easy to interpret when marked by a broad Devonshire accent. Searle joined the Association's staff in December 1895, and worked tirelessly and devotedly, for many years single-handed, in small vessels which have become part of the history of marine biology, *Anton Dohrn*, *Busy Bee*, *Huxley*, *Oithona* and finally *Gammarus*, now in her thirty-seventh year.

He was elected an associate member of the Marine Biological Association in 1953. He also received the Queen's Coronation Medal; and in 1957 his services to science were recognized by the award of the British Empire Medal, of which he was very proud. He retired from service in 1958. F. S. RUSSELL

NEWS and VIEWS

New Director of the Science Museum, London: Dr. D. H. Follett

ON taking up his duties as director of the Science Museum in succession to Dr. T. C. S. Morrison-Scott (see *Nature*, March 26, p. 888), Dr. D. H. Follett will relinquish his post as keeper of the Department of Electrical Engineering and Communications in the Museum, to which he was appointed in 1957. Dr. Follett graduated from Brasenose College, Oxford, in 1929, in the honours school of physics. He then entered the firm of Adam Hilger, Ltd., where he was engaged in developing the application of photoelectric methods, particularly to spectrophotometry. At the same time he carried on part-time research in cosmic rays at Birkbeck College under Prof. P. M. S. Blackett, for which he was awarded the internal degree of Ph.D. of the University of London. He joined the Science Museum staff in 1937 as assistant keeper in the Department of Physics, in which Department he remained, apart from the war years, until 1957, his special responsibility being for electricity and acoustics. During the War he served with the Meteorological Branch of the R.A.F. Volunteer Reserve and was engaged, among various duties, on the operational development of the cathode-ray direction-finding system for locating thunderstorms. He was appointed secretary of the Science Museum Advisory Council on its reconstruction in 1951, a post which he held for six years in addition to his other museum duties. During this period he acquired a broad view of the Museum's functioning in all its aspects. Apart from his special interest in museums and the history of science—he is a Fellow of the Museums Association and a member of the British Society for the History of Science—Dr. Follett has wide interests in science generally and physics in particular. He is a Fellow of the Institute of Physics, being vice-chairman of the Education Group, a Fellow of the Physical Society and a member of the Committee of Visitors of the Royal Institution.

Research at the Ministry of Aviation: Mr. E. B. Carter

MR. E. B. CARTER, at present serving as an assistant director in the Engine Research and Development Division of the Ministry of Aviation, has been promoted to deputy chief scientific officer and appointed director of engine production. He has a wide and varied experience of research and development on all types of aero-engine, ranging from piston engines through gas turbines to ramjets and rocket engines, which will be a considerable asset to him in his new job, in an engineering sphere where development and production are very closely linked together. Mr. Carter was born in 1912 in Halifax and received his early technical training at Halifax Technical College. On completion of the mechanical engineering course, he studied machine tool practice and was appointed assistant workshop instructor. In 1936, he became workshop superintendent and lecturer at Constantine College, Middlesbrough. Mr. Carter entered the Civil Service in 1939 on his appointment as a technical assistant in the Directorate of Engine Research and Development of the Air Ministry. From that time until 1955, his London Headquarters' service in the Air Ministry, Ministry of Aircraft Production, and Ministry of Supply alternated with periods of service as resident technical officer at the Bristol, Napier and de Havilland engine companies. In 1955, Mr. Carter was appointed assistant director in charge of research and development of ramjet and liquid-propellant rocket engines for aircraft and missiles, the post he relinquishes to take up his appointment as director of engine production.

Mr. J. D. Clare

MR. J. D. CLARE has been promoted to deputy chief scientific officer and appointed director of guided weapons research and development (Air) at the Ministry of Aviation Headquarters. In his new post he will be responsible for the development of the surface-to-air and air-to-air guided weapons for the Royal Air Force and the Army. Mr. Clare graduated at the University of Birmingham in 1940. He joined the General Electric Co., Coventry, as a student apprentice and later worked in the telecommunications laboratory on many aspects of carrier telephony systems. During this time he obtained his M.Sc. In 1945 he joined Sobell Industries as head of the radio laboratory and later became assistant chief engineer responsible for both the design and development for production of commercial radio and television receivers. In 1950 he joined the Ministry of Supply at the Radar Research and Development Establishment, Malvern, and worked on high-power precision tracking radars. On the amalgamation of the Radar Research and Development Establishment with the Telecommunications Research Establishment to form the Royal Radar Establishment, he joined the Guided Weapon Department and in 1955 he became superintendent, surface-to-air guided weapons guidance systems. In this post he has been responsible for research on new guidance techniques which now form the basis of the future systems for the air defence of the United Kingdom and the field army. He has also been responsible for the development of tracking radars and other components of the systems and for the technical co-ordination of the complete systems.

The Central Botanical Laboratory, Allahabad :

Dr. E. K. Janaki Ammal

Dr. E. K. Janaki Ammal retired from the post of director of the Central Botanical Laboratory, Botanical Survey of India, Allahabad, on October 13, 1959. Dr. Janaki Ammal has been intimately associated with the reorganization of the Botanical Survey of India, first as officer on special duty (1952–53) and as director, Central Botanical Laboratory. Dr. Ammal is widely known for the "Chromosome Atlas of Cultivated Plants" which she compiled with Dr. C. D. Darlington. She is at present officer on special duty, Regional Research Laboratory, Jammu (in Kashmir State).

Dr. G. S. Puri

Dr. G. S. Puri has been appointed director of the Central Botanical Laboratory, Allahabad, in succession to Dr. E. K. Janaki Ammal. Dr. Puri has had a varied experience during his past twenty-five years of botanical career. He has done work of international recognition in palæobotany, phytogeography and ecology, and had the privilege of working with Prof. Birbal Sahni at Lucknow and Prof. W. H. Pearsall at London. He was forest ecologist at the Forest Research Institute, Dehra Dun, for about ten years and during the past three years as regional botanist of the Western Circle of the Botanical Survey of India he completed a reconnaissance survey of the vegetation of western India. Dr. Puri has published about 200 botanical papers, including two major books, the "Indian Manual of Plant Ecology" and "Forest Ecology".

The Australian Academy of Science

The following new Fellows of the Australian Academy of Science have recently been elected: Prof. A. E. Alexander, professor of applied chemistry, University of New South Wales; Prof. G. M. Badger, professor of organic chemistry, University of Adelaide; Dr. S. Fazekas de St. Groth, reader in virology, John Curtin School of Medical Research, Australian National University; Prof. K. J. Le-Couteur, professor of theoretical physics, Research School of Physical Sciences, Australian National University; Dr. J. M. Rendel, chief of the Division of Animal Genetics, Commonwealth Scientific and Industrial Research Organization; Dr. F. W. G. White, chairman of the Commonwealth Scientific and Industrial Research Organization.

The Thomas Ranken Lyle Medal for 1959 was presented to Prof. E. S. Barnes, professor of mathematics in the University of Adelaide, who delivered an address on number theory, his special field of work in mathematics.

Awards of the Meldola Medal for 1959

The Meldola Medal, which is the gift of the Society of Maccabaeans, is normally awarded annually. On four occasions in the past, two candidates have been adjudged to be of equal merit in diverse fields of work and two awards were made. This year it has again been decided to make two awards of the Meldola Medal. The recipients will be Dr. J. I. G. Cadogan, Department of Chemistry, King's College, London, for his work in the field of organic chemistry, with special reference to reactions of free radicals in solution and to reactions of organophosphorus compounds; and Dr. T. C. Waddington, Department of Chemistry, University of Cambridge, for his work in the fields of physical and inorganic chemistry, with special reference to thermochemistry and reactivity of azides; photoconductivity of anthracene; lattice energies and infra-red spectra of inorganic salts; and liquid hydrogen chloride as an ionizing solvent.

The Food Research Advisory Committee

Mr. J. B. Godber, Joint Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, recently stated that the Minister and the Secretary of State for Scotland had set up a committee, under the chairmanship of the Permanent Secretary of the Ministry of Agriculture, Fisheries and Food, to assist them in advising the Agricultural Research Council on priorities in Government food research. This was in a written answer to a question in the House of Commons as to the arrangements for ensuring that the technical problems of the food industry are brought to the notice of the Agricultural Research Council now that the Council is responsible for the three Government research stations concerned with the handling and processing of foodstuffs. The Committee would be known as the Food Research Advisory Committee and its terms of reference would be: "To advise on those food problems (except for fish, which is dealt with separately) requiring investigation or research which should be undertaken with the aid of public funds and to make recommendations as to the priorities to be accorded to such problems". In addition to the chairman, Mr. E. Capstick, Dr. D. P. Cuthbertson, Sir Charles Dodds, Mr. J. D. Hutchison, Mr. D. Lowe, Mr. A. Sainsbury, Sir William Slater, Dr. J. A. B. Smith, Mr. T. A. H. Sycamore, Mr. J. P. Van den Bergh, Sir George Wilson and Mr. N. Wood had accepted invitations to be members of the Committee.

Ford Research Fellowships in Animal Reproduction

The Ford Foundation has made a grant of 550,000 dollars (£196,000) to the Zoological Society of London to endow a series of research fellowships in animal reproduction. Our present knowledge of reproductive processes is derived mainly from observations on a limited number of species, such as rats, mice, rabbits, guinea pigs, monkeys, and farm animals; but it is sufficient to show that there is great diversity in reproductive mechanisms. We know that some species are continuous breeders and that others are seasonal; that some animals ovulate spontaneously and that others do so only as a result of various forms of external stimulation. These differences have always served as pointers to research, which has in turn revealed issues which are vitally important to the control of reproduction. The animal collections maintained by the Society at Regent's Park and Whipsnade constitute the richest assemblies of living vertebrates in the world, and the Society also has in its possession breeding records which go back to the year 1828. The resources of the Society, however, have never been sufficient to promote a proper and continuing investigation of breeding behaviour.

Those appointed to the research fellowships, of which there will be six—three senior and three junior fellowships—will be expected to undertake systematic studies of the reproductive habits and the physiology of animals. It is hoped that they will have a secondary attachment to a university department or to a research institute in which reproductive physiology is a major research interest. Laboratories will be provided at Regent's Park by the Zoological Society, and a Breeding Research Committee, including British scientists who are in the forefront of research into reproductive physiology, has been established to supervise the work. Among those serving on the Committee are Prof. E. C. Amoroso, Prof. F. W. Rogers-Brambell, Prof. A. St. G. Huggett and Dr. A. S. Parkes.

The Beit Memorial Fellowships

THE trustees of the Beit Memorial Fellowships for medical research have announced the following elections: *Junior Fellowships* (£900 *a year*), D. C. Watts, to study the mechanism of enzymes in muscle from animals of various species and especially the role of the sulphydryl groups thought to be necessary for enzyme activity (at the Department of Biochemistry, University College, London); J. R. Casley-Smith, to investigate the ultra-structure and properties of the endothelium of lymphatics, in health and disease, with special reference to dropsy (at the Sir William Dunn School of Pathology, Oxford); P. F. Fottrell, to investigate the mechanism of adaptive enzyme formation in normal and malignant animal cells maintained in tissue culture (at the Tissue Culture Laboratory, Biochemistry Department, University of Glasgow); A. J. Rowe, to study the properties of the contractile muscle protein myosin, by means of the electron microscope (at the Department of Colloid Science, Cambridge); Dr. G. F. V. Seaman, to study the relationship between the chemical composition of the human red blood corpuscle membrane and its electrokinetic charge as determined by microelectrophoresis (at the Department of Medicine, Cambridge). *Senior Fellowship* (£1,300 *a year*), Dr. J. R. Tata, to purify and isolate thyroxine dehalogenase from various tissues and to investigate the relationship between metabolic transformation of thyroid hormones and their action in an isolated system (at the National Institute for Medical Research, Mill Hill, London).

Paul Instrument Fund Awards

AWARDS of grants by the Paul Instrument Fund Committee have been made as follows: £2,500, with the probability of further grants totalling up to £3,000, to Dr. J. H. Sanders, university lecturer and demonstrator in physics, Clarendon Laboratory, Oxford, for the construction of an optical maser; £3,000 to Mr. H. W. Gosling, lecturer in the Department of Engineering, University College of Swansea, for the construction of an instrument for checking the stability of the standard ampere. The Paul Instrument Fund Committee, composed of representatives of the Royal Society, Physical Society, Institute of Physics and Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Co-operative Research in Europe

A SHORT article, "O.E.E.C. and the Scientific Future", in the February issue of *European Productivity* notes some of the ways in which the Organization for European Economic Co-operation has been strengthening the scientific resources of Europe. First, the Organization is pursuing an inquiry into the scientific policies of member countries and their research resources, such as a study of fiscal measures which influence investment in industrial research. Secondly, co-operative research is in progress on fatigue failure in metals and the fouling of ships' hulls; representatives from Sweden and Yugoslavia joined the group of experts this year and the adhesion of Yugoslavia will make it possible to secure a better picture of fouling organisms in Mediterranean waters. Tests are still being made in Europe, Australia, North America, South Africa and Singapore, and a catalogue of the biological and hydrological characteristics of the testing stations in use will be published. Experts from nine European countries and the United States have met to plan co-operative research into aircraft noise and have recommended free exchange of all available information on aircraft noise and its effects, particularly its biological effects on people living near airports. A permanent group has been set up to advise the Committee on Applied Research on the long-term development of research into the abatement of aircraft noise. A group of nine member countries dealing with fire research is proposing to study unstable chemicals for plastics and also fire-fighting techniques and materials, while other work is in hand on the industrial utilization of oil-shale fires, the measurement of air pollution, static electricity in industrial tools, road safety and production engineering techniques. Thirdly, attention is being given to the supply of scientific and technical personnel in relation to Europe's economic needs, including such matters as the use of television in science teaching, and methods of teaching mathematics in schools.

British Library of Political and Economic Science

THE annual report of the British Library of Political and Economic Science for 1958–59 records little change in the funds available for purchase or in book prices; but acquisitions of Russian publications were slightly lower than in 1957–58 and were facilitated by exchange arrangements with the Saltykor-Shchedrin Public Library, Leningrad, the Lenin Library, Moscow, and the All-Union Library of Foreign Literature (pp. 16. London: British Library of Political and Economic Science, 1959). Additions during the year included 5,330 treatises, 1,510 pamphlets, 2,386 non-serial government publications and 8,235 current serials, including 5,913 periodical titles received as gifts from governments, municipalities, institutions and societies. Of the Library's total holdings of 401,752 bound volumes, 12,137 were in the Lending Library and 4,674 in the Shaw Library.

The Manchester Museum

The annual report of the Manchester Museum for 1958–59 records that the year has been notable for the continuation of the policy of the Committee to modernize display and provide showcases with internal lighting, the receipt of a number of valuable acquisitions including the Raby collection of coins and the Armstrong collection of bones and artefacts from Pin Hole Cave, Derbyshire, and the mounting of a series of exhibitions in the special gallery devoted to this purpose (pp. 20. Manchester: The Manchester Museum, The University, 1960). These latter included the R. W. Lloyd Japanese Collection and the Robinow Collection from ancient Egypt. During the year two departmental guides, devoted to ethnology and mammals, were published. It is also reported that the University has allocated certain funds for the conversion of the Archæological Balcony into a complete gallery, part of which can be used for the R. W. Lloyd Japanese material. The building programme of the University has made it possible for the Department of Zoology to relinquish the accommodation adjoining the Herbarium, and this is to be used for a much-needed botanical laboratory, an office and for storage.

Geological Surveying by Helicopter

Up to about 1950, after more than a century of effort, only about a third of Canada's 3·6 million square miles of land had been mapped geologically even on a reconnaissance scale. Conventional field work in increasingly remote regions was becoming prohibitively slow and costly, and insufficient trained geologists were available to carry out intensive pioneer explorations comparable to the all-out Russian efforts in Siberia. Clearly a radically new field technique was required to meet the urgent need for geological exploration, development and exploitation in the north. In a recent publication officers of the Geological Survey describe how this new technique has been found in the widespread use of helicopters (Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Bulletin No. 54: Helicopter Operations of the Geological Survey of Canada. By Officers of the Geological Survey of Canada. Pp. xii+60+7 plates. (Ottawa: Queen's Printer, 1959.) 75 cents). Seven major helicopter-supported geological surveys, instituted as experiments between 1952 and 1958, have covered close on half a million square miles—half as much ground as had been mapped in the previous 110 years. While these helicopter operations have afforded maps on the scale of 1 in. to 8 miles (1 : 506,880) instead of the 1 in. to 4 miles common in conventional reconnaissance, they have given more uniform coverage and more speedy results at an operating cost (in the region of 1·68–3·63 dollars per square mile) less than that of any other field method known. The rapid progress is indeed remarkable; but Canada still has some considerable way to go before it overtakes the U.S.S.R., now almost completely mapped on scales of between 1 : 500,000 and 1 : 1,000,000, and producing on a scale of 1 : 200,000 between 120 and 150 map-sheets per annum.

Fate of Bacteria in the Small Intestine

Recent work carried out by J. M. S. Dixon, of the Public Health Laboratory, Cardiff, confirms the view that the empty small intestine of healthy persons contains only a few transient organisms, even when free acid is absent from the stomach (*J. Path. and Bact.*, 79, No. 1; January 1960). The small gut appears to possess some antibacterial mechanism causing organisms that escape destruction in the stomach to be either destroyed or removed from the lumen before they can multiply. There has been some disagreement as to whether the small intestine is relatively free from organisms because of destruction of bacteria within the lumen or because peristaltic activity removes the bacteria before they can multiply. The *in vivo* experiments were designed to elucidate this point. Test organisms were inoculated directly into subcutaneously displaced loops of small intestine of non-anæsthetized rats together with an inert unabsorbable marker. The animals were killed after periods of time and the number of bacteria and quantity of marker present in regions of the small gut determined. The marker used was a radioactive isotope of chromium which, when tagged to red blood cells, is virtually unabsorbed from the intestine. The results of twenty-eight bacterial inoculations indicated that bacteria were rapidly moved onward and soon removed from the small intestine by peristaltic action. There was no indication of bactericidal action. Mechanical removal by peristaltic action, aided by the secretion of mucus, is probably the main fate of viable organisms that enter the small intestine.

Cave-dwelling Shrimps

The Australian Museum announces that it has acquired from the Milyering district, Western Australia, some freshwater shrimps of considerable interest to zoologists (*Aust. Mus. Mag.*, 13, No. 3; 1959). The specimens were collected by Mr. A. Snell, of Bunbury, West Australia, in the dark recesses of a well bored through coral and limestone country. The shrimps lack sight and have been identified as true troglodic (cave-dwelling) forms—the first to be recognized from the Australian continent, and not previously recorded. The task of providing the shrimps with a zoological name and preparing a description of them for publication in the *Records of the Australian Museum* is being undertaken by Dr. Lipke Holthuis, of the Leyden Museum, Holland.

Large Pine Weevil

The first of the leaflets published by the Forestry Commission has now been issued in revised form and illustrated with attractive colours (Forestry Commission Leaflet No. 1: The Large Pine Weevil (*Hylobius abietis*). Revised edition. Pp. 11. London: H.M. Stationery Office, 1960. 1*s*.). It deals with the large pine weevil, *Hylobius abietis* L., which is the only species of the genus *Hylobius* of importance in coniferous forests in Britain. It feeds on the bark of young coniferous trees, and, where it is unduly numerous, may cause the complete loss of a newly planted crop. Recent trials, both in Great Britain and abroad, have shown that it is possible to provide protection to young crops by the direct application of various insecticides. Two possible situations may arise—that in which the weevil attack is anticipated, and that in which the weevil attack occurs unexpectedly. In the former case, the dipping of planting stock before planting out should be used; but in the latter the young crop should be sprayed as soon as the attack develops. With both types of treatment the insecticide recommended for use is DDT. The main factor controlling the numbers of *Hylobius* is the availability of suitable breeding sites. When breeding grounds are provided by fellings or by natural catastrophes such as fire or wind-blow, numbers inevitably rise. Some control of weevil increase is afforded by insect parasites, such as *Bracon hylobii* Ratz. and *Ephialtes tuberculatus* Geoff. in Four., by fungal attack on larvæ and possibly by birds. Generally, this natural control is unable to keep populations below a density at which they can cause serious damage to young conifer crops.

The Nucleus in a Basidiomycete

A. BAKERSPIGEL has given a detailed account, with numerous photographic illustrations, of the structure and manner of division of vegetative hyphal nuclei in *Schizophyllum commune* (*Canad. J. Bot.*, 37, No. 5, 835; 1959). These nuclei do not divide in a manner directly comparable to ordinary mitosis. During division the tightly packed chromatinic granules become loosely arranged, after which they contract into a densely stained bar. As division proceeds, this bar of chromatin elongates and then constricts at its mid-region. At the end of division the extremities pull apart quickly to form the chromatin portions of the two sister nuclei. The Feulgen-negative central bodies decrease in size, and at the end of division their remnants lie free in the cytoplasm. New central bodies arise in the maturing sister nuclei. Throughout division, metaphase plates, spindles, or individual chromosomes were not observed in any of the stained or living preparations. A nuclear membrane has not been observed surrounding any of these nuclei.

Anchiceratops from Alberta

A NATURAL history paper by Mr. Wann Langston, jun. (No. 3; September 23, 1959), published by the National Museum of Canada, deals with specimens of *Anchiceratops* from the Oldman formation of Alberta. This is an Upper Cretaceous bed, and the material was collected by a National Museum expedition of 1937. The paper describes fully the specimens in the Museum and discusses the habitat of *Anchiceratops* and the characteristics of the sediments in which they are found.

Miniature Gyroscopes

IN the first of a series of articles devoted to micro-instruments, W. R. Simons of Smiths Aircraft Instruments Ltd., describes the use of miniature gyroscopes in aircraft and guided missiles (*Research for Industry*, 13, No. 2; February, 1960). The special requirements of guided missile control systems and recent developments in the design of aircraft auto-pilots have created a demand for miniaturized gyroscopes, possessing high accuracy together with exceptional reliability and robustness. Some of the fundamental problems associated with the design of these miniature gyroscopes are discussed and typical examples of the instruments are described.

Bibliography on Plasma Physics and Magnetohydrodynamics

THOUGH the subject of magnetohydrodynamics dates back to the nineteenth century, it is primarily in the past two decades that it has attracted wide attention. Its importance, first recognized in astrophysics, has spread to many fields, particularly the study of the flow of gases and the appearance of ionization, and the phenomena presented by completely ionized plasmas at extremely high temperatures. The literature on the subject has increased at a rapid rate, and we are indebted to J. D. Ramer, of the Engineering and Physical Sciences Library of the University of Maryland, for the collection of literature of the period 1937–59 which he has compiled (Bibliography on Plasma Physics and Magnetohydrodynamics and their Applications to Controlled Thermonuclear Reactions. Pp. ii + 105. College Park, Maryland: Engineering and Physical Sciences Library, University of Maryland, 1959). The bibliography contains 1,707 references arranged alphabetically by authors. In general, the titles of the papers are given in English, but the language of the original article is quoted. The author index seems superfluous (it covers twelve pages), but together with the numerical index to Atomic Energy Reports (five pages) and the alphabetical list of journals referred to in the bibliography (four pages) which complete the volume, it gives an excellent impression of the wide and useful coverage of the bibliography.

Scholarships in Chemical Engineering

CONSTRUCTORS John Brown, Ltd., have entered into an agreement with the Institution of Chemical Engineers for the award of two scholarships. The purpose of the scholarships is to encourage research in chemical engineering and, in particular, in chemical plant design. The scholarships are tenable at any educational institution in the United Kingdom in receipt of grants from the University Grants Committee, and having a department of chemical engineering under the direction of a professor of chemical engineering. Further information can be obtained from Dr. J. B. Brennan, Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. Applications should reach the Institution not later than June 1.

University News:

Birmingham

THE following appointments to lectureships have been made: Dr. G. H. Burkhardt (mathematical physics); Dr. D. C. Champeney (physics); Mr. D. A. O'Connor (physics); Dr. M. J. Lawrence (genetics); Mr. G. H. Trengrouse (mechanical engineering); and Mr. E. Amini (mechanical engineering).

Edinburgh

A CHAIR of electrical engineering has been instituted in the University of Edinburgh and applications for appointment to it will shortly be invited.

London

DR. K. W. CROSS, reader in physiology at St. Mary's Hospital Medical School, has been appointed to the University chair of physiology tenable at the London Hospital Medical College. Dr. B. C. L. Weeden, reader in organic chemistry at the Imperial College of Science and Technology, has been appointed to the University chair of organic chemistry tenable at Queen Mary College. Dr. D. V. Ager, lecturer in geology at the Imperial College of Science and Technology, has been appointed to the University readership in geology tenable at that College. The title of reader in the history and philosophy of science in the University of London has been conferred on Dr. N. H. de V. Heathcote in respect of his post at University College.

The following elections to fellowships of the Imperial College of Science and Technology have been made: Sir Harold Roxbee Cox, director, Wilmot Breeden (Holdings), Ltd., the Metal Box Company, etc., former special lecturer in aircraft structures;

Prof. C. W. Dannatt, professor emeritus, former professor of metallurgy and former dean of the Royal School of Mines; Prof. F. G. Gregory, professor emeritus and former professor of plant physiology; Mr. G. C. Lowry, former secretary of the College; and Sir William Pugh, director of the Geological Survey and Museum, member of the Governing Body.

Announcements

Mr. J. B. Adams, at present director of the Proton Synchrotron Division of the European Organization for Nuclear Research (CERN), has been appointed interim director-general of the Organization; this appointment became necessary as the result of the recent death in an aeroplane accident of Prof. C. J. Bakker. Mr. Adams was recently appointed director of the new Controlled Thermonuclear Research Establishment in the United Kingdom, but will remain with CERN until later this year.

Dr. W. F. Floyd, senior lecturer in physiology at the Middlesex Hospital Medical School, University of London, has been appointed to be first head of the Department of Ergonomics and Cybernetics at Loughborough College of Technology. Dr. Floyd will assume his appointment at Loughborough in September.

Dr. H. D. Kay, director of Twyford Laboratories, Ltd., Twyford Abbey Road, London, N.W.10, announces the following appointments: Microbiology Section, Dr. C. Elizabeth Work, who has carried out research in the Department of Chemical Pathology, University College Hospital Medical School, London; Dr. Work will be assisted by Dr. V. A. Knivett, formerly of the Microbiology Section of the National Chemical Laboratory (Department of Scientific and Industrial Research), Teddington. Biochemistry Section, Dr. J. Leggett Bailey, recently at the Rowett Research Institute, Aberdeen; he will be assisted by Dr. R. J. Sturgeon, of the Research and Development Department at Epsom of the Distillers Company, Ltd.

The sixth annual Guenter Loeser Memorial Lecture will be given by Dr. Hans E. Hinteregger on "Solar Extreme Ultra-violet Radiation as a Source of Interplanetary Ionization". The Lecture, organized by the U.S. Geophysical Research Directorate, will be given in the Lexington High School Auditorium, Lexington, Massachusetts, on June 1. Further information can be obtained from Arnold M. McCalmont, Geophysical Research Directorate, Air Force Cambridge Research Center, Bedford, Mass.

There will be open days at the National Physical Laboratory, Teddington, on May 25 and 26. The new Ship Hydrodynamics Laboratory at Feltham (see *Nature*, 184, 926; 1959) will be open to inspection for the first time.

The seventy-fifth anniversary exhibition of the Royal Scottish Geographical Society, entitled "Mapping Britain", is being held in the Royal Scottish Museum, Chambers Street, Edinburgh, during May 14–June 25. Further information can be obtained from the Secretary of the Society at Synod Hall, Castle Terrace, Edinburgh 1.

The second Congress on Catalysis is to be held in Paris during July 4–9. Further information can be obtained from Prof. G. Emschwiller, 10 rue Vauquelin, Paris 5°.

The eleventh International Astronautical Congress is to be held in Stockholm during August 15–20 under the auspices of the Swedish Interplanetary Society. Further information can be obtained from the Congress Information and Publicity Committee, *IAF*-60, Box 5045, Stockholm 5, Sweden.

An International Conference on Scientific Problems of Crop Protection, sponsored by the Hungarian Academy of Sciences, will be held in Budapest during July 19–22. Further information can be obtained from Z. Király, Research Institute for Plant Protection, Budapest.

An International Congress on Photobiology is to be held in Copenhagen during July 31–August 5 under the auspices of the International Committee of Photobiology. Further information can be obtained from Dr. B. Chr. Christensen, Finsen Memorial Hospital, Strandboulevard 49, Copenhagen Ø.

The sixth Commonwealth Conference on Mycology will be held at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, during July 15–23. Further information can be obtained from the Commonwealth Mycological Institute, Ferry Lane, Kew, Surrey.

The fourth International Conference on Goitre is to be held at Church House, Great Smith Street, London, S.W.1, during July 5–9. Further information can be obtained from the honorary secretary, Dr. Selwyn Taylor, 67c New Bond Street, London, W.1.

A conference on heat treatment practice, organized by the British Iron and Steel Research Association, will be held at Harrogate during July 5–6. Further details can be obtained from the Technical Secretary, Metallurgy (General) Division, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

An International Congress of Endocrinology, the first of its kind, is to be held in Copenhagen during July 18–23. Further information can be obtained from the Congress Secretariat, Dr. Svend G. Johnsen, Hormone Department, Statens Seruminstitut, Copenhagen S, or the general secretary, Prof. F. T. G. Prunty, Department of Chemical Pathology, St. Thomas's Hospital Medical School, London, S.E.1.

The annual meeting and summer conference of the Society for Applied Bacteriology will be held at Bangor during July 5–7. Further information can be obtained from Dr. Ella M. Barnes, Low Temperature Research Station, Downing Street, Cambridge.

The third International Conference on Medical Electronics and associated scientific exhibition are to be held at Olympia, London, during July 21–27. The conference is being organized jointly by the Electronics and Communications Section of the Institution of Electrical Engineers and the International Federation for Medical Electronics. Further information can be obtained from the Conference Secretariat, Institution of Electrical Engineers, Savoy Place, London, W.C.2.

A new list of medical and technical papers prepared by research workers has just been issued by Cyanamid International in London. The current range of subjects covers the trial administration of Lederle Laboratories' oral polio vaccine in many different countries and papers on specialty industrial chemicals. These paper are available from the Cyanamid International Information Service, 16 Bolton Street, London, W.1.

INHALED PARTICLES AND VAPOURS

THE British Occupational Hygiene Society held an international symposium under this title at Oxford, during March 29–April 1, when 38 papers were read. Inhalation of foreign substances in the atmosphere has never before been discussed on such a scale, and the gathering of 250 scientists from 19 nations enjoyed a unique presentation of most of the basic and a few of the applied aspects of the subject.

Six of the papers dealt with the deposition, translocation and effects of radioactive particles.

Papers on the mechanics of breathing included a study of maximal flow-rates, a consideration in designing respiratory equipment, and a demonstration that turbulent flow could be detected at the exit of a segmental bronchus with high air-flow. During gentle breathing the larynx probably causes some turbulence which is passed down the trachea when inhaling; even at high rates turbulence is not fully developed and cross-stream mixing is far from complete.

The mixing of tidal and alveolar air had been investigated with a half-micron aerosol as a tracer. The particles in this have practically no diffusion constant, and no rate of fall, so that they follow the mechanical movements of inspired air and reveal, by wash-in and wash-out analyses, the gas-phase exchange properties of the lung which cannot be demonstrated by even high molecular weight gases since they diffuse too quickly. This exchange is important in the deposition of aerosols in the lungs, which is further complicated by the desirability of distinguishing alveolar from bronchial epithelial deposition since only the former contributes to the pneumoconioses.

Previous approaches to the problem have been made by calculating the motion of particles in the airways; a formalized anatomy of the human lung for use in such calculations, and in expressing the fluid mechanics of gas-flow, was put forward at the meeting.

The loss of particles during inhalation was shown to be affected by their increase in size by absorbing moisture, while passing through the respiratory tract, which also results in their being less likely to penetrate deeply. Tobacco smoke has a high retention, in view of its initial particle size, for this reason, and sodium chloride crystals increase about 350 times in volume.

Sulphuric acid droplets behave similarly and are important in atmospheric pollution. The oxidation of sulphur dioxide, which dissolves rapidly in aqueous droplets, is promoted catalytically by trace contaminants in the liquid phase, and may be a factor in the relationship of atmospheric sulphur to human respiratory distress.

An increase in the response of guinea pigs to irritant gas, expressed as a rise in respiratory resistance measured with an intrapleural catheter, referred to tidal volume indicated by a body plethysmograph, was found to result when an inert aerosol of sodium chloride was inhaled along with sulphur dioxide or formaldehyde. The particle size had to be around 0·1μ in diameter, 2·5μ aerosol giving no potentiation. A physical explanation was advanced for this effect, based on the absorption of the gas by the particles so that the uptake on respiration was localized at discrete places on the bronchial surface instead of being diluted over a large area. This observation has not yet been confirmed in man.

The absorption of vapours during inhalation is subject to three possible rate-determining factors which can be expressed as a simple mathematical model. They comprise the rate of lung ventilation, the diffusion capacity across the lung wall, that is the gas-liquid boundary, and the rate of flow of the pulmonary blood allowing for the air–water partition coefficient of the foreign gas.

According to circumstances one or other of these factors predominates to control the build-up in tissue during exposure and the subsequent drainage, when the breathing of pure air is resumed. The three main storage depots recognized are viscera, connective tissue including skin and muscle, and body fat, between which the flow of blood is apportioned in the ratios 73 : 24 : 3. Allowing for tissue mass and fat–water partition it can be shown, in contrast to carbon monoxide, which is all held in the blood, that nitrogen is stored and that the equilibration-rate for fat is very slow so that a reservoir is formed and may result in the initiation of caisson disease.

A soluble vapour was shown, in experiments on the uptake of inhaled sarin (*iso*propylmethylphosphonofluoridate) in animals and man, to be absorbed in the nose and in the mouth and throat at low rates of oral inhalation; at high rates it penetrated to the lungs. Human nasal retention of particles was found to be practically complete at 9μ diameter, falling to 10–20 per cent at 0·4μ. The reason for this appreciable retention at the small size is obscure. Ammonia and iodine were entirely absorbed in the nose.

The elimination of dust deposited in the acinus of the animal lung was the subject of several papers. Some dust is eliminated via the ciliated epithelium while the rest penetrates the interstitial tissue and may reach the lymphatics. The view was put forward that phagocytes originating from the alveolar wall are responsible for the carriage of dust from the acinus to the mucus escalator which ends at the base of the terminal bronchioles, each of which feeds an acinus, the latter constituting the basic respiratory units of the lung. Only free, not phagocyted particles could enter the interstitium, the route being by means of the transition region between the acinus and the terminal bronchiole; the pick-up by the mucus escalator from the respiratory bronchioles is regarded as being incompletely effective.

Experiments were described showing that elimination from the alveoli is a slow and continuous process. The proportion of deposited dust following the lymphatic route depended on the kind of dust, and repetition of exposure stimulated elimination and mobilized existing dust deposits. Experiments on exposures to red and black dusts, with a time-interval between, proved that dust was conveyed, probably by phagocytes, to collection sites around the air passages and that these foci were not static structures, but the particles continually shifted about, as could be explained by the repeated death of dust-laden phagocytes with release of their burden, which was then incorporated by new cells.

After a single administration of dust, phagocyte counts in saline washed into and out of rat lungs demonstrated that the number of cells was related to the quantity of dust eliminated. The half-life of this phase of elimination by phagocytosis to the bronchial epithelium was about 17 hr. The proportion of dust eliminated in this way depended on the nature of the dust, but the time-constant did not; it did not appear to matter whether the dust was given by inhalation or by intratracheal injection.

Another series of experiments confirmed the destructive action of silica dusts on macrophages and once again led to the suggestion that the damage inflicted on the cells is the first step in the chain of causation of silicosis. The effect is believed not to be cytotoxic, but to comprise an activation either of a serum complement absorbed on the outside of the cells or of an enzyme, possibly a non-specific esterase, within the cells.

Examination of lung residues from 50 asbestosis cases was reported, with the conclusion that a fibrogenic agent was liberated when asbestos bodies break up. The deposition of an asbestos fibre in lung tissue is followed by its becoming enclosed in a protein sheath which passes through a sequence of changes and finally segments, after 10–15 years, with fracture of the contained fibre. The fragments of the sheath are collected by interstitial macrophages and fibrosis is marked in regions where this occurs. The time sequence of clinical events and of lung content of fibres exceeding 26μ in length supports the argument.

Papers on dust-sampling included the description of an ingenious centrifugal device called the 'conicycle', which collects only particles between upper and lower limits of falling speed. It has been engineered as a practical sampling tool for coal mines and is being tried out underground.

The relationship between the acceptance curve of a sampling instrument designed to control dust conditions relevant to the incidence of pneumoconiosis, and the actual deposition–particle-size curve of the human respiratory tract was given more emphasis by the engineers than our crude and incomplete knowledge of the latter can possibly justify.

Arguments in favour of selecting finer particles than the 50 per cent at 5μ diameter and unit density, which at present forms the basis of British selective sampling practice, are therefore poorly based. The opposite view was also put forward, that all dust should be sampled, irrespective of particle size; besides being physically impossible this would encourage the collection of large quantities of coarse dust which has no conceivable bearing on pneumoconiosis because, when inhaled, it would not penetrate beyond the bronchi, and larger bronchioles.

The papers and discussions will be published by Pergamon Press in due course.

C. N. Davies

CARDIOVASCULAR EFFECTS OF NICOTINE AND OF SMOKING

During March 23–25 a symposium on the Cardiovascular Effects of Nicotine and of Smoking was held by the New York Academy of Sciences. The papers presented covered more than the cardiovascular effects and included other interesting observations. For example, nicotine is found not only in the tobacco plant, but it also occurs widely in the plant kingdom. It is produced in the root system of the tobacco plant, and the growth of the roots is very closely related to the rate of nicotine production, from which R. F. Dawson (Columbia) and his colleagues conclude that the same reaction step limits both processes. Nicotine arises from the precursors nicotinic acid and ornithine. From the root it is transported primarily to the leaves, where it accumulates during the active life of the plant. It is believed to be a terminal product with no appreciable physiological activity for the plant. Such a conclusion seems to an animal physiologist to be highly unlikely.

Nicotine is absorbed not only by those who smoke but also by those who take snuff and those who chew tobacco. The figures given for the amount of nicotine absorbed when smoking one cigarette vary according to the degree to which smoke is inhaled. They range from estimates as low as 0·3 mgm. to others as high as 1·8 mgm. Since the intravenous injection of 0·7 mgm. nicotine (base) produces unpleasant symptoms, the higher figures must be regarded with doubt.

Nicotine taken in the form of snuff has been estimated to amount to 20–60 mgm. a day, and that absorbed as a result of chewing has been estimated as 10–90 mgm. a day (Larsen, Richmond, Virginia). It is obvious that the taking of snuff and the chewing of tobacco offer much less risk of producing cancer of the lung.

The metabolism of nicotine is not yet fully known, and further work is badly needed. Nicotine is found in the urine excreted unchanged, together with related substances (McKennis, Richmond, Virginia). Oxidation of the pyrrolidine ring appears to be a major step. The lactam (−)-cotinine which arises from the metabolism of (−)-nicotine is oxidized, and in the dog there is hydroxylation and methylation. It seems possible that the metabolism of nicotine changes with advancing years, some processes declining in rate or ceasing altogether. If the toleration of nicotine depends on a high rate of breakdown, the observation that some older people stop smoking who smoked much when young may depend on such a decline.

Nicotine has been known to cause poisoning in those using it as an insecticide. Travell (Cornell) has shown that its absorption through the skin is greatly affected by the *p*H of the solution. At a *p*H of 5·0 or less it is very little absorbed, but at an alkaline *p*H it is readily absorbed. This holds true for the membrane of the stomach and of the bladder. Nicotine excreted in the urine may be absorbed from the bladder into the blood if the urine is alkaline, and may produce toxic effects. The speed of absorption depends on the concentration of free base. On the cardiovascular system, nicotine has long been believed to owe its action to stimulation of the autonomic ganglia. Langley applied nicotine to ganglia in order to determine the effect of stimulating the cells present in the ganglia. Recently, attention has been directed to various peripheral effects of nicotine at sites where ganglia are not present. Thus, nicotine has a two-fold effect in the isolated heart. It causes first inhibition of contractions, and second acceleration and augmentation. The inhibition is excluded in the presence of atropine, but the acceleration is unaffected. In the heart there is a store of noradrenaline which can be extracted from the heart. Hitherto the existence of this store has been neglected by physiologists. It is now evident that the acceleration of the heart caused by nicotine is due to the release of some of the noradrenaline from the store. This follows from the observation that when there is no store of noradrenaline, nicotine loses its accelerating action (Burn and Rand, Oxford). Treatment of the animal with reserpine causes a disappearance of the store at the end of a few hours. The rise in heart-rate which follows smoking is thus probably explained by an action of nicotine on the heart itself releasing noradrenaline from storage sites in the heart.

In 1940 it was shown by Grace Roth and her colleagues that when a person smoked a cigarette in a warm room there was a large fall in skin temperature. This fall was believed to result from a constriction of the skin vessels caused by a stream of impulses passing down the vasoconstrictor nerves. However,, observations have recently been made in the isolated ear of the rabbit, which contains no ganglia. These have shown that when the vessels of the ear are perfused with a modified Ringer's solution, the outflow being measured with a sensitive recorder, the injection of 3 μgm. of nicotine into the fluid about to enter the ear causes vasoconstriction. The outflow from the ear veins is greatly reduced. This action also appears to be due to the release of noradrenaline from a store present in the ear, either in the walls of the vessels or in tissue nearby. For if a rabbit is injected with reserpine on one day, and then killed on the following day, the noradrenaline which can be extracted from the skin of the ear has disappeared, and when the ear is perfused with Ringer's solution, nicotine no longer causes vasoconstriction. When the skin of such an ear is extracted, no noradrenaline is found present in it. Some individuals suffer from a disease called thrombo-angiitis obliterans which when active causes such a restriction of the circulation through the fingers that the tissues become dry and bloodless, and the finger tips may become gangrenous. The disease may be quiescent for long periods; but if the patient begins to smoke, the symptoms get worse and the disease becomes active. It seems likely that the effect of smoking is explained by nicotine releasing noradrenaline from the neighbourhood of the small vessels.

The exact site of storage of noradrenaline in the heart and in or near the vessels is unknown. There is a possibility that it is held in tissue known as chromaffin tissue. These are cells which stain brown with potassium dichromate; they form the greater part of the cells of the adrenal medulla. Such cells have long been known to occur among the fibres of the sympathetic system, and side by side with the sympathetic ganglion cells. They originate in the neural crest like the sympathomimetic ganglion cells and were called by Kohn "paraganglia" in 1903. Evidence is beginning to accumulate that the distribution of chromaffin cells is much wider. Busacchi in 1912 described a "paraganglion cardiacum" lying around the origins of the coronary arteries. Adams-Ray and Nordenstam (1956) have described such cells in human skin, and Leach believes that they may be present in the skin of the rabbit ear, in the skin of the cat's tail and in the nictitating membrane of the cat's eye. In all these situations nicotine exerts an action on the normal tissue. Thus, as already mentioned, nicotine causes constriction of the vessels of the rabbit ear; it also causes erection of the hair on the cat's tail, and finally it causes contraction of the nictitating membrane when isolated from the body and free from ganglia. Yet if an animal is previously treated with reserpine, and if in consequence all local stores of noradrenaline disappear, nicotine loses these actions, and all the chromaffin cells are lost. It may therefore be that nicotine exerts its peripheral effects by discharging noradrenaline from chromaffin cells. J. H. Burn

THE NEW ZEALAND ANTARCTIC EXPEDITION

In the thirty-third Thomas Cawthron Memorial Lecture, Sir Edmund Hillary described some of the experience gained by members of the New Zealand Antarctic Expedition (Cawthron Institute, Nelson, New Zealand. Thomas Cawthron Memorial Lecture No. 33 (1958): The New Zealand Antarctic Expedition. By Sir Edmund Hillary. Pp. 12+4 plates. Nelson: Cawthron Institute, 1959). Although, for economy, the expedition made use of Ferguson tractors, Sir Edmund records that, with three 'Snocats', the journey could have been done "with twice the comfort and in almost half the time".

Comparison of the buildings which have been traditionally used on British expeditions and the newer module type of construction shows the advantages to rest almost entirely with the latter.

The experience gained with the dog teams should be of value to other expeditions. At the base, the dogs lived primarily on seal meat supplemented by vitamin pills, although this was varied at times with tinned dog food. In the field lightness was of primary importance and here pemmican was used. There were two forms of pemmican. One was the standard 'Bovril' pemmican which has been used a great deal in the Antarctic and the Arctic. Long and strenuous trips have been made on this pemmican, but the literature on the subject is filled with criticisms of it and descriptions of the deterioration in dog health when it is used. The Expedition's experience with 'Bovril' pemmican was much the same—loss of condition and continual scouring. "It was very fortunate that we also had generous supplies of the second type of pemmican, which was based on a formula developed by Dr. Malcolm of the Otago Medical School for the Byrd Expedition". This pemmican proved to be an outstanding success and played an important part in the achievements of the dog teams. The formula is :

Meat meal	42 per cent
Tallow	40 ,,
Whole wheat meal	10 ,,
Wheat germ	5 ,,
Molasses	2 ,,
Cod liver oil	1 ,,

Sir Edmund Hillary indicates that dogs can still do a useful task in the Antarctic. The expedition made it clear that dogs cannot compete with vehicles when travelling long distances or hauling profitable payloads. While the average man can quickly adapt himself to driving a tractor in snow, a dog driver and his team need long and constant training and practice to reach a pitch of proficiency. Although the men did extremely well, at no stage could they have reached the standard of skill shown by the professional drivers in a party such as Amundsen's.

But a dog team is a mobile form of transport and can give useful support to a survey or geological party in rough or crevassed country. If the dog teams are airlifted to the area to be explored, and if they are kept supplied by air so that they can travel with reduced loads and so move briskly about, they are probably still the best form of transport for a close examination of the many great mountain ranges and glaciers which fringe the barren wastes of the polar plateau.

RADIOCÆSIUM AND POTASSIUM-40 IN NORWEGIAN-PRODUCED MILK

By K. MADSHUS and J. BAARLI
Norsk Hydro's Institute for Cancer Research, Oslo, Norway

THE radioactive isotopes cæsium-137 and strontium-90 represent a major part of the radiation hazard to man caused by nuclear explosions, by reason of their long half-lives (28 and 27 years, respectively). The rate of fall-out depends to a large extent on the geographical locality, and on the weather conditions at the relevant places of interest[1,2]. There is evidence that the northern hemisphere and places with high rate of precipitation[3] receive the highest fall-out. These conditions obviously hold for Norway.

The degree of hazard which the ionizing radiation represents to man can, in principle, be estimated in two ways. One method is to determine the amounts of the isotopes in foodstuffs, taking into account the discriminating factors involved during passage of the food through the human body. The other method is the direct measurement of radiation from the human body. Milk appears to be one of the main constituents of the human diet carrying the radioactive material from the ground into the human body.

The present work was undertaken to obtain as reliable information as possible about the concentration of cæsium-137 in Norwegian-produced milk. This isotope is most important in view of the genetic effects of its γ-radiation ($E_\gamma = 660$ keV.), compared with the more localized damage caused by the β-radiation from strontium-90 ($E_\beta = 0{\cdot}61$ MeV.).

It seems an established fact[4] that the fall-out ratio strontium-90/cæsium-137 from atom-bomb debris is nearly constant. This is not only the case for soil and rain-water; milk samples collected within the same districts also show the same tendency[5]. As the experimental determination of cæsium-137 is a rapid process compared with the more laborious determination of strontium-90, the content of cæsium-137 can serve as a quick monitor of the rate of strontium-90 fall-out.

The equipment used for studies of low-level γ-radiation has been described elsewhere[6]. It is composed of a heavily shielded scintillation detector, consisting of a sodium iodide (thallium) crystal 2¼ in. diameter × 3 in. and a Du Mont 6363 phototube in connexion with an R.C.L. 256-channel pulse-height analyser. A cross-section of the equipment is shown in Fig. 1. The background radiation in the measuring space of this equipment is found to be 212 ± 1·0 counts/min. in the energy-range 80–1,700 keV. The background, in the two pulse-height regions of special interest to the present study, is 14·1 ± 0·1 counts/min. in the cæsium-137 photopeak range, and 5·3 ± 0·1 counts/min. in the potassium-40 peak. The position of the photopeak in the pulse-height spectrum is stable over a long period, being 0·75 per cent after the initial warm-up. The equipment has been calibrated using dried milk with a known concentration of cæsium-137 and potassium-40. The samples were canned in metallic containers, each holding 250 gm. of dried milk. We are much indebted to Dr. D. V. Booker, of the Atomic Energy Research Establishment, Harwell, for supplying us with several of his measured samples used here for calibration purposes.

Two kinds of standards were used, one containing full-cream dried milk, and the other skimmed dried milk. The calibration samples contained 670 pc./kgm. and 485 pc./kgm. of cæsium-137 (1 pc. = 10^{-12} curie) with a potassium content of 14·9 and 17·6 gm./kgm. for the skimmed milk, and 445 pc. cæsium-137/kgm. and 11·2 gm./kgm. for the full-cream dried milk.

Dried skimmed milk and full-cream dried milk were obtained from a dairy receiving milk from districts in the Trõndelag and Hedmark counties. The former county lies in central Norway, near the coast. It is one of the greatest farming districts in the country. Hedmark lies in south-east Norway, about 300 miles from the west coast.

The individual samples were taken from batches of about 22,000 l. Each sample contained 250 gm. of dried milk, the same as the standard sources used for calibration. The canning was also identical. Measurements of samples were carried out over periods of 4 hr. or more. Background and calibration runs were made from time to time. No significant variations in the number of counts stored in the cæsium-137 and potassium-40 photopeaks, exceeding the statistical errors, were observed. No radioactivity which could be attributed to radio-elements other

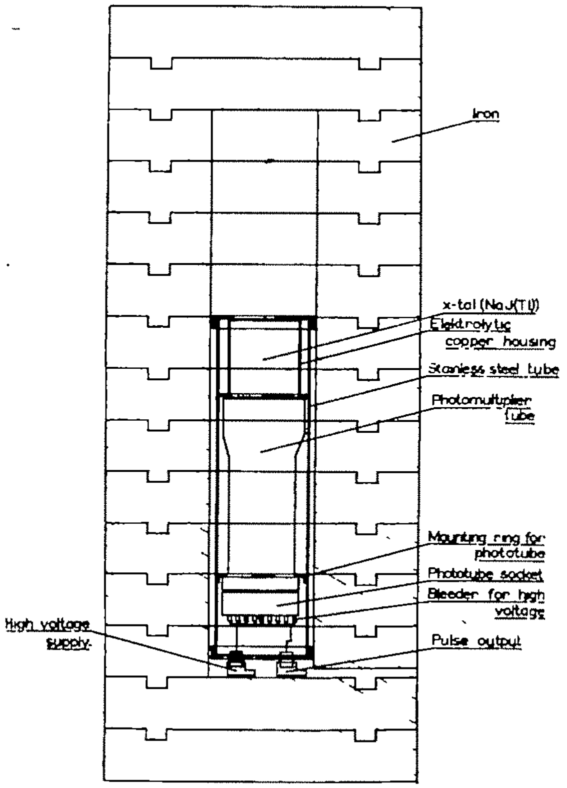


Fig. 1. Scintillation detector and shielding used

than cæsium-137 and potassium-40 was observed in the dry milk measured. In this connexion it must be mentioned that the measurements of the samples from 1958 were all made early in 1959. The other samples were usually measured one month after the date of manufacture.

The results were analysed by counting the observed pulses in the photopeak only, and subtracting the background, correcting for drift of the photopeak region exceeding 0·5 per cent. Because of the scattering of the 1·46 MeV. γ-radiation from potassium-40 and secondarily produced radiation (bremsstrahlung) caused by the β-particles from potassium-40 ($E_\beta = 1 \cdot 4$ MeV.), it was necessary to apply a correction term to the number stored in the cæsium-137 photopeak. This fraction was determined experimentally by observing the extra counts in the cæsium-137-region as a result of an added known amount of potassium-40 mixed into the samples.

With the crystal size and geometry used in the present arrangement, the correction factor has been found to be 22 per cent of the net counts in the potassium-40 photopeak. This value is in close agreement with theoretical calculations based on the resolution obtained for cæsium-137 and potassium-40 (11·0 per cent and 7·0 per cent respectively).

Because of the nature of the radiation process, each measurement carries a statistical error, consisting of the error in the background and sample determination. The results of the measurements are shown in Table 1, together with the experimental errors.

Table 1 shows that the potassium content in the samples amounts to 14–17 gm./kgm. for skimmed dry milk, and 10–12 gm./kgm. for full-cream dried milk. These values are in good agreement with results obtained elsewhere[5,7,8].

The cæsium-137 content during the period January 1958–August 1959 shows the same tendency for both the skimmed and full-cream dried milk from both areas. During the spring of 1958, there is a slow increase in the cæsium-137 content up to June, where an increase of nearly a factor of 2 is recorded. The reason for this sudden jump is primarily in the feeding of the cows with fresh grass. In the autumn, from October 1958, there is a general tendency towards decrease until January 1959, when a value of 310 pc. cæsium-137/kgm. is found in full-cream dried milk from Hedmark, and 650 pc. cæsium-137/kgm. in skimmed milk from Tróndelag. These values are considerably higher than those reported for January 1958. A decrease is further noticed during the spring of 1959, lasting until April. In May the content of cæsium-137 reaches a value of 1,005 pc./kgm. for skimmed milk from Trondelag. This increase continues, and a value of 1915 pc./kgm. is reached in August 1959. This is the highest level found by us in dried milk.

It is of interest to compare the values of the cæsium-137 content in milk, both with the measured

Table 1. Cæsium-137 in Milk

District	Date of manufacture	(pc.) Cæsium-137 per kgm.	Potassium (gm./kgm.)	(pc.) Cæsium-137/potassium (gm.)	
Hedmark	13/1/58	140 ± 20	10·6 ± 0·2	13·2	whole milk
,,	5/3/58	125 ± 20	12·3 ± 0·2	10·2	,, ,,
,,	2/4/58	190 ± 20	11·5 ± 0·2	15·5	,, ,,
,,	2/5/58	180 ± 20	11·8 ± 0·2	15·2	,, ,,
,,	2/6/58	245 ± 20	11·3 ± 0·2	21·8	,, ,,
,,	2/7/58	505 ± 20	10·2 ± 0·2	49·5	,, ,,
,,	20/10/58	550 ± 40	11·5 ± 0·4	47·9	,, ,,
,,	3/11/58	430 ± 20	10·8 ± 0·2	39·8	,, ,,
,,	27/11/58	185 ± 20	10·8 ± 0·2	17·1	,, ,,
,,	3/1/59	310 ± 40	11·0 ± 0·4	28·1	,, ,,
,,	8/1/59	310 ± 20	10·7 ± 0·2	29·0	,, ,,
,,	28/2/59	250 ± 20	11·4 ± 0·2	21·9	,, ,,
,,	3/3/59	210 ± 40	11·5 ± 0·4	18·2	,, ,,
Trondelag	1/2/58	570 ± 15	17·7 ± 0·3	32·1	skimmed milk
,,	2/4/58	440 ± 15	17·4 ± 0·2	25·3	,, ,,
,,	2/5/58	335 ± 15	16·3 ± 0·2	20·5	,, ,,
,,	2/9/58	860 ± 15	15·8 ± 0·3	54·5	,, ,,
,,	1/10/58	910 ± 15	16·4 ± 0·2	55·5	,, ,,
,,	1/12/58	760 ± 15	17·4 ± 0·3	43·7	,, ,,
,,	7/1/59	650 ± 15	18·1 ± 0·3	35·9	,, ,,
,,	5/2/59	650 ± 20	17·3 ± 0·3	37·6	,, ,,
,,	5/3/59	300 ± 15	17·6 ± 0·2	17·1	,, ,,
,,	29/5/59	1,005 ± 20	15·3 ± 0·3	65·3	,, ,,
,,	9/6/59	1,220 ± 20	16·3 ± 0·6	74·7	,, ,,
,,	31/7/59	1,915 ± 40	14·9 ± 0·5	128·8	,, ,,

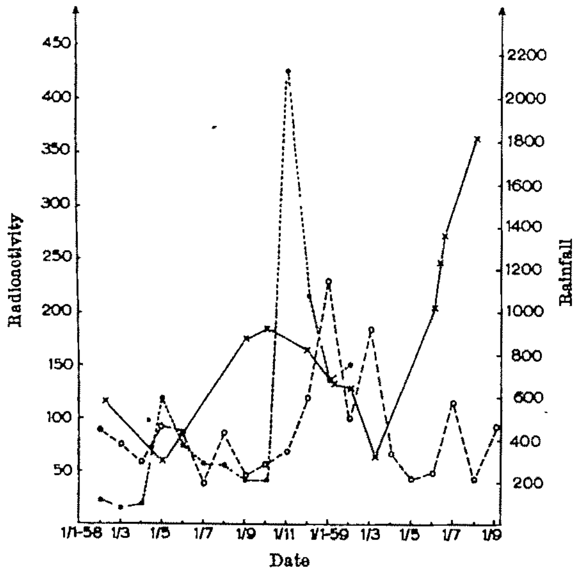


Fig. 2. Total fall-out/month, mm. rainfall/month, and cæsium-137 content (pc./kgm.) in dry milk as a function of time (from Trondelag). ●. . . ●, total fall-out/month (mc./km.²); ○ - - - ○, rainfall/month (mm.); × —— ×, cæsium-137/kgm.

values of the total fall-out[9] and the local rainfall. During the summer of 1957, the total fall-out in Tröndelag (Værnes) remained quite constant at 30–35 mc./km.², increasing to 84 mc./km.² in October. These values must be taken into consideration in predicting the content of cæsium-137 in the milk during the winter and spring of 1958, when the cows were fed on hay collected in the summer and autumn of 1957.

The value of the total fall-out is higher in the spring and summer of 1958 than in the preceeding year, ranging up to 119 mc./km.² in April. Fig. 2 shows the total fall-out, the cæsium-137 content in dry milk and the rainfall as a function of time. The seasonal variations in the cæsium-137 content in milk are easily seen from the curves. There is a remarkable increase during spring and summer, and a decrease in the late autumn and winter. There seems to be a slight tendency toward a correlation between the total fall-out and the measured concentration of cæsium-137, the latter lagging by 4–6 months. This correlation is, however, very doubtful, due to the large amount of short-lived fission products in the fall-out.

It is obvious from Table 1 and the curves that the content of cæsium-137 in milk has increased considerably during the past year and a half. It is of special interest to continue these measurements at the present time, when no test explosions have taken place for about a year, in order to establish the maximum level for cæsium-137 in milk and the time required to reach this point.

We are indebted to the Norske Melkefabrikker for the regular supply of milk samples, to the Norwegian Defence Research Establishment for interest and finally to the Norwegian Cancer Society for financial support.

[1] Libby, W. F., *Proc. U.S. Nat. Acad. Sci.*, **42**, 365 (1956).
[2] Langham, W. H., *Health Phys.*, **1**, 106 (1958).
[3] Machta, L., hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Part 1, 141–162.
[4] Sternert, N. G., *et al.*, The World-wide Deposition of Long-lived Fission Products from Nuclear Test Explosions, *AERE/HP/R* 2354 (1957).
[5] Löw, K., and Edvardson, K., *Nature*, **183**, 1104 (1959).
[6] Baarli, J., and Madshus, K., An Analysis of the Background Radiation in the Energy Range 0·08–1·7 MeV. (in preparation).
[7] Sievert, R. M., *et al.*, *Ark. Fys.*, **12**, No. 20 (Stockholm, 1957).
[8] Booker, D. V., *Phys. Med. Biol.*, **2**, 29 (1959).
[9] Hvinden, T., *Tekn. Ukebl.*, 16/10, 908 (1958); Radioactive Fall-out in Norway, 1958, Int. Rep. No. 374.

ALKALINE CONVERSION OF 4-HYDROXYPHENYLPYRUVIC ACID TO 4-HYDROXYBENZALDEHYDE

By Dr. C. H. DOY*

Chemical Microbiology Unit, Department of Bacteriology, University of Melbourne

DURING recent investigations of the biosynthesis of aromatic compounds by *Escherichia coli* and *Aerobacter aerogenes* (to be published) a compound, compound *C*, was detected in experimental samples by the appearance of an absorption maximum at 325–330 mμ, *p*H > 12. Compound *C* was later recognized as 4-hydroxybenzaldehyde, which absorbs as shown in Fig. 1. It was realized that this compound was largely an artefact resulting from the action of alkali on another compound, compound *D*. Compound *D* was then found to be identical with 4-hydroxyphenylpyruvic acid. It is the aim of this communication to bring to notice the alkaline conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde.

A sample of 4-acetoxy-α-acetamido-cinnamic acid was prepared by the method of Saul and Trikojus[1] and recrystallized from ethanol (m.p. 228° C., $C_{13}H_{13}NO_5$ requires: C, 59·3; H, 5·0; N, 5·3; O, 30·4 per cent; found: C, 59·3; H, 5·2; N, 5·5; O, 30·4 per cent). This was hydrolysed as required to 4-hydroxyphenylpyruvic acid using Dowex cation exchange resin 50 – × 8 (hydrogen form) as described by Acerbo, Schubert and Nord[2]. The product, m.p. 215–217° C., gave better crystals when recrystallized from 0·1 *M* hydrochloric acid although the m.p. fell to 212–216°, perhaps because of the presence of tautomeric forms. Paper chromatography indicated the presence of a little 4-hydroxybenzaldehyde. This impurity was consistent with the analytical figures for the recrystallized 4-hydroxyphenylpyruvic acid ($C_9H_8O_4$ requires: C, 60·0; H, 4·45; O, 35·5 per cent; found: C, 60·18; H, 4·69; O, 35·0 per cent). The spectrum of a 10^{-3} *M* solution in 0·1 *M* phosphate buffer, *p*H 7·7 (Fig. 2) closely approximated to the spectrum of the keto form of 4-hydroxyphenylpyruvic acid in aqueous solution given by Knox and Pitt[3]. $E_{276\,m\mu} = 2\cdot1 \times 10^3$ was

---

* Present address: Department of Bacteriology and Immunology, Harvard Medical School, Boston, Mass., U.S.A.

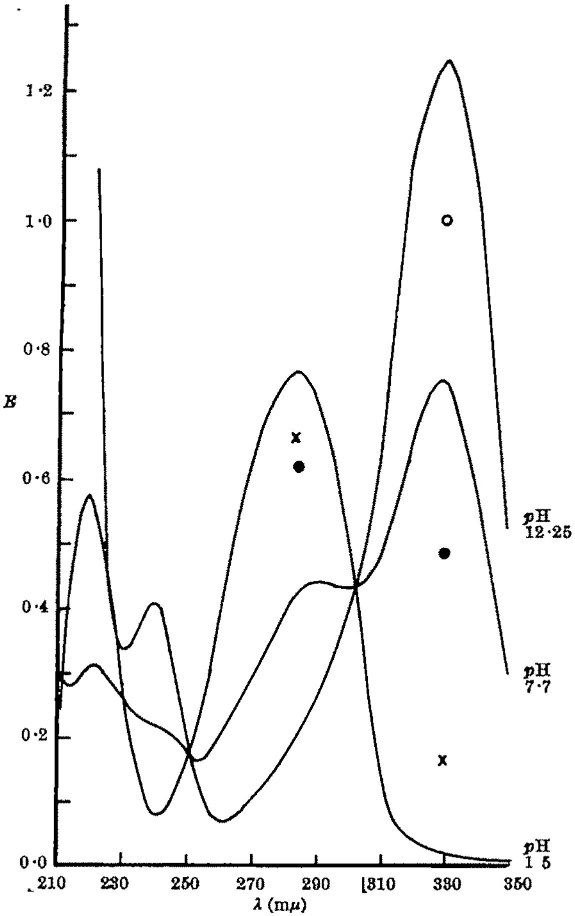


Fig. 1. Ultra-violet absorption of $0\cdot5 \times 10^{-4}$ *M* 4-hydroxybenzaldehyde. Original solution in 0·1 *M* phosphate buffer, *p*H 7·7. Samples were adjusted with 10 *N* sodium hydroxide or 10 *N* hydrochloric acid to the desired *p*H. Absorption at *p*H 12·25 is attributed to 100 per cent phenate ion (constant above approx. *p*H 9) and at *p*H 1·5 to 100 per cent undissociated phenol (constant below approx. *p*H 6·0). ○, *p*H 8·0; ●, *p*H 7·45; ×, *p*H 6·9

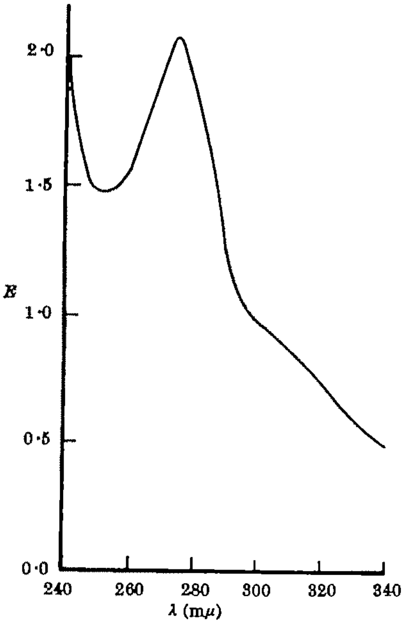


Fig. 2. Ultra-violet absorption of 10^{-3} *M* 4-hydroxyphenylpyruvic acid in 0·1 *M* phosphate buffer, *p*H 7·7

similar to the value $2\cdot27 \times 10^{3}$, calculated from Fig. 2 of these authors. With the exception of the case cited below, further purification by paper chromatography did not affect the changes to be described. Ultra-violet absorption measurements were recorded manually from short to long wavelength using a Unicam *SP* 500 spectrophotometer and 1-cm. silica cells. Because of the rapidity of some of the changes it would be preferable to use an automatic recording instrument if this work was extended.

Fig. 3 shows the irreversible spectral change which occurred when the *p*H was raised to >12. This change was almost instantaneous even at room temperature (20–25°). Subsequent variation of the *p*H produced changes of adsorption characteristic of 4-hydroxybenzaldehyde (cf. Fig. 1) with definite isobestic points at 300 mμ and 250–255 mμ. The absorption maximum at 330 mμ was attributed to the phenate ion and that at 280–285 mμ to the undissociated phenol. The *pK* value for this ionization was calculated from the absorption data as

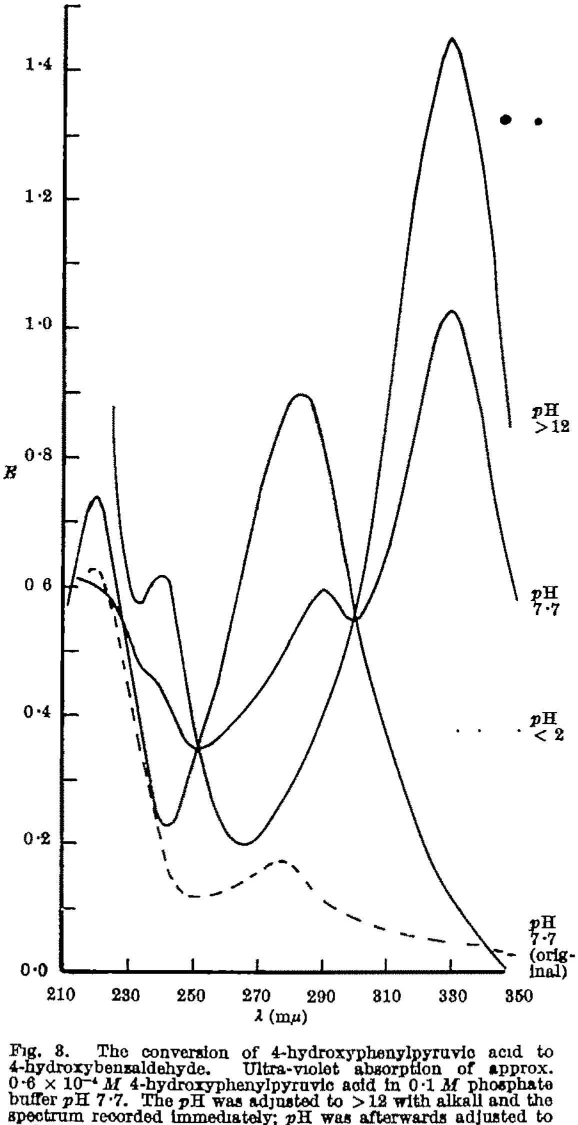
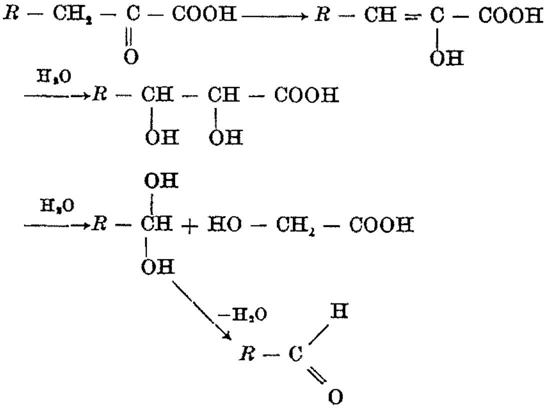


Fig. 3. The conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde. Ultra-violet absorption of approx. $0\cdot6 \times 10^{-4}$ *M* 4-hydroxyphenylpyruvic acid in 0·1 *M* phosphate buffer *p*H 7·7. The *p*H was adjusted to >12 with alkali and the spectrum recorded immediately; *p*H was afterwards adjusted to < 2 and then 7·7 (cf. original curve at *p*H 7·7). $E_{\max}$ 240 mμ tends to be lost on storage as found with 4-hydroxybenzaldehyde

7·68 ± 0·08 which was in agreement with the value 7·66 calculated from the literature[4].

The following mechanism is tentatively proposed for the alkaline conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde.



$$R-CH_2-\underset{\underset{O}{\|}}{C}-COOH \longrightarrow R-CH=\underset{\underset{OH}{|}}{C}-COOH$$

$$\xrightarrow{H_2O} R-\underset{\underset{OH}{|}}{CH}-\underset{\underset{OH}{|}}{CH}-COOH$$

$$\xrightarrow{H_2O} R-\overset{\overset{OH}{|}}{\underset{\underset{OH}{|}}{CH}} + HO-CH_2-COOH$$

$$\xrightarrow{-H_2O} R-C\genfrac{}{}{0pt}{}{\diagup H}{\diagdown\!\!\diagdown O}$$

Support for an intermediate chromophorically similar to tyrosine was obtained following paper chromatography of 4-hydroxyphenylpyruvic acid in water/ethylmethylketone/diethylamine (77 : 921 : 2)[5] and elution with phosphate buffer, pH 7·7. This treatment for some unknown reason slowed down the effect of subsequent alkali, and thus allowed the detection of transient maxima at 240 mμ and 290–295 mμ similar to the absorption of tyrosine at $pH > 12$ (Fig. 4).

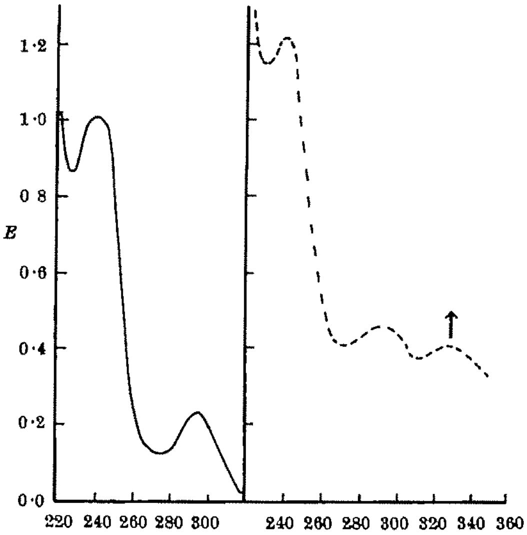


Fig. 4. The absorption at a transient stage in the alkaline conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde compared with the spectrum of DL-tyrosine, $pH > 12$ (see text). —, Approx. 10^{-4} *M* DL-tyrosine

It seemed possible that the alkali-induced replacement of a pyruvic acid side-chain by an aldehyde group was a more general reaction. Phenylpyruvic acid eluted from paper chromatograms and treated with alkali ($pH > 12$), first developed an absorption maximum at 320 mμ, which then declined in intensity to an insignificant level. Subsequent adjustment to $pH < 2$ did not result in the changes characteristic of phenylpyruvic acid. In general, the spectral changes seemed consistent with a slow conversion to benzaldehyde, but this was not investigated further. Kaper and Veldstra[6] reported that chromatography of indolepyruvic acid in alkaline solvents gave indolealdehyde as one product of breakdown. It would therefore appear that in the general handling and chromatography of pyruvic acid derivatives of these types, it is as well to avoid high pH particularly since the conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde was apparent even at pH10·0.

In lignin chemistry oxidation with nitrobenzene in alkali was introduced[7] as a degradative procedure by which various aromatic aldehydes were liberated, presumably from the lignin. The origin of one of these aldehydes, 4-hydroxybenzaldehyde, gave some concern, and it has been shown[8,9] that protein tyrosine may account for most of this compound released by the nitrobenzene oxidation of buckwheat. Since 4-hydroxyphenylpyruvic acid is considered to be a lignin precursor in grasses[9], the release of 4-hydroxybenzaldehyde from the former using alkali alone may be of particular interest.

This work was supported by a grant from the Australian National Health and Medical Research Council. The analyses were carried out by the Australian Microanalytical Service, Commonwealth Scientific and Industrial Research Organization, Melbourne.

[1] Saul, J. A., and Trikojus, V. M., *Biochem. J.*, **42**, 80 (1948).
[2] Acerbo, S. N., Schubert, W. J., and Nord, F. F., *J. Amer. Chem. Soc.*, **80**, 1990 (1958).
[3] Knox, W. E., and Pitt, B. M., *J. Biol. Chem.*, **225**, 675 (1956).
[4] Heilbron, J., and Bunbury, H. M. (eds.), "Dictionary of Organic Compounds", **2**, 231 (Eyre and Spottiswoode, London, 1946).
[5] Reio, L., *J. Chrom.*, **1**, 338 (1958).
[6] Kaper, J. M., and Veldstra, H., *Biochim. Biophys. Acta*, **30**, 401 (1958).
[7] Freudenberg, K., Lautsch, W., and Engler, K., *Ber.*, **73**, 167 (1940).
[8] Stone, J. E., Blundell, M. J., and Tanner, K. G., *Can. J. Chem.* **29**, 734 (1951).
[9] Brown, S. A., Wright, D., and Neish, A. C., *Canad. J. Biochem. and Physiol.*, **37**, 25 (1959).

GLUCOSE-6-PHOSPHATE DEHYDROGENASE DEFICIENCY IN RED BLOOD CELLS OF EAST AFRICANS

By Dr. A. C. ALLISON
National Institute for Medical Research, Mill Hill, London, N.W.7

MANY investigations, reviewed by Beutler[1], have shown that about 11 per cent of American Negro males have an intrinsic red blood cell abnormality. A striking feature of the abnormality—and perhaps the primary genetically controlled defect—is low activity of the enzyme glucose-6-phosphate dehydrogenase, which is responsible for the first and rate-controlling step in the hexose monophosphate shunt metabolic pathway in red cells[2]. The defect appears to be inherited as a sex-linked character with full expression in hemizygous males and homozygous females and partial expression in heterozygous

Table 1

Tribe	Locality	Males tested	Enzyme deficiency	Females tested	Enzyme deficiency	Hemizygote = gene frequency
Giriama	Malindi	101	17	65	10	16·8
Bondei	Muheza	121	33	124	24	27·3
Sambaa	Tanga district	29	6	33	5	20·7
Digo	Tanga district	26	6	33	6	23·1
Zigua	Tanga district	26	6	29	4	23·1
Kikuyu	Nairobi and Naivasha district	70	2	73	2	2·9
Masai	Kajiado	59	1	12	0	1·7
Luo	Nairobi and Kisumu district	50	14	27	4	28·0
Ganda	Kampala	40	6	46	5	15·0

females[3]. Persons with the defect are liable to develop severe hæmolysis on exposure to therapeutic doses of the antimalarial 8-aminoquinolines (primaquine, pamaquine, etc.) and certain other drugs, and also on ingestion of broad beans (*Vicia faba*).

The trait is known to be common in many Mediterranean populations, including Sephardic Jews, and also in many South-East Asian populations[1,4]. The only published indications of its presence among continental Africans are isolated reports of hæmolysis induced by pamaquine in a South African, a Nyasaland and an East African Bantu[5,6]. The development of a relatively simple screening test for red cell glucose-6-phosphate dehydrogenase deficiency[4] has made more extensive surveys of the distribution of the trait possible. This report embodies the results of tests on 964 East Africans belonging to 9 different tribes. The test was used as described[4] except that all volumes were reduced to one-half and incubations were carried out in 1-cm. diameter tubes.

The results of the tests are shown in Table 1. Hæmolysates from Western European subjects incubated in the presence of substrate and coenzyme decolorize brilliant cresyl blue in less than 120 min. Hæmolysates from male Africans show a clear bimodal distribution of decoloration times, with the antimode at about 120 min. Spectrophotometric analysis of glucose-6-phosphate dehydrogenase activity[7] in some of the subjects showing decoloration times of longer than 120 min. confirmed that they had significantly lower enzyme activities than normal subjects, and they were therefore classified as hemizygous for the enzyme-deficiency trait. Female Africans show a much less clear distinction between normal and abnormal groups, but those with decoloration times greater than 120 min. were assumed to be heterozygous or homozygous for the enzyme-deficiency trait. Limited family data were consistent with this assumption. The frequency of the abnormal gene, q, equals the frequency of hemizygotes in the male population. The expected frequency of heterozygotes and homozygotes in the female population is $2q(1 - q) + q^2$, and the proportion of females showing detectable enzyme deficiency was 41 per cent of that expected, other heterozygotes presumably falling within the normal range of variability in the tests.

The results summarized in Table 1 show that the trait is common in East Africans. However, the distribution is far from uniform. High frequencies of the trait (15–28 per cent) are found among tribes living near the coast and around Lake Victoria, and low frequencies (1·7–2·9 per cent) in the intermediate highland country. The distribution of the trait approximately parallels that of the sickle-cell trait in the same region[8]. All other populations known to have high frequencies of the enzyme-deficiency trait[4] live in regions where malaria is, or was until recently, endemic. Thus the local distribution of the trait in East Africa and the overall distribution are consistent with the interpretation that subjects with deficient glucose-6-phosphate-dehydrogenase activities in red cells are at a selective advantage in malarious environments. There are, in fact, metabolic reasons why malaria parasites might not multiply as well in enzyme-deficient cells as in normal red cells[4]. Recently, evidence has been obtained[9] that young malaria-susceptible East African children of both sexes from a region where *P. falciparum* is holoendemic show lower parasite-counts when enzyme deficient than when red cell enzyme activities are normal.

These results suggest that the trait may be maintained as a sex-linked polymorphism by a balance of selective forces. The hemizygote, and to some extent also the abnormal homozygote and heterozygote, are favoured through protection against malaria, and possibly in other ways. On the other hand, the hemizygote, and perhaps also the abnormal homozygote and in exceptional circumstances the heterozygote, may be at a disadvantage owing to their susceptibility to hæmolysis. The broad bean is not normally eaten by East Africans, and why persons with enzyme deficiency are at a disadvantage there is unknown. If there were no disadvantage, the gene might be expected to have become more common, instead of remaining at the same order of frequency among tribes supposed to have different ethnic origins (for example, the Nilo-Hamitic Luo and the Eastern Bantu Bondei). There is disagreement among theoretical geneticists whether a stable polymorphism at a sex-linked locus can be maintained by advantage of the hemizygote alone or whether the heterozygote must be favoured[10]. The finding that enzyme-deficient female as well as male children have lower malaria parasite counts than children with normal red cell enzymes means that both processes could apply in this particular case.

This investigation was supported by a grant from the Colonial Development and Welfare Fund received at the instance of the Colonial Medical Research Committee. I am indebted for hospitality and help to many East African workers, in particulars Drs. D. B. Wilson and D. F. Clyde, Amani; H. Foy, Nairobi and S. Buck, Kampala.

[1] Beutler, E., *Blood*, **14**, 103 (1959).

[2] Carson, P. E., Flanagan, C. L., Ickes, C. E., and Alving, A. S., *Science*, **124**, 484 (1956).

[3] Childs, B., Zinkham, W., Browne, E. A., Kimbro, E. L., and Torbert, J. V., *Bull. Johns Hopkins Hosp.*, **102**, 21 (1958).

[4] Motulsky, A. G., and Campbell, J. M., *Blood* (in the press).

[5] Mann, W. N., *Trans. Roy. Soc. Trop. Med. Hyg.*, **37**, 151 (1943).

[6] Smith, S., *Trans. Roy. Soc. Trop. Med. Hyg.*, **37**, 155 (1943).

[7] Kornberg, A., and Horecker, B. L., in "Methods in Enzymology", ed. Colowick, S. P., and Kaplan N. O., 323 (Academic Press, New York, 1955).

[8] Allison, A. C., *Trans. Roy. Soc. Trop. Med. Hyg*, **48**, 312 (1954).

[9] Allison, A. C., and Clyde, D. F. (to be published).

[10] Mandel, S. P. H., *Nature*, **183**, 1347 (1959).

A NEW COPPER PROTEIN FROM *CHLORELLA ELLIPSOIDEA*

By Dr. SAKAE KATOH

Department of Biophysics and Biochemistry, Faculty of Science, University of Tokyo

THE significance of copper in the metabolism of *Chlorella* was first described in 1939 by Green, McCarthy and King[1], who investigated the inhibitory effect of copper-chelating agents on respiration and photosynthesis in *Chlorella pyrenoidosa*. Their findings, that carbon dioxide uptake by *Chlorella* was markedly inhibited in the presence of copper-specific inhibitors in concentrations which were apparently without effect on the respiratory activity of the organism, and readily reversed on the removal of the poison by dialysing the cell suspension against water, indicated the participation of copper in the photosynthesis of *Chlorella*. However, there has been no positive effort to elucidate the function and properties of the copper compound in question. In a series of studies carried out in this laboratory to investigate the oxidation-reduction system in algae, a copper protein complex possessing the capacity to undergo a reversible oxidation-reduction reaction was isolated from *Chlorella ellipsoidea*. A similar substance was also found in the chloroplasts of higher plants. This article will briefly describe the isolation and purification as well as several properties of the copper protein obtained from *Chlorella ellipsoidea*.

The copper protein was readily extracted by disrupting the algal cells for 30 min. in a sonic oscillator (20 kc./s.) with the addition of about a half weight of alumina, or by soaking the lyophilized cells or acetone powder of *Chlorella* in a sufficient amount of dilute phosphate buffer of neutral *p*H. The typical procedure for extraction and purification of the substance is as follows: 1 kgm. of lyophilysed cells of *Chlorella ellipsoidea* was suspended in 8·0 l. of 0·01 *M* phosphate buffer (*p*H 7·0), and left at 10° C. for 16 hr. with several stirrings. The algal cells were removed by centrifugation at 3,000*g* for 20 min., and 300 gm. of ammonium sulphate was added with stirring to 1·0 l. of the supernatant. The precipitate formed was removed by centrifugation at 3,000*g* for 30 min. and the supernatant was saturated with ammonium sulphate and left at room temperature for 1 hr. The precipitate formed was collected by centrifugation, dissolved in a small amount of water and dialysed for 24 hr. against 0·02 *M* phosphate buffer, *p*H 7·0. Further purification of the substance was carried out by column chromatography, using diethylaminoethyl-cellulose as adsorbent. The substance dialysed was charged on a column (3 cm. in diameter and 10 cm. in height) packed with the adsorbent buffered with 0·02 *M* phosphate buffer, *p*H 7·0. The charged column was thoroughly washed with a sufficient amount of 0·05 *M* phosphate buffer *p*H 7·0, and the substance was eluted with 0·2 *M* phosphate buffer, *p*H 7·0.

The eluate thus obtained showed a bright yellow colour and, on addition of ferricyanide, its colour changed to green, indicating the oxidation of the copper protein which had been in the reduced form. The values for the degree of purity of the eluate as the ratio of extinction at 278 mμ (maximum of protein peak) to that at 597 mμ (maximum of peak in visible region, see below), was found to be 4·8. The oxidized substance, if not so highly purified, was generally found to undergo a gradual auto-reduction without any addition of reducing agents, and even after thorough dialysis against water. The substance was therefore subjected to subsequent chromatography in the reduced form to prevent the broadening of the elution pattern. The copper protein, dialysed and reduced with ascorbic acid, was again charged on a column of diethylaminoethyl-cellulose equilibrated with 0·02 *M* phosphate buffer, *p*H 7·0 (2 × 20 cm.). The column was washed with 0·05 *M* and 0·1 *M* of phosphate buffer (*p*H 7·0) and the substance was then eluted with 0·2 *M* of phosphate buffer, *p*H 7·0. This procedure was repeated until no yellow colour was observed in the eluate. The water-clear solution thus obtained had a purity index (see above) of 2·6 and showed the deep-blue colour of oxidized copper protein on the addition of ferricyanide. It was found that the oxidized substance, in this stage of purification, was no longer auto-reducible. The last manipulation of column chromatography was therefore carried out with the oxidized substance. In this case, the charged column was washed with 0·03 *M* phosphate buffer, *p*H 7·0, and the substance was eluted with 0·1 *M* of phosphate buffer, *p*H 7·0. The value finally obtained for the purity index was 1·63.

Fig. 1 shows the absorption spectra of the oxidized and reduced form of the substance. In the oxidized form, a sharp absorption peak due to the protein has a maximum at 278 mμ and a slight shoulder at 284 mμ. In the visible region, there is a broad absorption peak ranging from 500 mμ to 700 mμ and possessing a maximum at 597 mμ. In the reduced form, no absorption was observed in this region. The blue colour of the oxidized substance was found to disappear on addition of sodium diethyl-dithiocarbamate or on dialysing against salicylaldoxime or cyanide solution; this reappeared, although not completely, on dialysis for 24 hr. against a copper sulphate

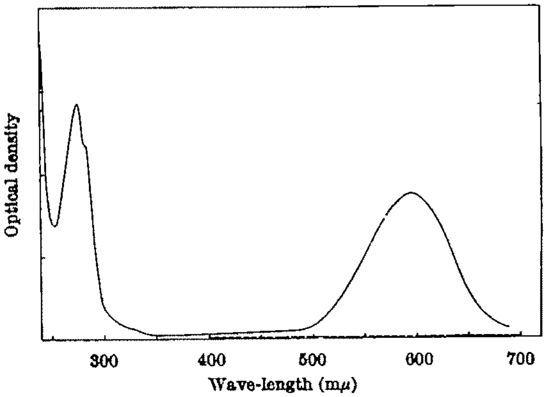


Fig. 1. Absorption spectra of copper protein from *Chlorella ellipsoidea*. Solid line, oxidized form; broken line, reduced form (reduced with ascorbic acid)

solution of 10^{-3} *M*. A spectrophotometric experiment revealed that the blue colour which reappeared was due to an absorption peak identical with that of the untreated preparation. It is inferred from these findings that the characteristic peak in the visible region is due to copper in the form of a complex with protein.

The oxidation-reduction potential of the substance is determined, using a ferri- and ferro-cyanide mixture as oxidation-reduction buffer. In Fig. 2, the values for log (ferrocyanide/ferricyanide) are plotted against those for log (reduced copper protein/oxidized copper protein). The slope of the curve indicates a one-electron change in the oxidation and reduction of the copper protein. From these results, the normal potential of the copper protein is calculated to be 390 mV. at 20° C. and *p*H 7·0.

The reduced form of the purified copper protein was found to be non-auto-oxidizable. The oxidized substance was reduced with ascorbic acid, hydroquinone and other ordinary reducing agents. It was found that the copper protein was instantaneously reduced by reduced mammalian cytochrome *c* and *Chlorella ellipsoidea* cytochrome 550, which was isolated and purified from *Chlorella ellipsoidea* (details will be published elsewhere). Since cytochrome *f* of *Chlorella* has not been successfully isolated, the reactivity of the copper protein was tested also, with positive results, with another algal cytochrome of high oxidation-reduction potential, *Porphyra tenera* cytochrome 553[2].

A rapid reduction of the oxidized copper protein with reduced pyridine nucleotide as electron-donor was found to be catalysed by the presence of the cell-free extract of *Chlorella*. This reductase was partially purified by fractional precipitation with ammonium sulphate and column chromatography, using diethylaminoethyl-cellulose as adsorbent. (The preparation thus obtained showed a yellow colour, which disappeared on reduction with sodium hydrosulphite. The absorption spectrum of this substance in the oxidized form showed three peaks with absorption maxima at 275, 380 and 465 mμ suggesting the flavoprotein nature of the enzyme.) As will be seen in Fig. 3, this enzyme catalyses the reduction of the oxidized copper protein with reduced pyridine nucleotide as electron donor. The rate of this reaction was markedly faster with reduced triphosphopyridine nucleotide than with reduced diphosphopyridine nucleotide. It was also found that this preparation had the capacity to catalyse the reduction of oxidized mammalian cytochrome *c* with reduced triphosphopyridine nucleotide (Fig. 3). It is impossible to compare the activity of this enzyme toward the copper protein with that toward cytochrome until the molar extinction coefficient of the former is estimated.

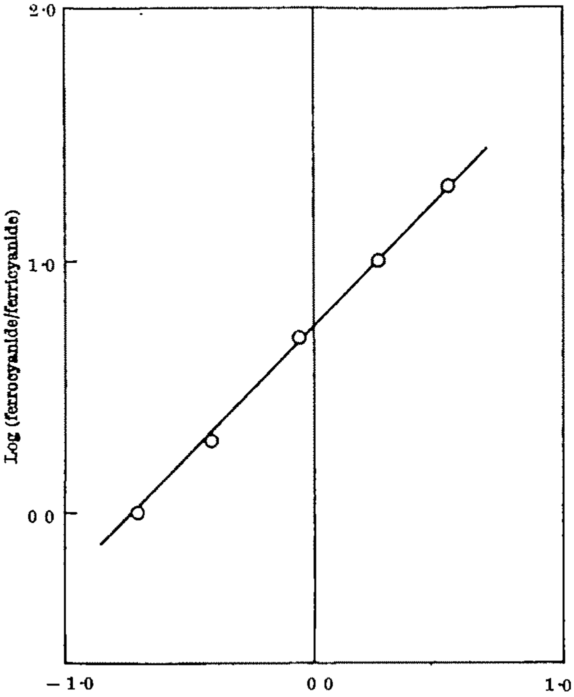


Fig. 2. Oxidation-reduction potential of copper protein from *Chlorella ellipsoidea*. The points refer to the degree of oxidation of copper protein of *Chlorella ellipsoidea* in the presence of varied ratios of ferrocyanide versus ferricyanide in the reaction mixture

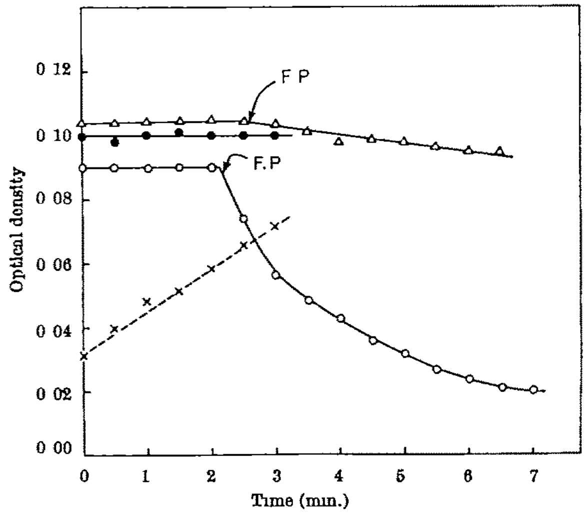


Fig. 3. Reduction of copper protein (and mammalian cytochrome *c*) with reduced pyridine nucleotide as catalysed by *Chlorella* flavoprotein. Reaction mixture, 1·0 ml. of 0·5 *M* phosphate buffer (*p*H 7·0), 0·5 ml. copper protein or horse heart muscle cytochrome *c*, 0·1 ml. reduced pyridine nucleotide, 0·05 ml. flavoprotein and deionized water in 3·0 ml. The reaction was followed spectrophotometrically at 596 mμ and 550 mμ for the reduction of copper protein and cytochrome *c*, respectively. ○, △, reduction of copper protein with reduced triphosphopyridine nucleotide and reduced diphosphopyridine nucleotide, respectively. Flavoprotein was added at the time marked *F.P.* ●, absorption in the presence of copper protein and flavoprotein alone (that is, without addition of reduced pyridine nucleotide); ×, reduction of cytochrome *c* with reduced triphosphopyridine nucleotide. Flavoprotein was added as catalyst at time zero

A substance with similar spectrophotometric and electro-chemical properties has been extracted from chloroplasts of spinach by K. Takamatsu (personal communication) in this laboratory. It has also been discovered by me in the chloroplasts of *Chrysanthemum coronarium*. The wide distribution of this substance in various photosynthetic organisms suggests that it is playing some part in the photosynthesis of these organisms. Further investigations to elucidate the physiological function of this substance are in progress.

I wish to thank Prof. A. Takamiya for his valuable advice and encouragement in this work. Lyophilized algal cells were kindly provided from the Tokugawa Biological Institute.

---

[1] Green, L. F., McCarthy, J. F., and King, C. G., *J. Biol. Chem.*, **128**, 447 (1939).

[2] Katoh, S., *J. Biochem.* (Tokyo), **46**, 629 (1959).

LETTERS TO THE EDITORS

MATHEMATICS

Gravitational Waves in General Relativity

THE emission of gravitational waves from a finite isolated axially symmetrical material system in otherwise empty space has been investigated by consideration of the metric :

$$ds^2 = \left(\frac{V}{r}e^{2\beta} - r^2e^{2\gamma}U^2\right)du^2 + 2e^{2\beta}du\,dr +$$

$$2r^2Ue^{2\gamma}du\,d\theta - r^2\left(e^{2\gamma}d\theta^2 + \sin^2\theta\, e^{-2\gamma}d\varphi^2\right)$$

Einstein vacuum field equations have been solved by an expansion in negative powers of r which represents radial distance in a well-defined sense. In this expansion it has been assumed that only outgoing waves are present. The expression :

$$\tfrac{1}{4}\lim_{r\to\infty}\int_0^\pi (r - V)\sin\theta d\theta$$

represents mass in the static case, and forms a suitable generalization of this static concept to the dynamical case.

The following results have been found :

(1) If a system is static before some instant, then undergoes motion, and eventually again returns to a static state, then its mass in the final state is less than its mass in the initial state.

(2) There exists a class of possible motions of the source in which the curvature tensor (measured by its physical components) falls off like r^{-3}. In this case no radiation is sent out and no loss of mass occurs. The existence of such a class of motions is related to Infeld's[1] result that a set of freely moving particles does not radiate. This case differs from the stationary one by, among other characteristics, lim $(r - V)$ being a function of θ though not of u.

(3) There exists a class of motions of the source in which the curvature tensor falls off like r^{-2}. In this case the power received by a set of small receivers covering a large sphere surrounding the source tends to zero as the radius of the sphere tends to infinity, since small receivers absorb energy at a rate proportional to the square of the curvature tensor. Nevertheless the source loses mass, because at any distance from the source a suitably constructed large receiver could absorb a finite amount of energy.

(4) For general motions the curvature tensor falls off like r^{-1}, but, because of (2), there is no close relation between the mass loss of the source and the energy that could be absorbed by distant small receivers. This point underlines the non-localizable nature of gravitational energy.

I am much indebted to Dr. F. A. E. Pirani for innumerable discussions that have done much to improve my understanding of the problem.

Full details of the work (carried on partly in collaboration with Dr. M. G. J. van der Berg, Department of Applied Mathematics, University of Liverpool) will be published elsewhere.

H. BONDI

King's College, London, W.C.2.

---

[1] Infeld, L., *Ann. Phys* (New York), 6, 341 (1959).

PHYSICS

Time-Dependent Tensile Strength of Solids

DURING the course of studying the strain-rate effects of a number of irradiated and non-irradiated polymeric solids as well as some metallic solids (refs. 1 and 2 and unpublished results) a common relationship between stress and strain-rate has been observed. For any given value of strain the stress obtained at different rates of straining is linearly related with the logarithm of the strain-rate. Mathematically, if ε is the total given strain at any given temperature T, then the stress σ is related with the strain-rate $\dot\varepsilon$ in the following manner :

$$\dot\varepsilon = \dot\varepsilon_0 e^{\frac{\sigma - \sigma_0}{m}}\Bigg|_{\varepsilon} \qquad (1)$$

where $\dot\varepsilon_0$ and σ_0 are constants independent of the strain ε, and m, which is also independent of the strain, is the slope of the straight line when the log of strain-rate is plotted against the stress. Or in another form, when the rate of straining is constant :

$$t = \frac{\varepsilon}{\varepsilon_0} e^{\frac{\sigma_0 - \sigma}{m}}\Bigg|_{\dot\varepsilon} \qquad (2)$$

Depending upon the value of ε, which is a measure of molecular configuration of the solid in terms of deformation[3], the time-dependent strength can be evaluated.

As one special case, if we let :

$$\dot\varepsilon = \dot\varepsilon_b = \frac{\varepsilon_b}{t_b}$$

then from (1) :

$$t_b = \frac{\varepsilon_b}{\dot\varepsilon_0} e^{\frac{\sigma_0 - \sigma_b}{m}} \qquad (3)$$

where t_b is the time to fracture, ε_b is the fracture strain and σ_b the stress maintained until fracture occurs. This agrees well with the current theoretical and experimental developments of the subject[4-8].

On the basis of considering the oscillation and breaking of atomic bonds, the time-dependent strength properties of solids has been reported and may be expressed as follows[4] :

$$t_b = \frac{1}{\omega} e^{\frac{E - 2\delta\frac{\delta}{n}\sigma_b}{kT}} \qquad (4)$$

where t_b is the time taken for the sample to break under the tensile stress σ_b, ω corresponds to some bond oscillation frequency, n is the number of bonds per unit area the normal of which is in parallel to these bonds, E is the bond energy, 2δ is approximately the distance the bond will stretch before

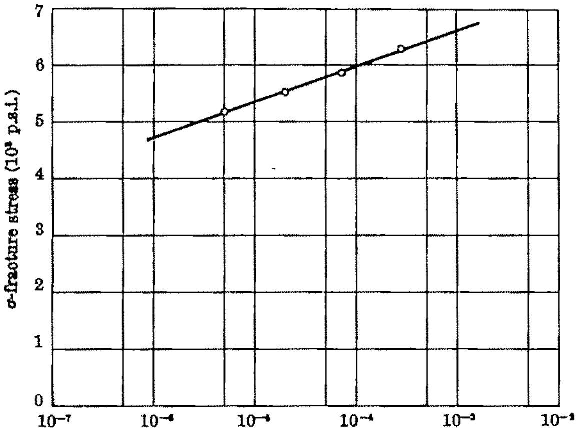


Fig. 1. Effect of strain-rate on breaking stress of polystyrene solid

breaking, k is the Boltzmann constant, and T is the absolute temperature.

According to another theoretical analysis based on the theory of absolute reaction-rates for simple tension[5], the time taken to fracture is related to a constant fracture stress σ_b of a solid body in the following manner:

$$\log t_b = A - B\,\sigma_b \tag{5}$$

where t_b is the time to fracture and A and B are constants.

Experimentally similar results have been obtained[7,8] for various solids. Hsiao and Sauer[7] have reported this linear relationship between breaking stress and logarithm of time for solid polystyrene at room temperature. Zhurkov and his colleagues[8] have made a systematic study of not only time- but also temperature-dependent fracture phenomena for a large number of various solids. The time t_b taken for a solid to fracture under a constant stress σ_b was found to obey a general law that:

$$t_b = t_0 e^{\frac{U_0 - \gamma\sigma_b}{kT}} \tag{6}$$

where t_0, U_0 and γ are constants which define the strength properties of the solid. It is interesting that the quantity U_0 was found to coincide in magnitude with the binding energy of atoms in the crystal lattice of metals and alloys. The quantity t_0 was found to be constant for all the metals investigated and of the same order of magnitude as the period of vibration of atoms in the crystal lattice. A very close resemblance between (6) and (3) is quite evident.

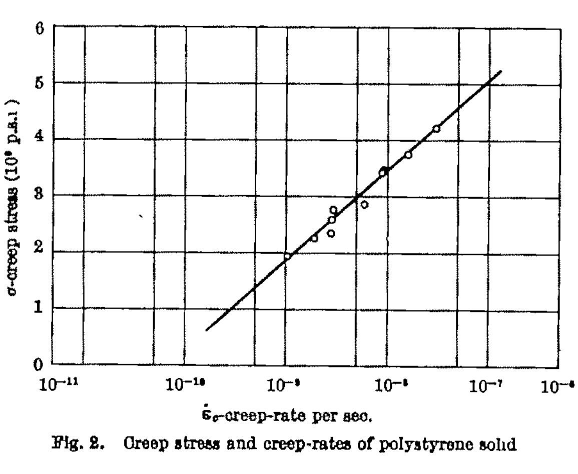


Fig. 2. Creep stress and creep-rates of polystyrene solid

As another special case in the creep process the total strain-rate is equal to the creep-rate, that is, $\dot{\varepsilon} = \dot{\varepsilon}_c$ and $\dot{\varepsilon}_0 = \dot{\varepsilon}_{0c}$, where ε_c and ε_{0c} are creep strains. Using these relations, if σ_c is the creep stress, then (1) can be reduced to the following form:

$$\dot{\varepsilon}_c = \dot{\varepsilon}_{0c}\, e^{-\frac{\sigma_0 - \sigma_c}{m}} \tag{7}$$

indicating that the plots of $\log t_b - \sigma_b$ from (3) and $\log \dot{\varepsilon}_c - \sigma_c$ from (7) have equal but opposite slopes. This is well illustrated by Zhurkov's excellent experimental work for metals and alloys[9].

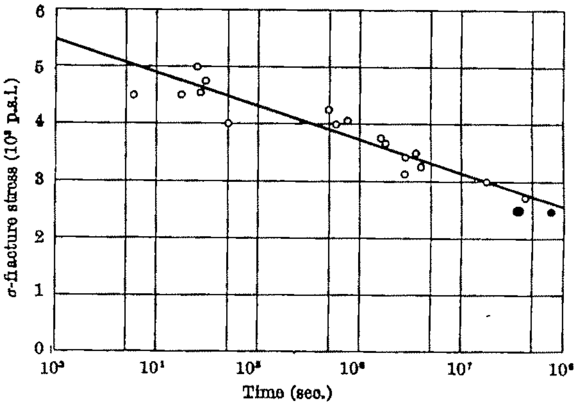


Fig. 3. Effect of time on fracture stress of polystyrene solid

Quite recently, Zhurkov and Sanfirova[9] have obtained the relation between the strength and the constant creep-rate of metals and alloys. They found that:

$$\dot{\varepsilon}_c = \varepsilon_{0c}\, e^{-\frac{Q_0 - \gamma_1\sigma}{kT}} \tag{8}$$

where $\dot{\varepsilon}_c$ is the creep-rate and $\dot{\varepsilon}_{0c}$, Q_0 and γ_1 are constants. They further determined that $Q_0 = U_0$ and $\gamma_1 = \gamma$ for a number of metallic solids. They also claimed that U_0 is dependent on stress, in contrast with the result by Dorn and his co-workers[10] that the activation energy is independent of the stress. But Basinski[11] and others have found that the activation energy is stress-dependent. According to the present analysis the activation energy is not only dependent on stress but also on strain.

However, in order to consider the possibilities of having different mechanisms of creep deformation for different types of solids, it is desirable to use m as the variable parameter.

For metals and alloys, m has one value which reflects one type of mechanism of deformation associated with various dislocations. But for polymer solids m has another value which reflects a different type of deformation mechanism. To give an actual example, consider the time-dependent mechanical properties of solid polystyrene. The effect of log of strain-rate on the fracture stress is shown in Fig. 1. The plot of the log of creep-rate against the creep stress is given in Fig. 2. The slopes of the two curves are evidently not the same. Comparing with the curve plotted in Fig. 3, the log of time against fracture stress, it is seen that the slope of this curve is equal but opposite to that of the curve in Fig. 1.

In conclusion, it seems reasonably safe to consider that in describing the time-dependent tensile strength properties of a large number of solids there exists a basic linear law between the logarithm of strain-rate $\dot{\varepsilon}$ and the applied tensile stress σ :

$$\dot{\varepsilon} = \dot{\varepsilon}_0 e^{\frac{\sigma - \sigma_0}{m}} \Big|_{\varepsilon}$$

where $\dot{\varepsilon}_0$ and σ_0 are constants and m is a material constant proportional to the absolute temperature T.

This work was supported in part by the U.S. Atomic Energy Commission.

C. C. Hsiao

University of Minnesota,
Minneapolis,
Minnesota.

[1] Hsiao, C. C., and Sauer, J. A., A.S.T.M. Bulletin, No. 172, **29** (1951). Hsiao, C. C., *Proc. A.S.T.M.*, **56**, 1425 (1956).

[2] Das, Y. C., and Hsiao, C. C., Atom. Energy Comm. *AT*(11-1)-532 Tech. Rep. No. 5, University of Minnesota (1959).

[3] Hsiao, C. C., *J. App. Phys.*, **30**, 1492 (1959).

[4] Bueche, F., *J. App. Phys.*, **26**, 1133 (1955); **28**, 784 (1957); **29**, 1231 (1958).

[5] Coleman, B. D., *J. Polymer Sci.*, **20**, 447 (1956); *J. App. Phys.*, **27**, 862 (1956); **28**, 1058 (1957); **29**, 968 (1958).

[6] Bartenev, G. M., *Rep. Acad. Sci., U.S.S.R.*, **9**, 53 (1955).

[7] Hsiao, C. C., and Sauer, J. A., *J. App. Phys.*, **21**, 1071 (1950).

[8] Zhurkov, S. N., *et al.*, *J. Tech. Phys.*, **3**, 1677 (1953); **25**, 66 (1955); *Doklady, Acad. Sci. U.S.S.R.*, **101**, 2, 237 (1955); *Bull. Acad. Sci. U.S.S.R.*, **11**, 78 (1957).

[9] Zhurkov, S. N., and Sanfirova, *J. Tech. Phys.* (U.S.S.R.), **28**, 1719 (1958).

[10] Dorn, J. E., *J. Mech. and Phys. Solids*, **3**, 85 (1955).

[11] Basinski, Z. B., *Phil. Mag.*, **4**, 393 (1959).

Size Distribution of Tobacco Smoke Droplets by a Replica Method

HITHERTO it appears that when size distributions of tobacco smoke droplets have been made by light or electron microscopy, the droplets have been caught on glass surfaces or one of the usual kinds of specimen support film, and upon deposition they have spread on the sampling surface (Fig. 1*a* and *c*). As a result, published size distributions obtained by these methods have been of the spread diameter of the droplets instead of their true diameter as they existed in the smoke at the time of sampling.

A replica method for determining the size distribution of non-volatile droplets by electron microscopy[1] makes it possible to relate the diameters of lens impressions, formed by spread-out droplets sampled on a wet gelatine film, to the diameter of the droplets themselves. This method has now been applied successfully to the determination of the size distribution of tobacco smoke droplets.

Comparative size distributions of cigarette smoke droplets have been made on samples obtained simultaneously on collodion support films by means of the thermal precipitator (Fig. 1*a*) and an electrostatic precipitator, and on wet gelatine film by means of the electrostatic precipitator followed by the replica method (Fig. 1*b*). The electrostatic precipitator was of the parallel-plate type with an electrode separation of 1 cm. and employing a potential difference of 5 kV. Droplets from the smoke of an artificially smoked cigarette without filter tip and a normally smoked cigarette also without filter tip have been examined. The artificial smoking was carried out by inserting the lighted cigarette in the inlet of a 1-litre glass sampling cylinder and drawing smoke through by means of a hand sampling pump at the rate of 35 ml./2 sec. To obtain the normally smoked cigarette cloud, the smoker drew smoke into the mouth and filled the sampling cylinder by gently blowing the smoke into it. In both cases the smoke was approximately 10 sec. old when sampling was commenced, and the concentration was such that a satisfactory thermal precipitator sample was obtained in 2 sec. and the electrostatic precipitator samples in 10 sec.

The size distribution of droplets in artificially produced cigarette smoke obtained by the three methods of sampling is shown in Fig. 2. Diameters shown are for the spread droplets and the number median diameters are 2·1μ for the thermal precipitator sample, 2·4μ for the electrostatic precipitator sample on collodion film and 0·38μ for the gelatine replica. Only in the case of the replica sample can these values be related to actual droplet diameters. The spread factor[1] (droplet diameter/replica diameter) for tobacco smoke droplets on gelatine was found to be 0·435, so that the median droplet diameter was actually 0·16μ and the maximum droplet diameter 0·54μ. For droplets in the smoke from a normally smoked cigarette the median values were 1·05μ for the thermal precipitator sample, 1·3μ for the electro-

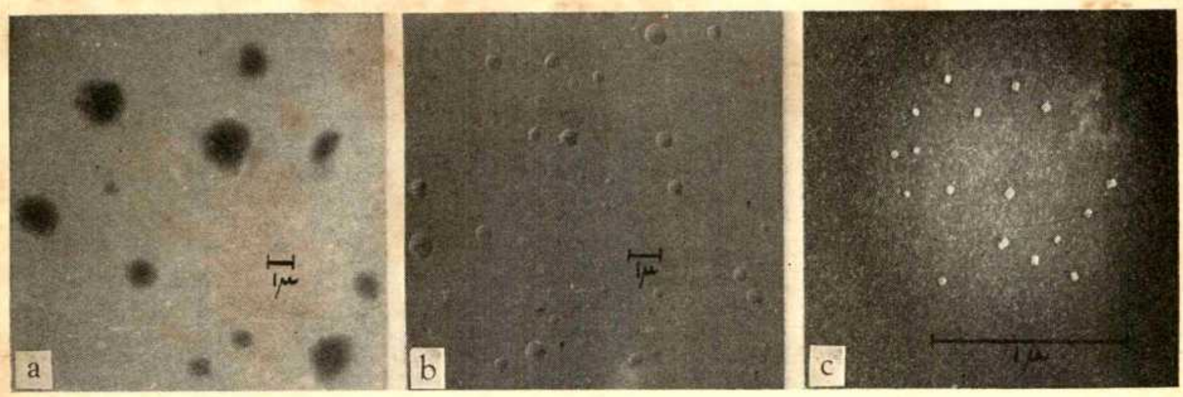


Fig. 1. Electron micrographs of tobacco smoke droplets: (*a*) spread droplets on collodion; (*b*) carbon replica of lens impressions formed by droplets sampled on wet gelatine film; (*c*) spread droplet containing crystals

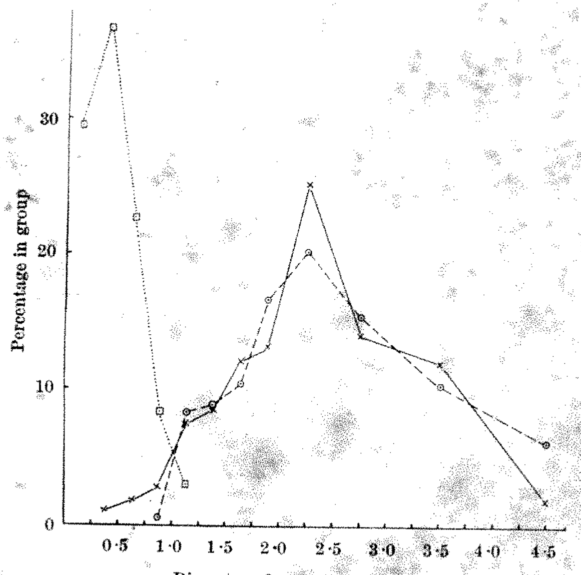


Fig. 2. Size distribution of spread droplets in smoke from an artificially smoked cigarette without filter tip. ×—×, Thermal precipitator and collodion film; ○ – – – ○, electrostatic precipitator and collodion film; □ · · · □, electrostatic precipitator and gelatine film (replica method)

static precipitator sample on collodion film and 0·46μ for the gelatine replica with a true droplet median diameter of 0·2μ.

It is interesting to compare these values with those obtained by other workers. Langer and Fisher[2], sampling on glass and sizing by dark-field microscopy, obtained values for the diameters of 0·6μ (median) and 1·6μ (maximum). For a smoke of similar age, Harris and Kay[3], sampling on 'Formvar' film and sizing by electron microscopy, appear to have obtained a maximum droplet diameter of approximately 5μ, which is the largest size for samples taken on collodion in the present investigation. DallaValle[4], by means of electrostatic separation studies, found a size range of 0·1–0·25μ, and Sinclair[5], using a light-scattering method, a size range up to 0·5μ diameter. It is evident that spreading of the droplets always occurs when they are deposited upon a sampling surface and, unless the spread diameter can be related to the original droplet diameter, size distributions obtained by measuring the diameters of deposited droplets differ considerably from those of the droplets as they exist in the aerosol.

Although the replica method[1] was developed chiefly for electron microscopy, it can conveniently be used for light microscopy; for the examination of tobacco smoke droplets, it virtually increases the resolving power by a factor of 2·3.

The samples taken on collodion film were re-photographed at a higher magnification (×10,000) and crystalline inclusions were observed in many of the spread droplets (Fig. 1c). It is not known whether these crystals (mostly in the size range 0·02–0·04μ) existed in the droplet phase or whether they were the result of some constituent crystallizing out under vacuum in the electron microscope. Kahler and Lloyd[6] found spherical particles of approximately the same size range in cigarette and cigar smoke, and it is possible that the physical form of included particles is some characteristic of the brand of tobacco from which the smoke has been formed.

This application of the replica method was suggested by Mr. H. L. Green, and helpful discussion with him is gratefully acknowledged.

W. J. HARRIS

Chemical Defence Experimental
Establishment,
Porton Down, Wilts.

[1] Harris, W. J., *Brit. J. App. Phys.*, **10**, 139 (1959).

[2] Langer, G., and Fisher, M. A., *Amer. Med. Assoc. Arch. Indust. Health*, **13**, 372 (1956).

[3] Harris, E., and Kay, H. F., *Nature*, **183**, 741 (1959).

[4] DallaValle, J. M., Clyde Orr, jun., and Hinkle, B. L., *Brit. J. App. Phys.*, **5**, Supp. 3, *S* 198 (1954).

[5] Sinclair, D., Handbook of Aerosols, U.S. Atomic Energy Commission, Washington, D.C., p. 86 (1950).

[6] Kahler, H., and Lloyd, B. J., *J. Nat. Cancer Inst.*, **18**, 217 (1957).

Helium–Butane Gas Mixtures as Fillings for Geiger-Müller Tubes

GAS-FLOW counters are finding an increasing use, especially in automatic methods of counting carbon-14 and tritium in sample-changing devices, and in chromatogram scanners. We have investigated the performance of various mixtures of counting gases in order to determine the factors affecting the choice of an optimum mixture. The gases investigated consisted of helium containing 1·0–2·5 per cent of butane; helium bubbled through ethanol at 0° C. (containing about 1·6 per cent ethanol vapour); and, as standards of reference, 'Tracerlab *G*–1 Geiger Gas' (composition, according to manufacturers, principally helium, *iso*butane, and butadiene, in undisclosed proportions) and 'Nuclear-Chicago *Q*–Gas' (containing nominally 98·7 per cent helium + 1·3 per cent butane).

Curves of counts per minute against voltage (in 50-V. intervals) were recorded to show the usual plateau for each gas in two very different types of gas-flow counter, as described below. Two carbon-14 standard planchettes were used, one for each type of counter. The curves were analysed to give (*a*) the plateau length; (*b*) the operating voltage, taken as one-third of the plateau length above the lower limit of the plateau; (*c*) the slope of the plateau at the operating voltage; and (*d*) the counts per min. of the standard planchette at the operating voltage.

Counter 1 was a Scott-type end-window gas-flow counter[1] used for exploring two-dimensional paper chromatograms and for planchette counting. The end window consisted of I.C.I. 'Melinex 0' (25 gauge), a polyethylene terephthalate film of thickness 0·00625 mm. (0·86 mgm. per cm.^{2}). The diameter of the window and of the cylindrical counting volume was 5·6 cm. The anode was an axial tungsten wire of 0·13 mm. diameter and 1·5 cm. length, supported from the top of the counter tube on a thin brass pillar, and terminating in a glass bead placed about 0·3 cm. behind the window. The carbon-14 planchette was 2·4 cm. in diameter. The counter was used with a 'Nuclear-Chicago Ultrascaler 1924', with the input sensitivity set at 60 mV. This input sensitivity was chosen after a series of 15 runs at different sensitivities between 1 and 800 mV., and has been extensively used in routine operation. Measurements were made at three different gas-flow rates for each gas mixture: 127, 287, and 613 ml. per min., corresponding to a positive pressure inside the counter of 1·2, 2·4, and 4·8 cm. of ethanol, respectively. 1-min. counts were taken.

Counter 2 was a standard 'Nuclear-Chicago *D*–47' counter mounted on a '*C*–110*B*' sample changer, and

Table 1. SUMMARY OF RESULTS IN SCOTT COUNTING TUBE

Gas mixture	Plateau length (V.)	Operating voltage (1/3 from bottom of plateau)	Counts/min. of standard carbon-14 planchette at operating voltage	Plateau slope at operating voltage (per cent/100 V.)
He + 1·0 per cent butane	350	1,600	15,300	4·0
He + 1·1 per cent butane	650	1,825	14,750	3·7
He + 1·5 per cent butane	700	1,900	14,600	1·7
He + 2·0 per cent butane	750	2,100	14,500	0·7
He + 2·5 per cent butane	700	2,200	14,450	0·3
He + ethanol	500	2,050	14,600	2·8
'Nuclear-Chicago *Q*-Gas'	750	2,050	14,350	1·0
'Tracerlab *G*-1 Geiger Gas'	300	1,650	14,400	1·4

connected to the 'Ultrascaler 192*A*'. The tube was used without a window, and the carbon-14 sample occupied an area 1·5 cm. in diameter on a metal planchette. The counting volume was approximately trochoidal in section, with a base diameter of 3·6 cm. The anode was of 0·05-mm. diameter tungsten wire in the form of a horizontal loop 1·5 cm. in diameter placed centrally, and about 1·3 cm. above the planchette. The operating conditions were those recommended by the manufacturers: gas-flow rate 50 ml. per min. after a preliminary flushing period at 200 ml. per min., and the scaler input sensitivity at 250 mV. The counts were each of 3-min. duration.

Tables 1 and 2 give the summarized results from each counter. Of the three flow-rates used in the Scott counter, the lowest was insufficient to sweep out the decomposition products of the discharges, so that the plateau was short and breakdown occurred at relatively low voltages. Increasing the flow-rate gave longer and flatter plateaux, but the difference between the two higher rates of gas flow was not sufficiently great to justify the highest consumption of gas. The results are therefore given for the medium flow-rate of 287 ml. per min. Tables 1 and 2 agree in the comparison of the mixtures investigated with the commercially available gases. Helium + 1·1 per cent butane, and helium + 1·5 per cent butane possessed characteristics closely resembling those of 'Tracerlab *G*-1 Geiger Gas' (except that the 'Tracerlab Gas' showed a smaller plateau slope); the 'Nuclear-Chicago *Q*-Gas' characteristics were in all respects between those of helium + 1·5 per cent butane and helium + 2·0 per cent butane, although the manufacturers stated that this gas consisted of helium + 1·3 per cent butane. The helium + ethanol mixture operated at a relatively high voltage, as did helium + 2·0 per cent butane, but the ethanol plateau was much shorter and steeper (Table 1).

Table 2. SUMMARY OF RESULTS IN *D*-47 GAS-FLOW COUNTER

Gas mixture	Plateau length (V.)	Operating voltage (1/3 from bottom of plateau)	Counts/min. of standard carbon-14 planchette at operating voltage	Plateau slope at operating voltage (per cent/100 V.)
He + 1·0 per cent butane	150	1,000	1,920	4·0
He + 1·1 per cent butane	300	1,250	1,910	4·2
He + 1·5 per cent butane	350	1,300	1,885	3·3
He + 2·0 per cent butane	350	1,500	1,890	2·0
He + 2·5 per cent butane	350	1,550	1,920	1·3
'Nuclear-Chicago *Q*-Gas'	400	1,400	1,900	2·0
'Tracerlab *G*-1 Geiger Gas'	350	1,250	1,900	1·1

These results show that certain helium–butane mixtures from the range investigated are entirely suitable as counting gases. The practical choice is between the 1·5 per cent and the 2·0 per cent proportion of butane. The higher proportion gave a considerably flatter plateau, but also a rather higher operating voltage. Even with a counter tube as large as the Scott-type counter, the helium + 1·5 per cent butane mixture required an operating voltage of less than 2 kV., which is within the range of most commercial high-voltage supplies fitted to scalers. As most counter tubes are smaller than the Scott type, the operating voltage would be well below 2 kV., as was in fact found with the *D*–47 tube.

We wish to thank Dr. A. Bracken of British Oxygen Research and Development, Ltd., for the helium–butane gas mixtures. The Scott-type counter tube was constructed by Mr. L. D. Kitchen and Mr. S. T. Smith of the Physics Department, King's College Hospital. The Nuclear-Chicago counting equipment was a gift from Miles Ames Laboratories to Prof. C. H. Gray.

V. MOSES*

Department of Chemical Pathology,
King's College Hospital Medical School,
London, S.E.5.

J. F. FOWLER†

Department of Medical Physics,
King's College Hospital,
London, S.E.5.

---

* Wyeth Fellow in Pharmacology of the Empire Rheumatism Council.

† Present address: Medical Research Council Radiotherapeutic Research Unit, Hammersmith Hospital, London, W.12.

[1] Fuller, R. C., *Science*, 124, 1253 (1956).

METALLURGY

The Delta Plutonium Transition Temperature

SINCE the first reports of the allotropes of the element plutonium[1], one aspect of continuing interest has been the existence of the δ'-phase occurring in the temperature-range 450–480° C. Recent determination of the latent heats of transition of the allotropes of plutonium[2] enable the thermodynamic aspect of the effects of alloying elements (at impurity-level concentrations) on the $\delta \rightleftharpoons \delta'$ transition to be considered.

It has been pointed out that the phase rule, commonly applied in the construction of equilibrium diagrams, is but one of a number of rules all of which are based on the same thermodynamic reasoning[3]. One of these rules is that when a polymorphic reaction occurs in one of the pure components, the initial slopes of the phase boundaries meeting at the transition temperature differ by $(L/RT^2)^{-1}$, where L is the latent heat, T the absolute temperature of the transition and R the gas constant. Applying this rule to the $\delta \rightleftharpoons \delta'$ transition for which L is 17 ± 10 cal./gm.–atom and T is 728° A., the difference in slopes of the phase boundaries is 620° C./atomic per cent. This very high value implies that small quantities of added elements may have a marked effect on the observed transition temperature. For the limiting condition that one of the phase boundaries of the

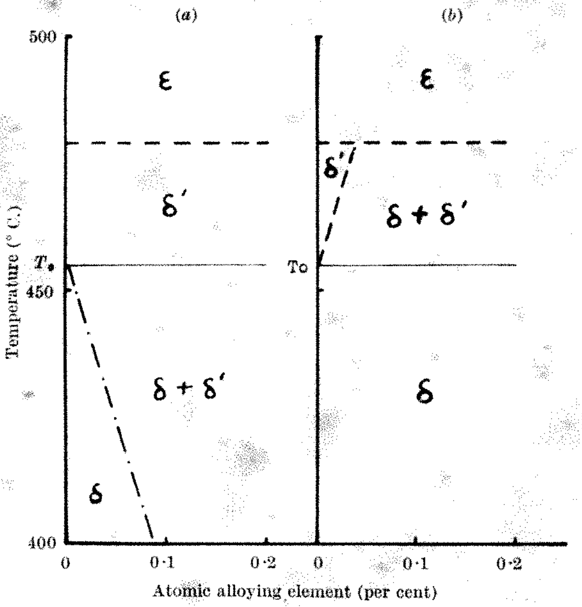


Fig. 1. Limiting cases for the effect of alloying elements on the $\delta \rightleftharpoons \delta'$ transition in plutonium

two-phase region $\delta + \delta'$ has zero slope (thereby minimizing the effect of alloying elements on the transition temperature) the other will have a slope of absolute value 620° C./atomic per cent. In Fig. 1 (*a*), the impurity addition does not affect the lower limit of the pure δ' region, whereas in Fig. 1 (*b*) the region is effectively eliminated by the addition.

The probability of the effect of any specific impurity being one of these limiting cases is thought to be small. Since the slopes of the phase boundaries must both have the same sign, it is probable that in most cases corresponding to Fig. 1 (*a*) the phase boundaries meeting at T (the pure metal transition temperature) will both be tilted downwards. For alloys corresponding to Fig. 1 (*b*), both boundaries will be tilted upwards—making it even less likely that the δ' plutonium structure will be observed. In view of the appreciable concentration of impurities present in nominal 'high purity' plutonium, in those materials where the pure δ'-phase is observed, the situation must be represented by a variation of Fig. 1 (*a*), which is shown diagrammatically in Fig. 2.

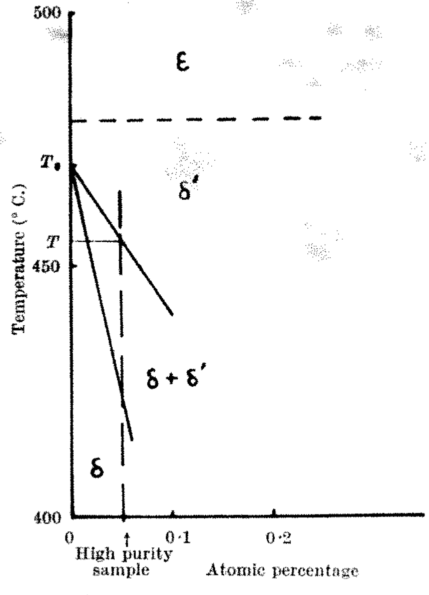


Fig. 2. Possible experimental case

From this figure it is obvious that the transition T observed in 'high-purity' metal may be a low approximation to the true transition temperature T_0. This observation is of particular interest owing to the small temperature-range of existence of δ' (about 25 deg. C.).

R. G. Cope

Development and Research Department,
The Mond Nickel Co., Ltd.,
Acton.

---

[1] Lord, W. B. H., *Nature*, **173**, 534 (1954). Ball, J. G., Robertson, J. A. L., Mardon, P. G., Lee, J. A., and Adams, E. T., *ibid.*, **173**, 535 (1954).

[2] Dean, D. J., Kay, A. E., and Loasby, R. G., *J. Inst. Metals*, **86** (10), 464 (1957–58).

[3] Wilson, A. J. C., *J. Inst. Metals*, **70**, 543 (1944).

CRYSTALLOGRAPHY

Growth of Single Crystals of Copper

In his communication on the growth of single crystals of copper, published in *Nature* of April 2, p. 33, Mr. D. S. Kemsley is good enough to refer to a paper by Andrade and Roscoe[1], in which was described a method suitable for growing single crystals of metals of low melting point.

He makes, however, no reference to a paper published some years later by Andrade and Henderson[2], which specifically states that this method is not suitable for growing crystals of metals of higher melting point and describes a method using a split graphite mould in a high vacuum. This method was used for preparing single crystals of gold, silver and nickel in the first place, and was afterwards used by Andrade and Aboav[3] for preparing single crystals of copper, which proved perfectly satisfactory.

Those who wish to prepare single crystals of copper may possibly find this method simple and well adapted to the purpose.

E. N. da C. Andrade

Department of Metallurgy,
Imperial College of Science and Technology,
Prince Consort Road,
London, S.W.7.
April 4.

---

[1] Andrade, E. N. da C., and Roscoe, R., *Proc. Phys. Soc.*, **49**, 152 (1937).

[2] Andrade, E. N. da C., and Henderson, C., *Phil. Trans. Roy. Soc.*, A, **244**, 177 (1951).

[3] Andrade, E. N. da C., and Aboav, D. A., *Proc. Roy. Soc.*, A, **240**, 304 (1957).

Crystal Structure of Potassium Trivanadate

When solutions of potassium vanadate are made weakly acid, with pH less than 6·5, the orange polyion $V_{10}O_{28}^{-6}$ is formed. These solutions are unstable, and on long standing or on heating, insoluble light-orange, flaky crystals of potassium trivanadate, KV_3O_8, are precipitated. This compound was evidently first described by Norblad[1].

Buerger precession and Weissenberg X-ray diffraction patterns of crystals of potassium trivanadate show a monoclinic lattice with the dimensions: $a = 7·63$ Å., $b = 8·43$ Å., $c = 4·97$ Å. and $\beta = 96° 45'$. The space group is $P2_1/m$ or $P2_1$, and the unit cell contains 2 formula units. The largest crystals are less than 0·1 mm. in the longest dimension, and grow as irregular stacks of thin platelets parallel to (100), somewhat elongated along the *c* axis. The optical properties were determined as follows (by A. van Valkenburg, U.S. National Bureau of Standards):

$\alpha = 1·78$, $X \sim \perp$ (100), lemon yellow
$\beta = 2·25$, $Y = b$, orange
$\gamma = 2·34$, $Z \sim \parallel c$, orange
$2V = 26°$ (negative)

γ was measured with sulphur-selenium melts, and β was estimated from the other measured results.

The diffraction intensities of the (*hk*0), (0*kl*) and (*h*0*l*) reflexions, which were used for the structure determination, were determined from the multiple photographs by visual comparison with a calibrated strip made with one crystal reflexion. Owing to the imperfect nature of the crystals, these data were not as accurate as one usually expects, so that refinement of the structure was somewhat hampered. The trial structure was obtained from the three Patterson projections and spatial considerations. Refinement of this structure proved to be troublesome by Fourier methods, owing to serious atom overlaps in all three projections. Application of the powerful least-squares programme (which solves the full matrix of the normal equations) written by Busing and Levy of the Oak Ridge National Laboratories for the IBM Type 704 computer, finally brought the agreement between observed and calculated structure factors to a satisfactory state. No evidence has been found to indicate that the structure departs from centrosymmetry, and the accepted space group is $P2_1/m$. At present, the reliability factors are as follows: $R(hk0) = 17·8$ per cent, $R(0kl) = 11·3$ per cent and $R(h0l) = 13·1$ per cent; overall $R = 14·0$ per cent. The corresponding parameters are given in Table 1.

Table 1. PARAMETERS FOR POTASSIUM TRIVANADATE
Space group $P2_1/m$ (Int. Tab. No. 11)

Atoms	*x*	*y*	*z*
2K in (*e*)	0·062	$\frac{1}{4}$	0·945
$2V_1$ in (*e*)	0·577	$\frac{1}{4}$	0·917
$4V_2$ in (*f*)	0·693	0·057	0·441
$2O_1$ in (*e*)	0·415	$\frac{1}{4}$	0·109
$2O_2$ in (*e*)	0·759	$\frac{1}{4}$	0·595
$4O_3$ in (*f*)	0·516	0·101	0·700
$4O_4$ in (*f*)	0·518	0·063	0·441
$4O_5$ in (*f*)	0·744	0·092	0·130

The structure, as illustrated in Fig. 1 projected along the *a* axis, consists of a sheet arrangement of fused VO_6 octahedra, with potassium ions occupying interlayer positions. Two-thirds of these octahedra are linked into zig-zag chains stretched parallel to the *b* axis; the remaining one-third lie on the mirror planes and tie these chains into layers parallel to the *b* and *c* axes. Although the V—O bond-lengths are not accurately known (± 0·1 Å.), it is apparent that the octahedra are highly distorted. For the vanadium atom on the mirror plane, the distances are 1·65, 1·69 (2), 2·01 (2) and 2·24 Å.; for the other vanadium atom they are 1·58, 1·66, 1·85, 2·01, 2·13 and 3·01 Å.

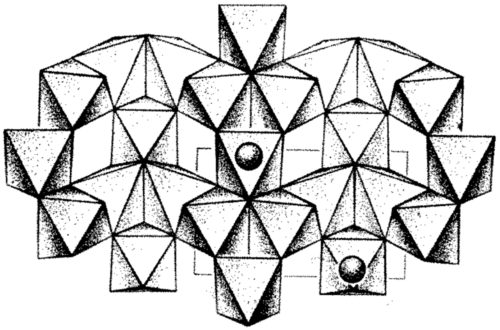


Fig. 1. The layer co-ordination structure of potassium trivanadate projected along the *a* axis. Two of the interlayer potassium ions are shown as shaded circles. (Drawn by H. T. Evans, jun.)

The structure found for KV_3O_8 has been confirmed also for the isostructural CsV_3O_8 by H. T. Evans, jun. (personal communication), and has reached a better degree of refinement, owing to the better quality of crystals formed by the cæsium compound. Details of the analysis of both these structures will be published elsewhere. There is, incidentally, no relation between these structures and that of KCr_3O_8 recently described by Wilhelmi[2].

I wish to express my thanks to J. D. H. Donnay for his encouragement and guidance of the work described; and to H. T. Evans, jun., of the U.S. Geological Survey, who suggested the problem, for his helpful discussions and guidance. Thanks are also due to the latter for providing computer facilities, and to P. O'Hara of the National Bureau of Standards for his assistance with the IBM Type 704 computer.

STANLEY BLOCK*

Department of Chemistry,
The Johns Hopkins University,
Baltimore,
Maryland.

---

* Present address: Weizmann Institute of Science, Rehovoth, Israel.

[1] Norblad, J. A., *Bull. Soc. Chim.*, **23**, 64 (1875).

[2] Wilhelmi, K.-A., *Acta Chem. Scand.*, **12**, 1965 (1958).

Electron Microscopy and the Crystal Structure of Indanthrene

IN the course of work on the direct observation of crystal lattices using high-resolution electron microscopy, indanthrene ($C_{28}H_{14}O_4N_2$) has been examined in a manner similar to that used by Menter[1] with phthalocyanine ($C_{32}H_{18}N_8$) and its metal derivatives.

The crystal structure of indanthrene has been ascertained by Bailey[2] using conventional X-ray techniques: he finds the crystal to be monoclinic, space group $P^2{}_1/a$, with two molecules in the unit cell and the following dimensions: $a = 30·83$ Å.; $b = 3·833$ Å.; $c = 7·845$ Å.; $\beta = 91° 55'$ (see Fig. 1).

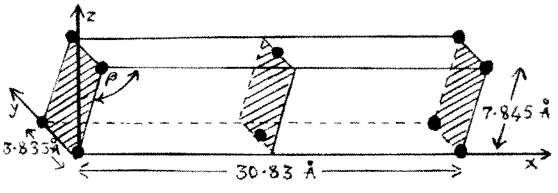


Fig. 1. Indanthrene: the unit cell

The work with the electron microscope bears out those values he obtained for lattice translations *a* and *b*, but, more important, it adds further evidence that images seen in the microscope are in fact images of planes of molecules and are not merely fringes formed by electron diffraction. Labaw and Wyckoff[3], in their study of the derivative indanthrene scarlet *R* ($C_{38}H_{22}N_2O_6$), were unable to use the technique of electron micro-diffraction and left this question unresolved.

Crystals of indanthrene, platy but with very ill-defined terminal faces, were deposited on specimen grids from a suspension in acetone, and examined at high magnification in a Siemens Elmiskop I electron microscope operated at 80 kV. Parallel fringes lying along the length of the crystals were frequently observed (Fig. 2) and comparison of the spacing of these fringes with that of the '$(20\bar{1})$ planes' of platinum phthalocyanine (11·94 Å.) in photographs taken under identical conditions gave a value of 15·2 ± 0·4 Å.

Electron micro-diffraction photographs such as that in Fig. 3 from the circular region of the 'raft' of crystals in Fig. 4 have the characteristic appearance of fibre photographs. Measurements of the distance apart of neighbouring layer lines of the fibre pattern indicate that the maximum period of the lattice structure along the fibre axis is 3·86 ± 0·13 Å., and measurements in a perpendicular direction along the central layer line produce a spacing of 15·51 ± 0·21 Å. Observation of the diffraction pattern in the electron microscope shows that it is only the innermost two spots on the central layer line which are uncovered by the objective aperture in normal microscopy conditions. Thus only the diffracted beams from a structure of period ~ 15·5 Å. are allowed to produce an image on the electron microscope screen after recombination by the later electron lenses.

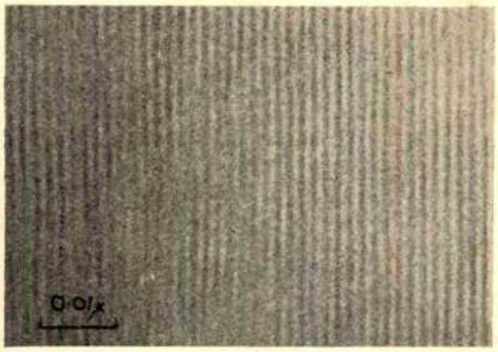


Fig. 2. Electron micrograph of part of a crystal of indanthrene (× 1,000,000)

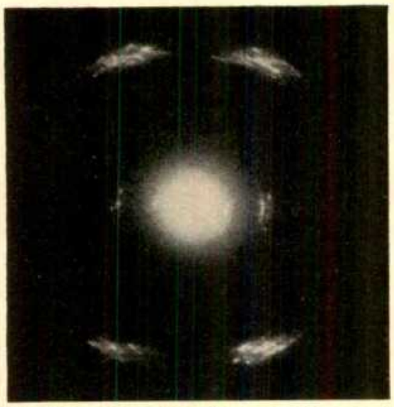


Fig. 3. Micro-diffraction pattern from circular region in Fig. 4

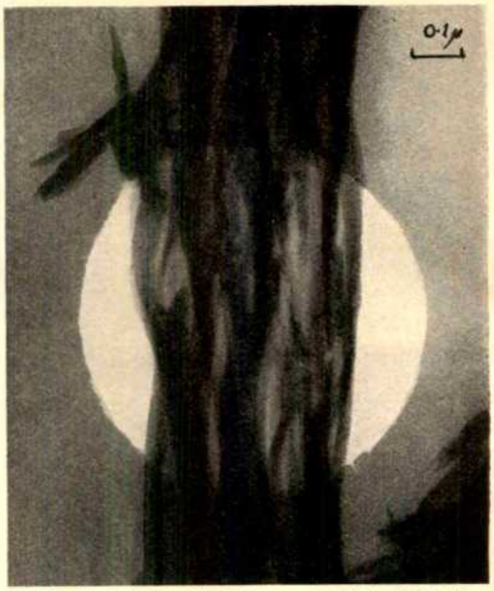


Fig. 4. A 'raft' of indanthrene crystals (× 60,000)

It is compatible with these observations that the crystals examined were platy on {001}, with small {100}, that those planes separated by lattice translations *a*/2 and *b* give rise to the diffraction pattern observed, and that the (200) planes of indanthrene are directly imaged in the electron microscope under normal conditions.

I thank Dr. F. P. Bowden for his help, Dr. J. W. Menter for discussion, the Department of Scientific and Industrial Research for a research grant, and the Imperial Chemical Industries, Ltd., for crystal specimens.

LEWIS T. CHADDERTON
Physics and Chemistry of Solids,
Cavendish Laboratory,
Cambridge.

[1] Menter, J. W., *Proc. Roy. Soc.*, A, **236**, 119 (1956).
[2] Bailey, M., *Acta Cryst.*, **8**, 182 (1955).
[3] Labaw, L. W., and Wyckoff, R. W. G., *Proc. U.S. Nat. Acad. Sci.*, **43**, 1032 (1957*b*).

Crystal Structure of Mellitic Acid

IN a recent communication, Bezjak and Grdenić[1] have described the crystal structure of mellitic acid ($C_6(COOH)_6$). I have also recently completed an independent and full refinement of the structure[2]. While there is agreement on the general features of the structure, my conclusions are different, and are that:

(1) The twelve independent C—O bonds are not identical, but have lengths ranging from 1·18 ± 0·03 to 1·34 ± 0·03 Å. (Bezjak and Grdenić quote them all as 1·23 ± 0·01 Å.). The variations of bond-lengths within the carboxyl groups are consistent with the variations in the C—C—O bond angles.

(2) Within each layer there are six inter-molecular contacts of lengths between 2·64 and 2·68 Å. for each molecule. As these are the lengths expected for hydrogen bonds from the infra-red evidence[3,4], and

correspond to the number of hydrogens in the structure, they are assumed to be the hydrogen bonds. The two contacts of 2·68 Å. between oxygens in different layers given by Bezjak and Grdenić are found to be 2·90 and 3·06 Å. by me, and are not considered to be hydrogen bonds.

A further point of more general application may be made concerning the possible ambiguity of structures solved in projection only, when the space group has fairly high symmetry. The present structure serves as an example.

The space group *Pccn* has eight equivalent general positions given by :

$$x,y,z\ ;\ \tfrac{1}{2}-x,\tfrac{1}{2}-y,z\ ;\ \tfrac{1}{2}+x,\bar{y},\tfrac{1}{2}-z\ ;\ \bar{x},\tfrac{1}{2}+y,\tfrac{1}{2}-z\ ;$$
$$\bar{x},\bar{y},\bar{z}\ ;\ \tfrac{1}{2}+x,\tfrac{1}{2}+y,\bar{z}\ ;\ \tfrac{1}{2}-x,y,\tfrac{1}{2}+z\ ;\ x,\tfrac{1}{2}-y,\tfrac{1}{2}+z.$$

If the y co-ordinate is replaced by $\frac{1}{2}-y$, the eight positions become :

$$x,\tfrac{1}{2}-y,z\ ;\ \tfrac{1}{2}-x,y,z\ ;\ \tfrac{1}{2}+x,\tfrac{1}{2}+y,\tfrac{1}{2}-z\ ;\ \bar{x},\bar{y},\tfrac{1}{2}-z\ ;$$
$$\bar{x},\tfrac{1}{2}+y,\bar{z}\ ;\ \tfrac{1}{2}+x,\bar{y},\bar{z}\ ;\ \tfrac{1}{2}-x,\tfrac{1}{2}-y,\tfrac{1}{2}+z\ ;\ x,y,\tfrac{1}{2}+z\ ;$$

which are different in three dimensions, but give the same set of positions in all three axial projections, $0kl$, $h0l$ and $hk0$. This may easily be seen from the two sets of co-ordinates given. Exactly this ambiguity between y and $\frac{1}{2}-y$ exists for each carboxyl group in the crystal structure of mellitic acid, as the carbon framework of each molecule lies approximately in the plane $y = \frac{1}{4}$ or $y = \frac{3}{4}$. Thus whether a carboxyl group is rotated clockwise or anti-clockwise about the C—C bond joining it to the ring depends on whether the oxygens have co-ordinates y or $\frac{1}{2}-y$. With four independent carboxyl groups per molecule and two independent molecules in the structure, there are 2^8 or 256 possible structures which will give identical projections, and they can be distinguished only by using some general reflexions. Between different carboxyl groups within the same molecule, all but four of these possible structures give oxygen–oxygen contacts which are too small. I used $h1l$ and $h3l$ reflexions to distinguish between these four possibilities.

S. F. Darlow

Physics Department,
College of Science and Technology,
Manchester 1.
March 17.

---

[1] Bezjak, A., and Grdenić, D., *Nature*, **185**, 756 (1960).
[2] Darlow, S. F., *Acta Cryst.* (in the press).
[3] González-Sánchez, F., *Spectrochim. Acta*, **12**, 17 (1958).
[4] Nakamoto, K., Margoshes, M., and Rundle, R. E., *J. Amer. Chem. Soc.*, **77**, 6480 (1955).

RADIATION CHEMISTRY

Radiation-induced Changes in α-Lead Azide

Using techniques of micro-hardness determination already described[1] and standard methods of X-ray diffraction analysis, preliminary changes in the lattice of X-irradiated α-lead azide have been measured and decomposition products analysed. Specially grown 99·9 per cent pure 1 mm. crystals were used to determine hardness changes and microcrystalline 99·5 per cent pure azide material used in the parameter studies. Nickel-filtered 45-kVp. copper radiation with a half-value layer in aluminium of 0·06 mm. was used to produce and record the parameter changes, whereas somewhat harder radiation with a half-value of 0·09 mm. and from a tungsten tube operated at 50 kVp. was used (*a*) to induce hardness changes and (*b*) to bring about ultimate decomposition of the azide. Approximate dose-rates in each series of experiments were 5·0 × 10² röntgens/min., 2·5 × 10⁴ röntgens/min. and 1·4 × 10⁵ röntgens/min. respectively.

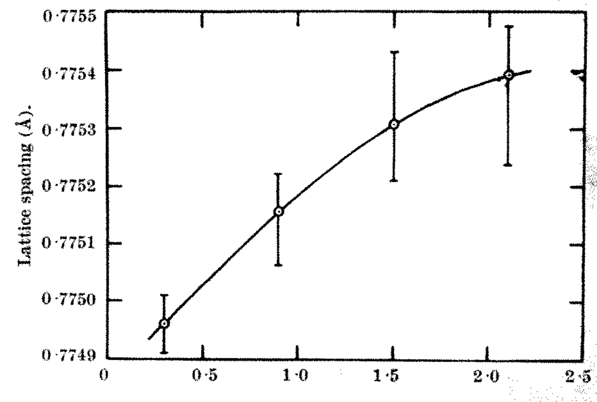


Fig. 1. Mean increase in an unindexed lattice spacing of α-lead azide with X-ray dose, at a dose-rate of 5·0 × 10² röntgens/min. in air. The spread of the results used for each graphical point is indicated

To study parameter changes the highest reflexion recorded with copper $K\alpha_1$ was selected for measurement. This could not be indexed, but was calculated to refer to an uncorrected spacing of $0{\cdot}7749_6$ Å. at 70° F. with a measured temperature coefficient of 0·00002 Å./deg. F. Fig. 1 shows increase in this parameter with increasing X-ray dose. Six trials were carried out and each graphical point is the mean of six determinations with experimental error as shown. Serious loss of line-to-background intensity terminated the series before saturation if any could be effectively observed, and within the scope and experimental accuracy of the work, it was not possible to test critically for any relaxation with time or instability to light. Qualitatively similar results were obtained for other parameters.

Hardness changes for the 013 form ($a<b<c$) of α-lead azide undergoing X-irradiation were measured at 10-gm. load. Five dual trials were carried out, and it was readily apparent that the hardness increases noted were not permanent but

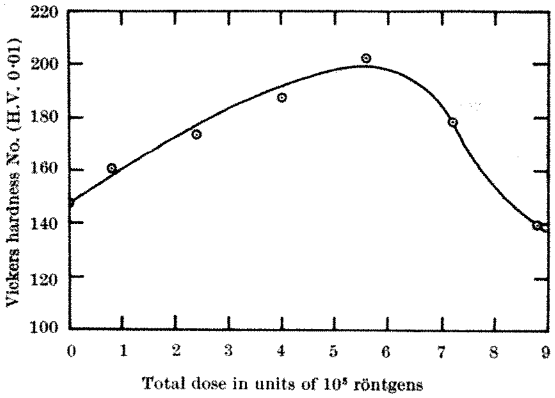


Fig. 2. Showing the increase in Vickers hardness at 10 gm. load for the 013 form of an α-lead azide crystal while receiving X-rays at a dose-rate of 2·5 × 10⁴ röntgens/min. in air

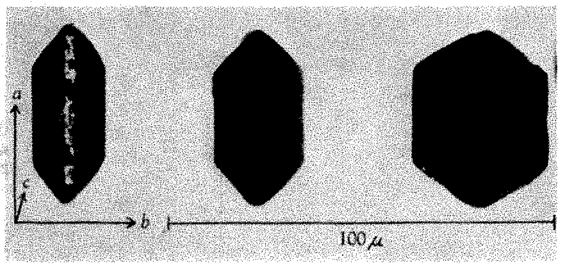


Fig. 3. Showing the anomalous *b*-axis expansion in the habit of a single crystal of α-lead azide receiving X-rays at a dose-rate of $1 \cdot 4 \times 10^5$ röntgens/min. in air

tended to relax with time and even in the dark. Fig. 2 relates hardness to dose for a run in which all operations were carried out with maximum speed. Five indentations were used to derive each graphical point, good consistency being obtained.

Changes in parameter[2] and mechanical properties[3] have already been observed in other irradiated materials and are generally ascribed to vacancy production. If, as is probable, decomposition of α-lead azide proceeds by electron transfer from azide ions to liberate free nitrogen, this would result in vacancy production consistent with the results obtained.

Optical, gravimetric, and X-ray methods were used to study more extensive X-ray damage in the α-lead azide, both in air up to a total dose of $3 \cdot 4 \times 10^8$ röntgens and corresponding to more than 97 per cent destruction of the azide, and in a number of other atmospheres. Although the ultimate X-ray product in vacuum or under an inert atmosphere is necessarily lead, this is not encountered in the presence of carbonic acid or of water. Thus, X-ray studies show that the stable end-product of X-ray decomposition in normal air is basic lead carbonate of the formula $2PbCO_3.Pb(OH)_2$, whereas in severe deficiency of carbon dioxide but excess of water vapour, amounts of basic lead azide of unestablished formula[4] are formed. The latter may be finally converted into basic lead carbonate by X-irradiation in normal air.

X-ray examination of a single crystal of α-lead azide undergoing decomposition to disoriented basic lead carbonate shows that the conversion is complex. After a dose of $6 \cdot 7 \times 10^7$ röntgens there is evidence for partially disoriented residual lead azide together with a disoriented unidentified phase. Higher doses produce a further unidentified phase before stable basic lead carbonate is finally formed.

These features, together with the anomalous *b*-axis habit expansion of the decomposing crystal (Fig. 3), have not yet been satisfactorily explained.

We are indebted to the Ministry of Aviation Explosives Research and Development Establishment for the supply and chemical analysis of the α-lead azide starting material, and to the War Office Armament Research and Development Establishment Chemical Services Branch for miscellaneous analyses.

G. Todd
E. Parry

Armament Research and Development Establishment,
War Office,
Fort Halstead.

---

[1] Todd, G., and Parry, E., *Nature*, **181**, 260 (1958).

[2] Berry, C. R., *Phys. Rev.*, **98**, 934 (1955).

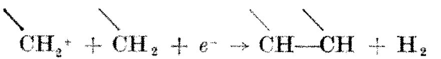
[3] Yin-Yuan Li, *Acta Metallurgica*, **1**, 455 (1953).

[4] Todd, G., *Chem. and Indust.*, 1005 (1958).

Modes of Radiation-induced Cross-Linking in Hydrocarbon Polymers

Since the earliest observations[1,2] on the cross-linking of organic polymers by ionizing radiation, much research has been devoted to this phenomenon, but there remains no generally accepted mechanism applicable to all polymers[3]. For polyethylene it has been proposed[4] that linkages between molecules arise from three independent processes:

(*a*) By the direct action of ions according to either an ion–molecule–electron reaction as originally suggested by Dole[1] and represented in (1):



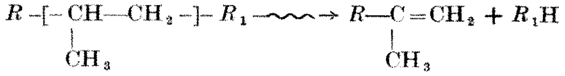
(1)

or by an ion–molecule process followed by subsequent neutralization of the product ion by its cognate electron[5,6].

(*b*) From the interaction of free radicals of low mobility primarily formed in crystalline regions of the polymer[7], as in a post-irradiation fusion of the solid.

(*c*) As a result of the decay of unsaturation initially present and of the unsaturated groups formed during radiolysis[8]; in this case an end- or cross-link would result depending upon the position of the unsaturated group in the polymer. It has been postulated that the mechanism of this process occurs by excitation energy transfer from the main polymer chain[8,9].

A recent paper by Black and Lyons[10] on the radiolytic changes incurred in polypropylene indicates that the formation of vinylidene double bonds corresponds to the occurrence of main-chain fracture according to (2):



$$R\text{-[-}\underset{\displaystyle CH_3}{\underset{|}{CH}}\text{—}CH_2\text{-]-}R_1 \rightsquigarrow R\text{—}\underset{\displaystyle CH_3}{\underset{|}{C}}=CH_2 + R_1H \qquad (2)$$

Further, at doses exceeding $5 \cdot 0 \times 10^{21}$ eV. gm.$^{-1}$, it is shown that the sol fraction–dose relationship for this irradiated polymer is in accordance with an expression derived by Charlesby[11] on the assumption that the ratio of cross-linking to chain fracture approaches unity. These results are interpreted[10] in terms of a mechanism whereby an excited intermediate state of the polymer leads either to fracture F or cross-linking C, the latter process depending upon the concentration $[F]$ of stable chain fragments, that is, vinylidene groups, arising from previous fracture processes during irradiation.

If the processes of vinylidene group growth and decay in polypropylene are considered analogous to the kinetics of *trans*-vinylene formation in polyethylene[8], the corresponding relation:

$$\frac{dF}{dD} = \varphi_f - k_f[F] \qquad (3)$$

would be expected to hold where φ_f refers to the initial rate of chain fracture and k_f is the decay constant for vinylidene groups leading to cross-linking. Since the vinylidene groups are located at the ends of fractured chains, that is, *iso*propenyl groups, it is more correct to refer to their disappearance by end-linking. In formulating equation (3) the process leading to fracture as represented by φ_f is considered to be independent of the magnitude of the subsequent decay process governed by $k_f[F]$ and thus differs from the competitive reaction mechanism envisaged by Black and Lyons[10]; studies on polyethylene have shown[8] that the initial rate of *trans*-vinylene formation is not reduced by a higher initial vinyl group concentration in the polymer so there would appear to be no direct competition between unsaturation formation and disappearance in this system. A test of equation (3) is provided by the data of Black and Lyons in Fig. 4 of their paper[10]; neglecting the two points at low-irradiation doses, the remainder of the results conform to a reasonable linear relation between $\frac{dF}{dD}$ and $[F]$ with a k_f value of 0·094 Mrad^{-1} or 1·51 × 10^{-21} gm. eV.$^{-1}$. It is of special interest that this latter value compares closely with the decay constant of 1·49 × 10^{-21} gm. eV.$^{-1}$ previously obtained for initial vinylidene decay in a sample of high-pressure polyethylene[8]. At high doses it follows directly from equation 3 that the rate of cross-linking would equal the rate of fracture at a limiting concentration of vinylidene groups formed by fracture, in agreement with experiment.

The evidence cited suggests that the cross-linking of polypropylene depends mainly on the process (*c*) above; by contrast, the cross-linking of saturated polyethylene chains in the initial stages of irradiation proceeds chiefly according to (*a*) and (*b*), the latter contribution depending upon the crystallinity of the sample and the post-irradiation treatment[7,12]. In general, the importance of (*c*) will depend on the concentration of unsaturation in the polymer, whether initially present or formed during irradiation, and hence on the irradiation dose. The relatively low cross-linking yields reported for highly unsaturated polymers (rubber, polybutadiene, etc.) by comparison with the measured decay of unsaturation[9,13] suggest that in such cases the main reaction is the formation of internal links by process (*c*) within the polymer chains aided by the coiled configuration of the molecule in the amorphous state[14]; in this connexion it is noteworthy that Roberts and Mandelkern[15] have observed that the cross-linking of rubber is much increased if the irradiation is carried out on the highly oriented polymer whereas for polyethylene the cross-linking is greater in the liquid state[4,7].

T. F. Williams

Chemistry Division,
Atomic Energy Research Establishment,
Harwell, Berkshire.

[1] Dole, M., Report of the fourth symposium on "Chemistry and Physics of Radiation Dosimetry", Army Chemical Centre, Maryland, 112 (1950).

[2] Charlesby, A., *Proc. Roy. Soc.*, A, **215**, 187 (1952).

[3] Charlesby, A., and Swallow, A. J., "Ann. Rev. Phys. Chem.", **10**, 305 (1959).

[4] Williams, T. F., and Dole, M., *J. Amer. Chem. Soc.*, **81**, 2919 (1959).

[5] Stevenson, D. P., *J. Phys. Chem.*, **61**, 1453 (1957).

[6] Weiss, J., *J. Polymer Sci.*, **29**, 425 (1958).

[7] Lawton, E. J., Balwit, J. S., and Powell, R. S., *J. Polymer Sci.*, **32**, 257 (1958).

[8] Dole, M., Milner, D. C., and Williams, T. F., *J. Amer. Chem. Soc.*, **80**, 1580 (1958).

[9] Dole, M., and Williams, T. F., *Disc. Farad. Soc.*, No. 27, 74 (1959).

[10] Black, R. M., and Lyons, B. J., *Proc. Roy. Soc.*, A, **253**, 322 (1959).

[11] Charlesby, A., *J. Polymer Sci.*, **11**, 513 (1953).

[12] Williams, T. F., Ph.D., thesis, University of London (1960).

[13] Kuzminsky, A. S., Nikitina, T. S., Zhuravskaya, E. V., Oksentievich, L. A., Sunitsa, L. L., and Vitushkin, N. I., *P*/2085. Second United Nations Conf. on Peaceful Uses of Atomic Energy, **29**, 258 (1960).

[14] Flory, P. J., "Principles of Polymer Chemistry", Chap. 11, 432 (Cornell Univ. Press, Ithaca, New York, 1953).

[15] Roberts, D. E., and Mandelkern, L., *J. Amer. Chem. Soc.*, **80**, 1289 (1958).

GEOCHEMISTRY

A New Interpretation of the Mullite Problem

The published phase diagrams for the Al_2O_3–SiO_2 system have been many and varied. Bowen and Grieg[1] maintained that mullite of invariable composition $3Al_2O_3.2SiO_2$ (71·8 weight per cent Al_2O_3) is the only stable alumino-silicate found at high temperatures in this system. Several workers have since found homogeneous mullites containing from 75 to as much as 82·6 per cent Al_2O_3, and it is at present generally accepted that continuous mullite solid solutions exist at least over the range $3Al_2O_3.2SiO_2$–$2Al_2O_3.SiO_2$ (71·8–77·3 per cent Al_2O_3). Some investigators also claim the existence of mullites intermediate in composition between sillimanite ($Al_2O_3.SiO_2$) and $3Al_2O_3.2SiO_2$, although continuous solid solution between these compositions has never been authenticated. More recently, the melting behaviour of mullite has been disputed, some workers adhering to Bowen and Grieg's belief that mullite melts incongruently, whereas others maintain that no decomposition into corundum and liquid occurs during melting, and that therefore mullite melts congruently.

Recently it has become possible to observe the behaviour of melts directly by hot-stage microscopy, instead of having to rely solely on the indirect techniques of quenching or thermal analysis used by previous investigators. The application of this new technique to a study of the Al_2O_3–SiO_2 system appears to have resolved some of the outstanding questions, particularly in regard to the melting behaviour and constitution of mullite. Briefly, direct observations have been made on $3Al_2O_3.2SiO_2$ compositions near the liquidus temperature which show repeatedly that corundum crystals, whether present in the starting material or obtained by appropriate undercooling of the melt, are entirely dissolved by the liquid in the presence of residual mullite. The survival of corundum has been observed only when prolonged heating has caused the melt composition to change through volatilization of silica, or when the temperature of the melt has been increased without regard to the much slower rate at which corundum dissolves as compared with mullite.

These observations therefore support the view that the $3Al_2O_3.2SiO_2$ composition, under conditions of equilibrium, does not form corundum during melting; the corollary, that mullite melts congruently, is also disproved, however, by the following observations. Heated melts of $3Al_2O_3.2SiO_2$ composition tend to lose silica by volatilization. Despite this tendency, such melts contain an appreciable amount of siliceous residual glass after mullite single crystals have been grown from them on the microscope hot-stage. The inference that these mullite single crystals must be more aluminous than the parent composition has been checked by chemical separation and analysis. Such crystals were found to contain 77·2 per cent Al_2O_3 (cf. $2Al_2O_3.SiO_2 \equiv 77·3$ per cent and $3Al_2O_3.2SiO_2 \equiv 71·8$ per cent Al_2O_3). Refractive indices of these crystals measured in sodium light gave $N_\alpha = 1·638$, $N_\gamma = 1·653$. Identical indices were reported by Wright[2] for crystals obtained by fusion of an $Al_2O_3.SiO_2$ composition, and the same figures have been quoted by Larsen and Berman[3] for 'artificial mullite'. Different heat treatments have been used to prepare mullites the analysed Al_2O_3

contents of which have ranged from 79·5 down to 75 per cent, the median being represented approximately by $2Al_2O_3.SiO_2$ (77·3 per cent). The refractive index measurements show an apparently linear relation with composition as shown in Fig. 1. From this diagram the supposedly constant refractive indices of mullite reported by Bowen and Grieg[1] could in fact represent mullites containing some 75–77 per cent Al_2O_3, if allowance is made for the stated accuracy of their measurements ($N_\alpha = 1·642$, $N_\gamma = 1·654$ ($\pm 0·003$)).

The mullite containing the least amount of Al_2O_3 (75 per cent) was crystallized from a $CaO–Al_2O_3–SiO_2$ melt over the temperature-interval 1,550–1,500° C., that is, at a temperature below the reported solidus for the system $Al_2O_3–SiO_2$. It is probable, therefore, that the mullites the optical properties of which have been described by other investigators lie much closer in composition to $2Al_2O_3.SiO_2$ than $3Al_2O_3.2SiO_2$, and that the synthesis of true $3Al_2O_3.2SiO_2$ is only likely to be successful at temperatures well below the $Al_2O_3–SiO_2$ solidus.

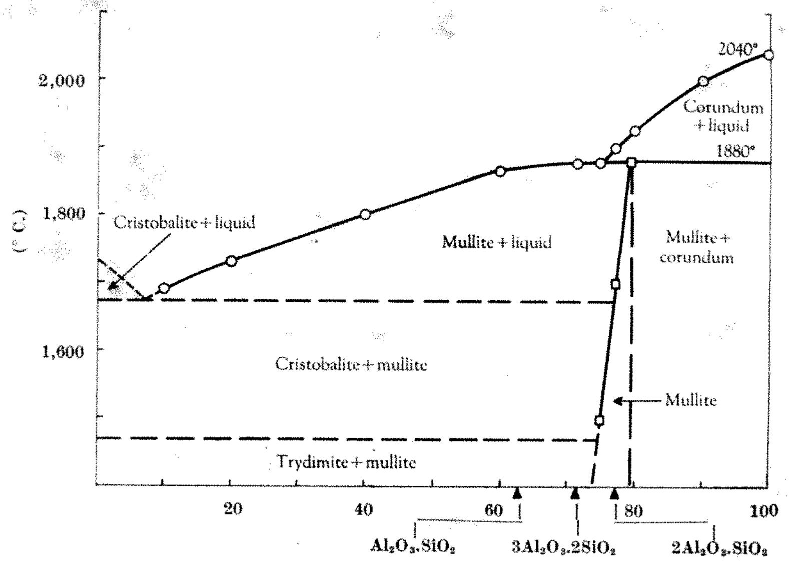


Fig. 2. Redetermined equilibrium diagram for Al_2O_3—SiO_2

During the investigation some unusual forms of mullite were encountered. Seen under the microscope, these appeared to be almost or completely homogeneous, and they were characterized by lowered refractive index, birefringence, and $2V$ as compared with normal mullites. They occurred in rapidly cooled melts of more siliceous composition than $3Al_2O_3.2SiO_2$, and are attributed to the almost or completely sub-microscopic intergrowth of mullite and glass. It is hoped to obtain confirmation of this theory by X-ray examination, because a mixed phase of this type apparently cannot be differentiated by optical or chemical methods.

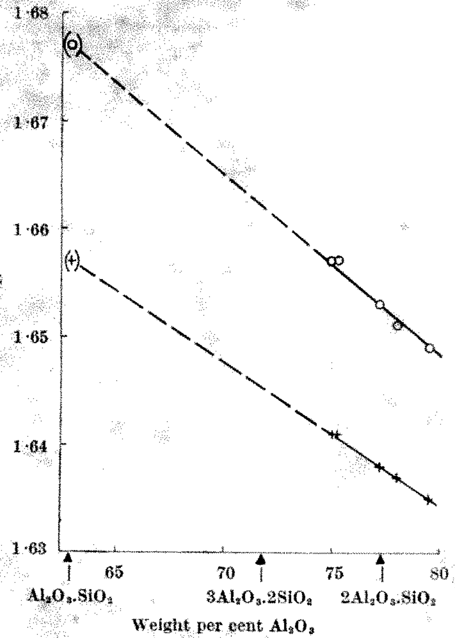


Fig. 1. Variation of refractive index with mullite composition

Liquidus temperatures have been determined by hot-stage microscopy for a major part of the $Al_2O_3–SiO_2$ system, as shown in Fig. 2. The mullite primary phase region, including the composition $3Al_2O_3.2SiO_2$ which has no special significance, ends at about 75 per cent Al_2O_3, where mullite is transformed peritectically to a mixture of corundum and liquid at 1,880° C.

A detailed account of this work is being presented at the Seventh International Ceramic Congress, London, in May.

J. H. WELCH

Building Research Station,
Garston, Watford, Herts.

---

[1] Bowen, N. L., and Grieg, J. W., *J. Amer. Ceram. Soc.*, **7**, 238 (1924).

[2] Shepherd, E. S., Rankin, G. A., and Wright, F. E., *Amer. J. Sci.*, **28**, 293 (1909).

[3] Larsen, E. S., and Berman, H., Bull. 848, "The Microscopic Determination of the Nonopaque Minerals", 2nd ed. (U.S. Gov. Printing Office, Washington, 1934).

CHEMISTRY

Reaction of Active Nitrogen with Polyethylene

THE nature of active nitrogen, the mechanism of its afterglow[1], and its gas phase reactions with organic molecules[2] have been discussed. I have now investigated a heterogeneous active nitrogen reaction at a polymer surface.

'Marlex-50' polyethylene was chosen as the polymer because it has a simple, well-defined structure. It is a high-density, unbranched, highly crystalline polyethylene with polymer chains terminating in one methyl and one vinyl group. Thin sheets of this material were exposed in a flow system to active nitrogen, which was produced by a condensed discharge. Reactions proceeded for periods up to 2 hr. at a pressure of 1·9 mm. mercury, and at temperatures between 39° and 120° C. Condensable products were trapped and analysed quantitatively by vapour phase chromatography and infra-red spectroscopy. The latter was also used to determine the concentration of vinyl bonds in the polymer. Solubility tests established the extent of cross-linking. The concentration of active nitrogen was obtained from the intensity of the afterglow, which was calibrated by the titration reaction of active nitrogen with nitric oxide[3]. The results of a typical experiment are given in Table 1. The activation energies of the various experimentally determined processes and their probable errors are listed in Table 2.

Table 1. TYPICAL REACTION OF ACTIVE NITROGEN WITH POLYETHYLENE

	Product formation :
Temperature, 89° C.	Hydrogen cyanide, 84 per cent
Duration, 60 min.	Cyanogen, 16 per cent
Flow of molecular nitrogen, 610 ml./min.	Total nitrogen equivalent, 60·0 μlitre
	Gel formation, 7·1 per cent
Flow of active (atomic) nitrogen, 14·2 ml./min.	Vinyl decrease, 24 per cent
Conversion, $N_2 \rightarrow 2N$, 1·1 per cent	
Conversion $N \rightarrow N$ equivalent, $0·9 \times 10^{-2}$ per cent	

Table 2. ACTIVATION ENERGIES (IN KCAL./MOLE)

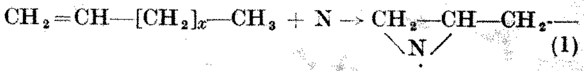
Hydrogen cyanide formation	3·0 ± 0·5
Cyanogen formation	1·9 ± 0·7
Formation of total nitrogen equivalent	2·5 ± 0·6
Vinyl decrease	3·1 ± 1·2
Cross-linking (gel formation)	6·3 ± 1·9

The condensable gas products, the quantity of which varied from 20 to 80 μlitres, contained about 80 per cent hydrogen cyanide, 20 per cent cyanogen, and only traces of ammonia. No derivatives of hydrocarbon fragments were found. Previous reactions of hydrocarbon with active nitrogen in the gas phase gave a maximum formation of 2 per cent cyanogen. In the present less-reactive polyethylene system, the concentrations of hydrocarbon fragments and hydrogen atoms were much smaller than in the comparable gas-phase reaction. The polymer chains were broken but were not fragmented too extensively, and many of the hydrogen atoms were consumed in the process of cross-linking by hydrogen abstraction. Thus, relatively more CN radicals were available for the formation of cyanogen. This also indicated that the CN radical is an important precursor of secondary products in the gas reaction. All C=C double bonds are convenient sites for addition of nitrogen. In 'Marlex-50', 95 per cent of the double bonds are vinyl groups[4], which may initiate a mechanism of chain-unzipping. The remaining 5 per cent of double bonds are vinylene and vinylidene groups, addition to which may lead to scission of the chains. Chain fragments, in turn, will unzip or cross-link.

Up to 10 per cent of the polyethylene was cross-linked by the active-nitrogen reaction. Weight losses amounted to less than 1 per cent. Hence the extent of cross-linking indicated that the reaction was propagated below the surface, either by nitrogen atoms, hydrogen atoms, or free radicals. A mechanism of diffusion would be a reasonable explanation for this observation.

There is a parallelism between reactions due to active nitrogen and those induced by radiation because the physical and chemical properties of a polymer after the nitrogen reaction resemble those after a mild treatment with radiation. Hence, the results of the present investigation can be interpreted by combining the unified mechanism of active nitrogen reactions[2] with established mechanisms of polymer reactions in radiation[5].

(1) *Formation of nitrogen complex.* In the primary process a nitrogen atom can form one of three reaction complexes, at either end of the polyethylene ('Marlex-50') chain or within the chain ; for example :



$$CH_2{=}CH{-}[CH_2]_x{-}CH_3 + N \rightarrow \underbrace{CH_2{-}CH}_{\dot{N}}{-}CH_2{-} \qquad (1)$$

(2) *Formation of nitrogen-containing compound or radical.* Attack on the double bond may be slightly favoured, but all three cases are energetically favourable. The nitrogen atom will attack the C—C bond, rather than the C—H bond and this will lead to splitting-off of either the CN radical, or hydrogen cyanide and hydrogen atoms. The products of reaction 1 may be a new vinyl bond (chain-unzipping) or a chain terminating in a free radical.

$$(1) \rightarrow HCN + H \text{ (or } CN + 2H) + CH_2{=}CH{-} \text{ (chain-unzipping)}$$

or

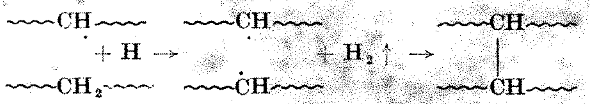
$$(1) \rightarrow HCN \text{ (or } CN + H) + .CH_2{-}CH_2{-} \text{ (free radical chain-termination)}$$

(3) *Hydrogen abstraction from polyethylene chain.* Hydrogen is not directly abstracted by nitrogen atoms. This is made possible, however, by the action of the hydrogen atoms liberated in the formation of free radicals :

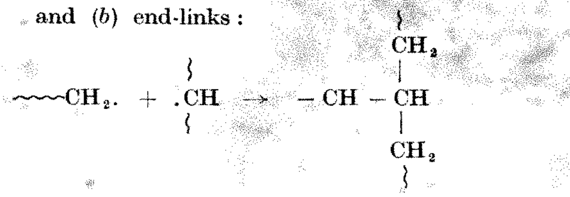
$$-CH_2{-}CH_2{-}CH_2{-} + H \rightarrow -CH_2{-}\underset{\cdot}{CH}{-}CH_2{-} + H_2$$

Cross-linking requires the existence of the radical $-CH_2{-}\underset{\cdot}{CH}{-}CH_2{-}$, because chain ends, such as $.CH_2{-}CH_2{-}$, could only couple or unzip. The evidence of cross-linking in depth as shown by gel tests, together with the larger activation energy of cross-linking, points to diffusion of nitrogen (and hydrogen) atoms into the polymer. With free radical chains of two types present, $-CH_2{-}\underset{\cdot}{CH}{-}CH_2{-}$ and $.CH_2{-}$, two mechanisms of cross-linking are possible :

(*a*) Cross-links of neighbouring chains :



and (*b*) end-links :



I am grateful to my colleagues at the General Electric Research Laboratory for advice and assistance in the course of this work. Special thanks are due to Dr. H. A. Dewhurst for valuable discussions and his continued interest.

J. L. WEININGER

Dielectric Studies Unit,
Physical Chemistry Section,
General Electric Research Laboratory,
Schenectady, New York.

---

[1] Jennings, K. R., and Linnett, J. W., *Quart. Rev. Chem. Soc.*, **12**, 116 (1958).

[2] Evans, H. G. V., Freeman, G. R., and Winkler, C. A., *Can. J. Chem.*, **34**, 1271 (1956).

[3] Harteck, P., Reeves, R. R., and Manella, G., *J. Chem. Phys.*, **29**, 608 (1958).

[4] Smith, D. C., *Indust. Eng. Chem.*, **48**, 1161 (1956).

[5] Miller, A. A., Lawton, E. J., and Balwit, J. S., *J. Phys. Chem.*, **60**, 599 (1956).

Broadening of the Water Proton Line in High-Resolution Nuclear Magnetic Resonance Spectra of Starch Gels

Reports in the literature of measurements of proton magnetic resonance absorption for starch–water systems have been confined to dilute solutions[1], to starch suspensions in water[2] and to native starch granules containing up to 15 per cent water of crystallization[3]. In this communication we are reporting measurements made on suspensions containing 8 per cent–40 per cent starch and on the gels made by heating these suspensions at 80°. These results are the first to be recorded on starch-gels, and from the broadening of the water line on gelation we have postulated that the effect of hydration on the nuclear magnetic resonance band extends considerably beyond the water which is directly hydrogen bonded on to the starch hydroxyls.

At temperatures between 20° and 50° C. water is absorbed into the amorphous regions of the granules, which swell about 30 per cent by volume[4]. The crystallites remain largely intact, but on heating the suspension at a temperature above 60° some of the crystallites are disrupted, and the granules can swell to about 10 times their original volume if there is sufficient water available. Provided the starch concentration is sufficiently high (usually about 12 per cent with wheat starch) the swollen particles adhere together to form a coherent gel. All the mixtures used in these experiments formed a coherent gel at 80°, apart from the 8 per cent suspension which on heating formed an aqueous suspension of swollen granules.

The nuclear magnetic resonance spectra were obtained on the prototype of the Fairey spectrometer. This comprises a permanent magnet with 4-in. diameter pole faces, a gap of 0·72 in. giving a field of approximately 3,800 gauss at which the ^{1}H frequency is 16·1 Mc./s. The samples were contained in soda glass tubes of 5·2 mm. outside diameter and approximately 3 mm. inside diameter. Sample spinning at 3,000 r.p.m. was employed and a resolution of 1 part in 10^7 was attained under these conditions. All measurements were made at 35° C. The gels were made by heating the suspensions in the soda-glass tubes for 10 min. at 80°. The gels were then equilibrated for 15 min. in the nuclear magnetic resonance spectrometer at 35° C. before measurements were made.

Symmetrical gaussian curves were obtained at all concentrations, and their widths were measured at half-peak heights.

In all these suspensions and gels the proton magnetic resonance consists of a narrow line (0·4–1·35 p.p.m. wide) due to protons in the water, superimposed on a very broad band (> 1,000 p.p.m.) due to protons on the starch. The measurements made all refer to the water line.

Table 1

Starch (per cent)	Line width (p.p.m.) Suspension	Gel
0	0·4 (pure water)	
8·2	0·45	0·45
15·0	0·45	0·61
25·8	0·43	1·06
25·8*	0·41	1·31
25·8†	0·45	0·68
40·1	1·35	1·12

* Wheat starch in 1 per cent sodium dodecyl sulphate.
† Waxy maize starch (100 per cent amylopectin) in water.
The remaining samples are wheat starch in water.

The suspensions containing up to 26 per cent starch showed a band of similar width to pure water, confirming the results of Shaw and Elsken[2].

However, on gelling there was a marked broadening which increased with increased starch concentration.

Broadening in this type of system could be due to three possible causes: (*a*) A decrease in the spin lattice relaxation time (T_1) as a result of an increase in the micro-viscosity of the water[5]. In gels this is generally of the same order as the viscosity of pure water, and must of course be distinguished from the bulk viscosity of the gel, which is very much higher than that of water. (*b*) Exchange between protons in liquid water and those in hydrate complexes, as proposed, for example, in octylamine–water mixtures[6] and in aqueous solutions of aluminium chloride[7]. (*c*) Exchange between water protons and starch hydroxyl protons.

In these mixtures the ratio of starch to water hydroxyl groups is too low to have much effect and the broadening is probably due largely to the extra binding of water into a four co-ordinated water lattice. This will increase the water line width due to factors (*a*) and (*b*). Pure water at 35° C. contains scarcely any molecules in this compact state; but there are several examples of hydrated macromolecules increasing the order of the water lattice[8], and in fact this explanation has been proposed to explain the broadening of the nuclear magnetic resonance water band in aqueous solutions of deoxyribonucleic acid[1].

The four co-ordinated water lattice is nucleated from water directly hydrogen bonded on to the starch hydroxyls and extends beyond the immediate neighbourhood of the starch. It is clear that the line width will increase with increased hydration, and hence it is not surprising that a broadening occurs on gelation. The broadening is greater in gels containing sodium dodecyl sulphate, which is known to increase starch swelling[9] at 80°.

The band-width depends partly on the amount of water which is bound into the more highly ordered lattice and also to some extent on the mobility of the macromolecule from which the water lattice is nucleated. In this connexion it is significant that the line width of a gel containing 26 per cent of waxy maize starch (100 per cent amylopectin) is considerably lower than that of the corresponding wheat starch gel. Waxy maize starch has less tendency to crystallize due to the higher proportion of branched-chain molecules. This will affect the line width in two opposing ways. Increased hydration will tend to broaden the water line, but this is more than offset by the increased mobility of the macromolecules.

The 40 per cent suspension, unlike the more dilute suspensions, gave a broader line than pure water. Presumably at this high concentration there are sufficient hydroxyls in the granules available for hydration to increase the structure of most of the water since there was no narrow 'free water' line superimposed on the broader line. On gelation there was actually a decrease in line width. This can be attributed to the increased mobility of the macromolecules in the gel, which is in agreement with results obtained from elasticity measurements[9].

In conclusion we can say that the width of the water line in starch gels and suspensions depends partly on the degree of hydration, which governs the number of molecules in a more highly ordered lattice than normally prevails in pure water, and partly on the mobility of the macromolecules on which the water is solvated. At the lower starch concentrations the most important change on gelling is an increase in hydration due to the swelling of the granules. At the high concentration any effect on gelation due to increased hydration is more than offset by the increased mobility of the macromolecules, which causes a narrowing of the water band.

ROGER COLLISON

British Baking Industries Research Association,
Chorleywood,
Herts.

M. P. McDONALD

Fairey Aviation, Limited,
Heston Division,
Hounslow,
Middx.

---

[1] Jacobson, B., Anderson, W. A., and Arnold, J. T., *Nature*, **173**, 772 (1954).

[2] Shaw, T. M., and Elsken, R. H., *Anal. Chem.*, **27**, 1983 (1955).

[3] Shaw, T. M., and Elsken, R. H., *J. Chem. Phys.*, **21**, 656 (1953).

[4] Sandstedt, R. M., *Cereal Chem.*, **32**, Supp. (1955).

[5] Bloembergen, N., Purcell, E. M., and Pound, R. V., *Phys. Rev.*, **73**, 679 (1948).

[6] McDonald, M. P., *Arch. Sci.*, **12**, 141 (1959).

[7] Shoolery, J. N., and Alder, B. J., *J. Chem. Phys.*, **23**, 805 (1955).

[8] Klotz, I. V., and Luborsky, S. W., *J. Amer. Chem. Soc.*, **81**, 5119 (1959).

[9] Collison, R., Campbell, J. D., and Elton, G. A. H., *J. Colloid Sci.* (in the press); *Chem. and Indust.* (in the press).

The 'Irving–Williams' Order in the Metal-ligand Stretching Frequencies of Some Metal Hydrazine Complexes

MANY infra-red spectra of metal complexes have been examined in the 2–15μ region, but until now very few co-ordination compounds have been studied in the cæsium bromide region in which some metal-ligand atom-stretching frequencies are expected[1]. Furthermore, no correlation between the frequency of this vibration and the nature of the metal has been found[2].

We have measured the infra-red absorption spectra in the 15–35μ zone of the hydrazine complexes of the 3*d* sub-group metals of the general formula $M(N_2H_4)_2Cl_2$. The two bands in the 660–518 and 440–343 cm.$^{-1}$ regions have been assigned to the N_2H_4 rocking and to the M—N stretching vibrations, respectively. The sequence of these frequencies agrees closely with the 'Irving–Williams' order of the stability of bivalent metal complexes: manganese < iron < cobalt < nickel < copper > zinc (ref. 3).

In Table 1 the observed infra-red frequencies are recorded.

It is interesting to compare such frequencies with the strengths of the M—N bonds in complexes having four such co-ordinate links. As a measure of the bond energy, the heats of formation in aqueous solution of the *bis*-ethylenediamine metal ions, $M(\mathrm{en})_2^{2+}$ (ref. 4), have been used (Fig. 1). The M—N stretching and the N_2H_4 rocking frequencies plotted against the ΔH_{1-2} values lie on two straight lines.

Table 1. N_2H_4 ROCKING AND M—N STRETCHING FREQUENCIES FOR $M(N_2H_4)_2Cl_2$ COMPLEXES

Mn++	Fe++	Co++	Ni++	Cu++	Zn++		Type of vibration
518	554	582	613	660	580	cm.$^{-1}$	N_2H_4 rocking
343	369	388	409	440	385	cm.$^{-1}$	M—N stretching

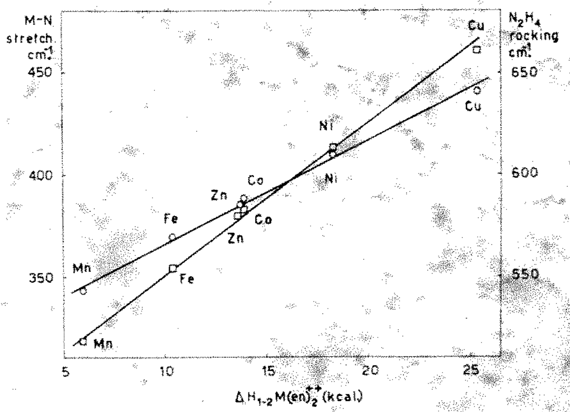


Fig. 1. Graph of the N_2H_4 rocking (□) and M—N stretching (○) frequencies versus the heats of formation of $M(\mathrm{en})_2^{2+}$ complex ions

L. SACCONI
A. SABATINI

Institute of General Chemistry,
University of Palermo.
March 3.

---

[1] Bertin, Nagagawa, Mizushima, Lane and Quagliano, *J. Amer. Chem. Soc.*, **80**, 525 (1958).

[2] Barrow, Krueger and Basolo, *J. Inorg. Nuclear Chem.*, **2**, 340 (1956). Cf. Cotton, "The Infrared Spectra of Transitional Metal Complexes", in Lewis and Wilkins, "Modern Co-ordination Chemistry" (Interscience Pub., Inc., New York, 1960).

[3] Irving and Williams, *J. Chem. Soc.*, 3192 (1953).

[4] Ciampolini, Paoletti and Sacconi (unpublished work). Poulsen and Bjerrum, *Acta Chem. Scand.*, **9**, 1407 (1955).

Analogy to the Kirkendall Effect in the Gas Phase

THE Kirkendall effect[1] was first observed as a movement of fine molybdenum wire markers in a contact plane between brass and copper during interdiffusion. If diffusion occurs by a random walk movement of individual atoms, then, no matter what theory is employed for their detailed motion, it is difficult to see how it could produce movement of markers. Darken[2] considered that diffusion of copper and zinc occurred in opposite directions, at independent rates, and that the difference was compensated by a 'bulk flow'. If it fails to occur, voids are left behind by the more rapidly moving component, and this result of diffusion in metals has in fact been observed[3].

The concepts used by Darken were also developed by Hartley and Crank[4] for liquids, and their consequences have recently been studied in this Laboratory[5]. Lately, however, Adamson[6] failed to observe the Kirkendall effect in liquids, using colloidal particles as markers in sucrose solutions. Now, as Darken's concepts do not depend upon mechanism, they should be equally applicable to solids, liquids and gases[7], and we decided therefore to find if the Kirkendall effect could be demonstrated in gases.

A Loschmitt cell was used consisting of two glass cylinders (4 in. diameter, 7 in. length) which were sealed into two circular plane steel plates. By turning one plate over the other, the gases formed a diffusion boundary of sufficiently large area to make wall effects negligible. The gases used were CF_2Cl_2 and hydrogen, to give widely different diffusion-rates. As marker, ammonium chloride smoke was used, formed by adding about 1 per cent hydrochloric acid to CF_2Cl_2 in the lower cylinder and 1 per cent ammonium to hydrogen. Fig. 1 shows photographs of the movement of the smoke, together with a stopwatch to indicate the elapsed time. It is considered that these provide evidence for the Kirkendall effect in gases. Hydrogen diffuses rapidly into the lower cylinder, and the resulting increase of pressure causes an upward bulk flow of the gas from this cylinder, carrying the smoke particles with it. The cloud does not move as a thin layer, since it consists of particles of various sizes which are settling under gravity. Some even fall almost at once into the lower cylinder and form a faint cloud there. In the following, only the movement of the finest particles at the top boundary of the cloud will be considered. No upward movement of a smoke formed at the boundary was observed when both cylinders contained CF_2Cl_2, with the same concentrations of hydrochloric acid and ammonia as before. A cloud formed in the lower cylinder as before due to larger particles falling rapidly, but the top of the cloud was sharp and settled with a slow, uniform velocity.

Some approximate calculations indicated that the rate of movement of the boundary was of the correct order. If the intrinsic diffusion coefficients of hydrogen and CF_2Cl_2, respectively, are denoted by D_A and D_B, Darken showed that, if N_A is the mole fraction of A in the boundary, and v is the rate at which the boundary is moved by bulk flow :

$$v = (D_A - D_B)\,\frac{\partial N_A}{\partial x}$$

For cylinders of infinite length :

$$\frac{\partial N_A}{\partial x} = \frac{N_{OA}}{2}\,\frac{1}{\sqrt{\pi D_{AB} t}}$$

where N_{OA} = initial value of hydrogen = 1, and D_{AB} = interdiffusion coefficient.

Thus, if x_m equals shift of boundary in time t:

$$x_m = \int_0^t v\,\mathrm{d}t = \frac{(D_A - D_B)}{\sqrt{\pi D_{AB}}}\cdot\sqrt{t}$$

The value of D_{AB} has been shown in this laboratory to be about 0·4 cm.²/sec., and it can readily be proved that, for this value, the assumption of infinite length for the cylinders is approximately valid up to $t = 200$ sec. Assuming that movement of the boundary is given by the surface of the smoke cloud, it can be seen in Fig. 2 that x_m versus $\sqrt{t}$ gives a reasonably straight line. From its gradient, a value of $(D_A - D_B) \simeq 0\cdot43$ was obtained. This is probably low, since the cloud was sedimenting. A correction was attempted by measuring the rate of sedimentation at the end of the experiment and using this to calculate the distance it would fall in time t. The corrected values in Fig. 2 show an upward curvature from a straight line, indicating an over-correction, as would be expected if particles were coarser when sedimentation was measured than when first formed in the early stages of a diffusion experiment. The gradient at the lower part of the corrected curve corresponds to $(D_A - D_B) \simeq 0\cdot63$.

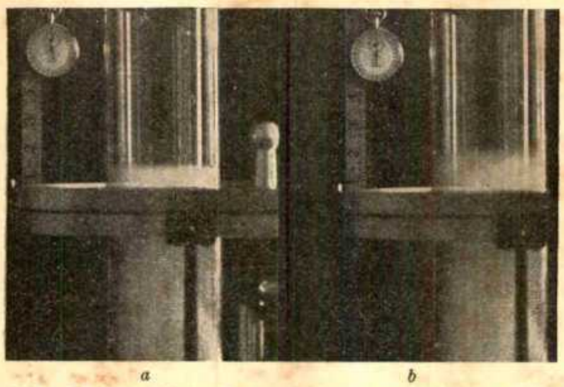


Fig. 1. Position of the smoke stream after 59 sec. (*a*) and 150 sec. (*b*)

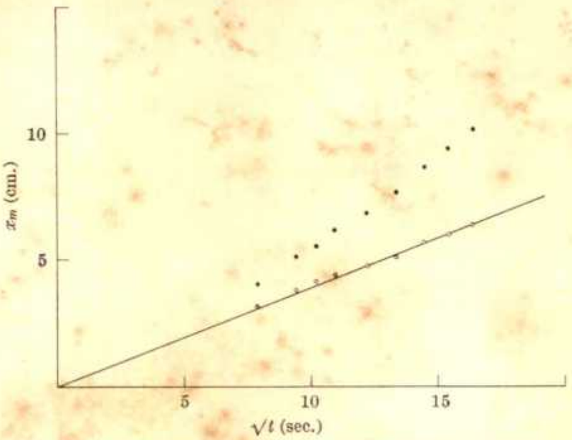


Fig. 2. Upward movement of the smoke boundary. ○, Uncorrected position ; ●, corrected position

Values of D_A and D_B have not been measured, but the self-diffusion coefficient for hydrogen is about 1·3 cm.²/sec. and a value of about 0·04 cm.²/sec. can be calculated for CF_2Cl_2[8]. For gases, the intrinsic diffusion coefficient of a component equals its self-diffusion coefficient[7], and the difference of the self-diffusion coefficients of components in a 50 per cent mixture, corresponding to the diffusion boundary, should be about half the difference for the two pure gases, that is, about 0·7 cm.²/sec. Within the limitations of the experiment, therefore, the agreement is reasonably good.

Though the observed motion of smoke particles supports the concept of a bulk flow as part of an interdiffusion process, Waldmann[9] has put forward a theory for such motion which does not require the assumption of a bulk flow. Parameters to apply his equation quantitatively are not available, but it would seem that his effect should be of a similar order to that given by Darken's equation.

L. MILLER
P. C. CARMAN

National Chemical Research Laboratory,
South African Council for
Scientific and Industrial Research,
Pretoria.

[1] Smigelskas, A. D., and Kirkendall, E. D., *Metals Technol.*, **13**. Tech. Pub., 2071 (1946).
[2] Darken, L. S., *Trans. A.I.M.E.*, **175**, 184 (1948).
[3] Seith, W., and Kottmann, A., *Naturwiss.*, **39**, 41 (1952); Proc. Internat. Symp. on Reactivity of Solids, 63 (Gothenburg, 1952).
[4] Hartley, G. S., and Crank, J., *Trans. Farad. Soc.*, **45**, 801 (1949).
[5] Carman, P. C., and Miller, L., *Trans. Farad. Soc.*, **55**, 1831, 1838 (1959).
[6] Adamson, A. W., and Irani, R., *J. Chim. phys.*, **55**, 102 (1958).
[7] Carman, P. C., and Stein, L. H., *Trans. Farad. Soc.*, **52**, 619 (1956).
[8] Miller, G. A., and Bernstein, R. B., *J. Phys. Chem.*, **63**, 710 (1959).
[9] Waldmann, L., *Z. f. Naturf.*, **14**, *a*, 589 (1959).

A Model to account for the Production of Vibrationally Hot Molecules in Free-Radical Reactions

THE application of the flash photolysis technique to the study of the photodecomposition of molecules like ozone[1,2], nitrogen dioxide[3] and chlorine dioxide[3], by Norrish and co-workers, has revealed the occurrence of a very unusual series of reactions of the general type:

$$A + BCD \rightarrow (AB)^* + CD + \text{heat}$$

in which a large proportion of the heat of reaction remains concentrated as vibrational energy in the newly formed bond $A—B$. Table 1 summarizes the known reactions of this type, together with two apparently analogous reactions in which no vibrationally excited AB has been detected.

Table 1

Reaction	Excited molecule produced	Maximum energy of vibration (kcal./mole)
$O + ClO_2 \rightarrow O_2 + ClO$	O_2	34
$O + NO_2 \rightarrow O_2 + NO$	O_2	34
$O + O_3 \rightarrow O_2 + O_2$	O_2	63
$Cl + O_3 \rightarrow ClO + O_2$	ClO	12
$Br + O_3 \rightarrow BrO + O_2$	BrO	8
$H + O_3 \rightarrow HO + O_2$	HO	75
$I + Na_2 \rightarrow NaI + Na$	NaI	?
$O + SO_2 \rightarrow SO + O_2$	none	—
$O + Cl_2O \rightarrow O_2 + Cl_2$	none	—

Up to the time of writing no model has been proposed which could be used either to correlate the experimental evidence tabulated above or to rationalize the 'abnormal' behaviour shown in such reactions[4]. This communication describes the development of such a model.

There are three points of similarity in all the reactions which yield vibrationally excited molecules; it is always the newly formed molecule, AB, which is vibrationally excited; the number of vibrational quanta possessed by AB is always far in excess of that 'allowed' by equipartition and Maxwell–Boltzmann energy distribution restrictions, so that clearly the collisions between the atom A and the molecule BCD must be of a specialized type; the bond-strength $B—C$ is moderate or weak.

In order to correlate these observations, a sequence of events may be suggested, as follows.

(1) The atom A approaches the terminal atom B with such a velocity that when A is finally brought to rest relative to B, the internuclear distance $A—B$ is very short compared with the equilibrium distance in the molecule AB. This requires the existence of some attractive force to overcome the repulsion experienced by non-interacting particles in the systems to which the Maxwell–Boltzmann statistics and equipartition principles apply.

(2) The bond $B—C$ must be weak relative to the newly formed bond $A—B$, so that the dissociation of the intermediate complex $(ABCD) \rightarrow AB + CD$ can occur easily, and so that little of the impact of A on B will be transmitted through to the bond $C—D$.

(3) In consequence, the final products of the 'encounter' will be a molecule AB produced initially in a highly compressed state, that is, vibrationally hot, and a molecule CD, produced vibrationally cold. The greater the attraction between A and B, and the weaker the bond strength $B—C$, the greater will be the proportion of the energy of reaction appearing in the new bond $A—B$.

Examination of Table 1 shows that in all the reactions which yield vibrationally hot molecules, the conditions implicit in the above scheme are operative, that is, attraction between A and B and weakness in the bond $B—C$.

In the first two reactions, both the atoms and the reactant molecules are paramagnetic, so that the probability of electron spin coupling will result in an attractive potential field between the atom and the molecule. The ClO—O and NO—O bond-strengths are both moderate, being about 60 and 72 kcal./mole, respectively.

The most striking feature of the next four reactions is the fact that they all involve the ozone molecule: it would be surprising indeed if this were fortuitous. It is at once obvious that ozone satisfies the requirement of a weak $B—C$ bond, since the $O_2—O$ bond dissociation energy is only 24 kcal./mole. However, since the molecule is diamagnetic it is not immediately obvious that there will be an attraction between the approaching atom and the terminal oxygen atom. In order to overcome this difficulty, it is convenient to consider the ozone molecule from a somewhat inverted point of view, that is, not as a strongly bound molecule in a singlet state, but rather as a weakly bound complex of a triplet oxygen molecule and a triplet oxygen atom. Although the complete system will have singlet multiplicity, at large $O_2—O$ separations the terminal oxygen atom will assume in large measure the character of an unbound ^3P atom. This will be particularly favoured in ozone since the $O_2—O$ bond-strength is so small, and, in consequence, the $O_2—O$ vibrations have a large amplitude. Thus the formation of electron pair bonds between an approaching free atom and the terminal oxygen atom in ozone becomes a possibility; as in NO_2 and ClO_2, this possibility will result in an attractive potential field between the approaching atom and the molecule. The well-known addition of ozone to olefins yielding covalently bound ozonides provides confirmation of its ability to form electron pair bonds.

The production of vibrationally excited sodium iodide following a collision between an iodine atom and a sodium molecule in the gas phase would be especially favoured, since not only is the Na—Na bond-strength extremely weak (17·5 kcal./mole), but also the coulombic attraction between the halogen atom and the alkali metal would be very strong indeed. This is consistent with the observation that sodium iodide is produced possessing nearly all the energy liberated in the reaction[5].

In the last two reactions tabulated, no vibrationally excited species are produced[6,7]. Again, this is consistent with the general scheme proposed, since both Cl_2O and SO_2 are diamagnetic, and at the same time the SO—O and $Cl_2—O$ bond-strengths are large, being about 130 and 100 kcal./mole, respectively. (It will be necessary to break two Cl—O bonds in order to obtain the reaction $O + Cl_2O \rightarrow O_2 + Cl_2$, since in Cl_2O oxygen is the central atom.)

Summarizing, it is apparent that all the reactions tabulated can be understood in terms of the simple collisional model which has been proposed. The comparative rarity of reactions in which the products are vibrationally excited is consistent with the strict requirements necessary for such reactions. On the basis of the model, the reaction $O + ClCO \rightarrow ClO +$

CO should yield vibrationally excited ClO radicals, and experiments are being planned to determine whether or not vibrationally hot ClO is formed.

J. P. Simons

Chemistry Department,
University of Birmingham.

[1] McGrath and Norrish, *Proc. Roy. Soc.*, A, **242**, 265 (1957).
[2] McGrath and Norrish, *Z. phys. Chem.* (Frankfurt), **15**, 245 (1958).
[3] Lipscomb, Norrish and Thrush, *Proc. Roy. Soc.*, A, **233**, 455 (1956).
[4] Norrish, Liversidge Lecture, *Proc. Chem. Soc.*, 247 (1958).
[5] Evans and Polanyi, *Trans. Farad. Soc.*, **35**, 178 (1939).
[6] Oldershaw and Norrish, *Proc. Roy. Soc.*, A, **249**, 498 (1958).
[7] Edgcombe, Norrish and Thrush, *Proc. Roy. Soc.*, A, **243**, 24 (1957).

Electrical and Magnetic Properties of β-Carotene Triiodide

Charge–transfer complexes formed between iodine and condensed ring aromatic hydrocarbons have been studied in some detail recently, most extensively by Akamatu, Inokuchi, Matsunaga and their co-workers[1]. We should like here to point out that iodine also reacts with β-carotene, a non-aromatic hydrocarbon containing eleven conjugated double bonds, to form a compound exhibiting electrical and magnetic properties similar to those of iodine-aromatic charge–transfer complexes. The stoichiometric formula of this compound is $C_{40}H_{56}I_3$; that is, it contains three iodine atoms per β-carotene molecule.

This material was prepared first by Arnaud[2] and later by Willstätter and Mieg[3] in the course of their investigations of the structure of carotene. It is formed by adding crystalline iodine to a concentrated solution of β-carotene in benzene or carbon disulphide. The triiodide, which is precipitated immediately, is washed with diethyl ether and dried in vacuum. The resulting powder has the same physical appearance (red by reflexion, green by transmission) and melting point (137° C.) as reported by Arnaud[2]. Iodine analyses were made on two samples, independently prepared, giving 41·1 and 42·9 per cent iodine (cal.: 41·5 per cent).

Evidently, the triiodide can be prepared only in the way outlined above. If one mixes solutions of iodine and β-carotene, only a slow reaction occurs giving a substance of formula $C_{40}H_{56}I_2$, presumably an iodine addition compound[3].

The samples of $C_{40}H_{56}I_3$ we have prepared all exhibit a strong electron spin resonance absorption consisting of a single line of Gaussian shape with $\Delta H_{p\text{-}p} = 11{\cdot}4$ gauss and $g = 2{\cdot}003$. A comparison of the electron spin resonance intensity of a freshly prepared sample with that of Coppinger's radical[4] indicates a spin density of $7\text{–}15 \times 10^{18}$ cm.$^{-3}$, corresponding to 0·01–0·02 spins per molecule of $C_{40}H_{56}I_3$. The electron spin resonance intensity and line shape show no dependence on temperature from −170° C. to +30° C. The signal intensity decays with time with a half-life of several days for a sample exposed to air; the half-life is several weeks for a sample prepared and stored under nitrogen.

The d.c. electrical conductivity of a powder sample was measured in a high-resistance powder press in which the sample could be compressed until its conductivity no longer increased with further compression. The sample and cell were reassembled several times; the conductivity in no case differed by more than 10 per cent. Fig. 1 illustrates the variation of conductivity with temperature for a sample approximately 24 hr. old. A reasonable fit to these data is obtained using the expression $\sigma = \sigma_0 \exp(-E/kT)$, with $E = 0{\cdot}55 \pm 0{\cdot}5$ eV. and $\sigma\,(25°\,\text{C.}) = 5 \times 10^{-9}$ ohm^{-1} cm.$^{-1}$. All the samples measured exhibit the same value of the quantity E, whereas the quantity σ_0 was observed to vary considerably from sample to sample. The conductivity decays slowly with time in a manner similar to the decay of the electron spin resonance signal intensity.

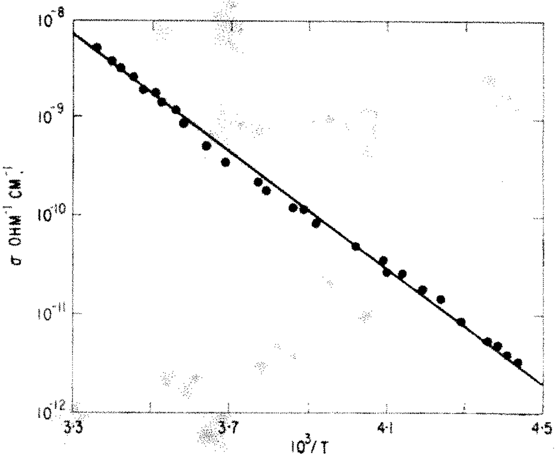


Fig. 1. Variation of electrical conductivity with temperature over the range $T = 225°$ K. to $T = 300°$ K.

Conductivity measurements on powder samples, such as we present here, certainly are open to serious criticism[5]. However, we believe that these measurements have sufficient qualitative significance to establish the complete dissimilarity between the dependence on temperature of the conductivity and that of the electron spin resonance signal intensity in $C_{40}H_{56}I_3$. This result is in marked contrast to that of Singer and Kommandeur for the pyrene–iodine complex[6]. Our observations can be interpreted in two ways: either (1) the electron spin resonance intensity is not a measure of the number of carriers involved in conduction, or (2) the electron spin resonance intensity is a measure of the number of carriers involved in conduction, and since the intensity is independent of temperature, the dependence of the conductivity on temperature arises entirely from the temperature dependence of the carrier mobility.

We have also investigated the visible and ultraviolet spectra of dilute solutions of iodine and β-carotene in chloroform. Intense new bands appear at 2920 and 3600 Å. From a preliminary study of the spectra as a function of solute concentrations, it appears that both bands arise from a chemical species formed in a fairly rapid, reversible reaction between iodine and β-carotene, and that this species is most probably $C_{40}H_{56}I_3$. Unfortunately, this work is complicated by poor stability of the solutions. The bands at 2920 and 3600 Å. disappear in a matter of hours due, presumably, to the competing reaction in which the addition product $C_{40}H_{56}I_2$ is formed.

Dr. Edel Wasserman of the Bell Telephone Laboratories has undertaken a determination of the crystal structure of $C_{40}H_{56}I_3$ by X-ray diffraction[7]. This should clarify considerably the nature of the chemical bonding involved and should determine whether this material can reasonably be described as a charge-transfer complex.

CHARLES M. HUGGINS
OLIVER H. LEBLANC, JUN.

General Electric Co.,
Research Laboratory,
Schenectady,
New York.

[1] For complete references, see Matsunaga, Y., *J. Chem. Phys.*, **30**, 85 (1959).

[2] Arnaud, M. A., *C.R. Acad. Sci., Paris*, **102**, 147 (1886).

[3] Willstätter, R., and Mieg, W., *Ann. Chem. Justus Liebigs*, **355**, 1 (1907).

[4] Coppinger, G. M., *J. Amer. Chem. Soc.*, **79**, 501 (1957).

[5] Garrett, C. G. B., "Semiconductors", edit. by Hanay, H. B., Chap. 15 (Reinhold, 1959).

[6] Singer, L. S., and Kommandeur, J., *Bull. Amer. Phys. Soc.*, Ser. II, **6**, 427 (1959).

[7] Wasserman, E., Solid State Physics Seminar on Thermochromism and Linear Radicals, New York University (December 1959).

BIOCHEMISTRY

Action of a Bacterial Dextranase on Branched Dextrans

SEVERAL mould species[1,2] and strains of Bacteroides[3] have been shown to secrete dextranases which hydrolyse, to different degrees, dextrans of various branched structures. Although glucose, *iso*maltose and *iso*maltotriose[1–3] have been shown to be among the main products of the hydrolysis, no oligosaccharides containing the glucosidic branch linkages have so far been identified in the enzyme hydrolysates. Recently, several rumen strains of an organism, closely resembling *Lactobacillus bifidus*[4], were found to secrete a dextranase which hydrolysed an unbranched *Streptococcus bovis*[5] dextran to a mixture of *iso*malto-triose, -tetraose, -pentaose and -hexaose[6]. The enzyme also hydrolysed a dextran (produced by *Leuconostoc mesenteroides*, Birmingham strain) containing 12–15 per cent of α-1,3-branch links[7] to a mixture of tri- and higher saccharides, which were not examined further. We have now investigated the oligosaccharide mixture produced by the enzyme from this and other branched dextrans.

Solutions were prepared containing dextranase[6] (10 mgm.), purified[7] dextran (30 mgm.), and citrate buffer (0·2 *M*, *p*H 5·5, 5 ml.). A solution of the above composition, containing unbranched *S. bovis* dextran, was used as a control. The solutions were incubated under toluene at 37° C. for 36 hr., after which time there was no further increase in reducing sugars. The final digests were desalted with 'Biodeminrolite', concentrated under reduced pressure to a small volume, and analysed by paper chromatography using the ethyl acetate, pyridine, acetone, water solvent of Malpress and Hytton[8]. Reducing sugars were located with silver nitrate[9]. Intense spots, corresponding to *iso*malto-triose, -tetraose and -pentaose, were present on chromatograms of all the hydrolysed dextrans. In addition, chromatograms of the *Leuconostoc* branched dextran digest showed two minor reducing components moving just in front of *iso*malto-tetraose and -pentaose respectively. These chromatograms also revealed a mass of unresolvable reducing components, $R_G <$ *iso*maltopentaose, which was absent from the control digest. Portions of the two extra oligosaccharides were eluted and hydrolysed in *N* sulphuric acid for 4 hr. at 100° C. The hydrolysates contained a single component which was chromatographically identical to glucose.

Table 1. POSSIBLE OLIGOSACCHARIDES IN ADDITION TO *iso*MALTOTRIOSE— -PENTAOSE DETECTED IN DEXTRANASE–DEXTRAN DIGESTS

Dextran; organism and type of branch link	Fast-moving tetraose	Fast-moving pentaose	Saccharides of $R_G <$ *iso*maltopentaose
(1) *S. bovis*; unbranched (ref. 5)	absent	absent	*iso*malto-hexaose^{+++}, -heptaose^{++}
(2) *L. mesenteroides* (Birmingham); modified, 2 per cent α-1,3- (ref. 9)	trace	trace	*iso*malto-hexaose^{++}, -heptaose^{+}
(3) *L. mesenteroides* (Birmingham); 12–15 per cent α-1,3- (ref. 7)	++	+++	intense unresolved mixture $R_G <$ *iso*maltopentaose
(4) *L. mesenteroides* (N.R.R.L. *B*512); 5 per cent α-1,3- (ref. 10)	trace	trace	possible hexaose^{+++}, heptaose^{+++}, octaose^{++}
(5) *Betabacterium vermiforme*; 5 per cent α-1,3-, 5 per cent α-1,4- (ref. 11)	trace	trace	possible hexaose^{+++}, heptaose^{+++}, octaose^{++}
(6) *Acetobacter capsulatum*; 10 per cent α-1,4- (ref. 12)	absent	absent	possible hexaose^{+++}, heptaose^{+++}, octaose^{++}, nonaose^{+} and unresolved higher saccharides

Gradings allocated on the basis: trace, just visible; +, clearly visible; + + +, definite black spot. Under the conditions used *iso*maltotriose spot = + + + + + +.

The three main components in the digest have been shown, by movement in five solvent systems and reaction with four spray reagents, to be chromatographically identical with *iso*malto-triose, -tetraose and -pentaose, respectively. It seems likely, therefore, that the two extra saccharides contain, in addition to α-1,6-links, the α-1,3-branch links of the original dextran. Their absence from the control digests seems to rule out the possibility that they were formed by an enzymic transferase action on the *iso*maltodextrins produced in the digests. Attempts are now being made to elucidate the structure of these two sugars. As the dextranase has been shown to hydrolyse *iso*malto-heptaose and -octaose, the mass of higher saccharides present in the branched dextran digest probably also contains α-1,3-branch links which prevented their further hydrolysis. Two acid-degraded specimens of the branched *Leuconostoc* dextran, mol. wt. 300,000 and plasma grade, were also treated with dextranase. The same two extra saccharides were detected on chromatograms of the digests at possibly lower concentrations. The three *iso*maltodextrins and the unresolved mixture of $R_G <$ *iso*maltopentaose were also present.

Several other dextrans, the structures of which have been examined by chemical methods, were treated with the dextranase and the hydrolysates examined by paper chromatography. The results, with those already obtained, are listed in Table 1.

It appears that *L. bifidus* dextranase is unable to cleave branching links in dextrans. This is not surprising as the organism was cultured in a medium containing unbranched *S. bovis* dextran. The mixture of saccharides produced seems to depend not only on the type of branching, but also on the degree of branching; compare dextrans Nos. 3 and 4 in which there appears to be a definite difference in the composition of the saccharide mixture of $R_G <$ *iso*maltopentaose. Another dextran, produced by *L. mesenteroides* (N.R.R.L., *B*742) and containing 36 per cent of α-1,3- and α-1,4-links[11], was also treated with the enzyme. This dextran was not hydrolysed by the dextranase, a result which is in agreement with the markedly different serological properties reported[13] for a similarly branched dextran produced by another strain (N.R.R.L.-*B742-LR*) of this organism. The possibility that dextranases produced by *L. bifidus* and other organisms may be of help in establishing the structures of dextrans is being investigated further.

This work was carried out as part of a programme of research supported by the Department of Scientific and Industrial Research and directed by Prof. E. J. Bourne. Thanks are due to Dr. A. E. James, of Glaxo, Ltd. (Barnard Castle), for the gift of the samples of degraded *Leuconostoc* dextran.

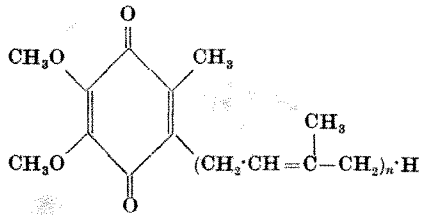
R. W. BAILEY
D. H. HUTSON
H. WEIGEL

Chemistry Department,
Royal Holloway College,
University of London,
Englefield Green, Surrey.

[1] Tsuchiya, H. M., Jeanes, A., Bricker, H. M., and Wilham, C. A., *J. Bact.*, **64**, 513 (1952).
[2] Jeanes, A., Wilham, C. A., Jones, R. W., Tsuchiya, H. M., and Rist, C. E., *J. Amer. Chem. Soc.*, **75**, 5911 (1953).
[3] Sery, T. W., and Hehre, E. J., *J. Bact.*, **71**, 373 (1956).
[4] Clarke, R. T. J., *J. Gen. Microbiol.*, **20**, 549 (1959).
[5] Bailey, R. W., *Biochem. J.*, **71**, 23 (1959).
[6] Bailey, R. W., and Clarke, R. T. J., *Biochem. J.*, **72**, 49 (1959).
[7] Barker, S. A., Bourne, E. J., Bruce, G. T., Neely, W. B., and Stacey, M., *J. Chem. Soc.*, 2395 (1954).
[8] Malpress, F. H., and Hytton, F. E., *Biochem. J.*, **68**, 708 (1958).
[9] Barker, S. A., Bourne, E. J., James, A. E., Neely, W. B., and Stacey, M., *J. Chem. Soc.*, 2096 (1955).
[10] Van Cleve, J. W., Shaefer, W. C., and Rist, C. E., *J. Amer. Chem. Soc.*, **78**, 4435 (1956).
[11] Jeanes, A. R., Haynes, W. C., Wilham, C. A., Rankin, J. C., Melvin, E. A., Austin, M. J., Cluskey, J. E., Fisher, B. E., Tsuchiya, H. M., and Rist, C. E., *J. Amer. Chem. Soc.*, **76**, 5041 (1954).
[12] Barker, S. A., Bourne, E. J., Bruce, G. T., and Stacey, M., *J. Chem. Soc.*, **4414** (1958).
[13] Allen, P. Z., and Kabat, E. A., *J. Amer. Chem. Soc.*, **78**, 1890 (1956).

Ubiquinones and Ubichromenols in the Rat

UBIQUINONE, a naturally occurring quinone of considerable biological interest, was first isolated by Morton *et al.*[1], who found it in many kinds of animal tissue. Lester *et al.*[2] have shown that a series of such quinones exist, and have isolated, from different organisms, five compounds of general formula:



differing from each other by single isoprene units ($n = 10$, 9, 8, 7 and 6). Further studies[3] suggested that ubiquinone 50 ($n = 10$) was the normal quinone in higher mammals, but Rüegg *et al.*[4] have recently shown that rat liver contains ubiquinone 45 ($n = 9$).

By the use of analytical procedures described elsewhere[5], we have now found that the ubiquinone fraction of rat tissues may contain up to six substances. These are the isoprenologues, ubiquinones 50, 45, 40 and 35 and two other quinones, one of which has been tentatively identified as dihydroubiquinone 45 (side-chain reduced), whereas the second is an unsaturated substance of greater molecular weight than ubiquinone 50, and possessing a distinctive ultra-violet spectrum with sharp absorption peaks at 252·5, 259, 267·5 and 271·5 mμ.

The six substances do not usually occur together. Rather, two distinct patterns are found. One, in which only ubiquinones 45, 40 and 35 are present, has so far only been found in the tissues of older rats, more than 12 months of age. The second pattern, in which all or some of the other three compounds occur together with ubiquinone 45, is always observed in younger animals and sometimes in the older ones. In most of the 14 tissues so far studied, ubiquinone 45 is the predominant quinone. Although we do not yet understand the significance of the two quinone patterns, it seems that (at least in rats of our Norwegian hooded strain) they only vary in a quantitative manner from organ to organ. Thus we have never observed ubiquinone 50 in the same pattern as ubiquinone 40 in the tissues of our animals. There may, however, be strain differences, since in rats of another strain, we have seen an occasional mixed pattern containing five quinones (including the unidentified quinone referred to above). Our investigations of the quantitative relationships and the influence of dietary and other factors on these quinone patterns will be reported elsewhere.

The discrepancy between the melting points given by Lester *et al.*[2] for ubiquinones 50 and 45 (49·9° and 45·2°, respectively) and those given by Morton *et al.*[1] for specimens isolated from "different sources" is still unresolved, and it has been suggested[6] that the preparations of Morton *et al.* contained artefacts caused by replacement of methoxyl by ethoxyl groups during the preliminary purification with ethanolic alkali. However, in view of our present findings, it seems possible that, since Morton *et al.* used rat liver as one of their sources, their melting-point data may be sufficiently explained by the likelihood that they were dealing with mixtures.

The recent demonstration by Laidman *et al.*[7] that substance *SC* is a cyclic isomer of ubiquinone 50 (which they have called ubichromenol) suggests a biochemical relationship between the two compounds. We have now found that the mixture of ubiquinones in rat tissues is almost invariably accompanied by a similar mixture of ubichromenols, although—because of chromatographic and identification difficulties—it is not always possible to detect the completely corresponding series. So far, we have tentatively identified ubichromenols 50, 45, 40 and 35 and observed that these substances are only normally present if the preparation contains the corresponding isomeric quinone or mixture of quinones. Thus ubichromenol 50 is not found in preparations that contain the 45–40–35 pattern of quinones. Ubichromenol 45 is usually the main chromenol present, but the patterns can be varied under suitable experimental conditions (these are at present under study).

The ubiquinones were identified by their spectra and paper chromatographic behaviour in comparison with known markers. The ubichromenols and dihydroubiquinone 45 were characterized by their spectra and also their chromatographic behaviour, followed by calculation of R_M values from a series of parameters obtained from model compounds. Dihydroubiquinone 45 was also converted to perhydroubiquinone 45 for identification purposes.

These findings suggest that ubiquinones and ubichromenols may be synthetically connected in biological systems, perhaps through intermediary dihydroquinones. Further work (to be published) confirms this concept and has demonstrated that the synthesis of ubiquinone is, contrary to the findings of other workers[8,9], significantly affected by vitamin E.

A. T. DIPLOCK
E. E. EDWIN
J. GREEN
J. BUNYAN
S. MARCINKIEWICZ

Walton Oaks Experimental Station,
Dorking Road,
Tadworth, Surrey.

[1] Morton, R. A., Wilson, G. M., Lowe, J. S., and Leat, W. M. F., *Chem. and Indust.*, 1649 (1957).

[2] Lester, R. L., Crane, F. L., and Hatefi, Y., *J. Amer. Chem. Soc.*, **80**, 4751 (1958).

[3] Lester, R. L., and Crane, F. L., *J. Biol. Chem.*, **234**, 2169 (1959).

[4] Rüegg, R., Gloor, U., Goel, R. N., Ryser, G., Wiss, O., and Isler, O., *Helv. Chim. Acta*, **42**, 2616 (1959).

[5] Diplock, A. T., Green, J., Edwin, E. E., and Bunyan, J., *Biochem. J.* (in the press).

[6] Linn, B. O., Trenner, N. R., Shunk, C. H., and Folkers, K., *J. Amer. Chem. Soc.*, **81**, 1263 (1959).

[7] Laidman, D. L., Morton, R. A., Paterson, J. Y. F., and Pennock, J. F., *Biochem. J.*, **74**, 541 (1960).

[8] Moore, T., *Nature*, **184**, 607 (1959).

[9] Morton, R. A., and Phillips, W. E. J., *Biochem. J.*, **73**, 427 (1959).

Identification of Isomeric Chondroitin Sulphates

CHONDROITIN SULPHATE occurs in three isomeric forms, *A*, *B* and *C* (see review by Hoffman *et al.*[1]). Mathews[2] has recently found the *pK* values of the carboxyl groups of chondroitin sulphate *A* and chondroitin sulphate *B* to be 3·1 and 3·5–3·6 respectively. In addition the *A* and *B* isomers have very similar electrophoretic mobilities in free solution at *p*H values of 2, 3 and 7. Results for chondroitin sulphate *C* were not given.

This communication describes the results of experiments on the ionophoretic behaviour of the three compounds on paper. Using buffers of varying compositions and *p*H (*p*H 2·3, 5·5, 6·0, 9·0 and 9·5), chondroitin sulphate *C* was found to have a consistently lower mobility of 0·9 times that of either *A* or *B* isomeric forms. The latter was found to have the same mobilities in all the buffers used. Analyses of the chondroitin sulphate *A* and chondroitin sulphate *C* used in these experiments have been reported previously; they contained negligible amounts of protein (0·5 per cent)[3]. Additional preparations of the *A* form were made from bovine nasal septum and were found to have identical ionophoretic mobilities to that isolated from bovine trachea. The *B* form was kindly supplied by Dr. A. Dorfman. When mixtures of the isomers were subjected to ionophoresis, resolution could not be obtained (Fig. 1). Extension of the path of migration from 20 cm. to 28 cm. did not facilitate the separation of mixtures. Depolymerization of chondroitin sulphate *C* by a very brief treatment with testicular hyaluronidase[3] did not alter its mobility relative to chondroitin sulphate *A*. Similar results were obtained when either the sodium or the calcium salts of the *A* and *C* isomers were used. It seems likely that the difference in ionophoretic mobility between the *A* and *C* isomers is related to the position and conformation of the sulphate group. This group is axial in *A* and equatorial in *C*[4].

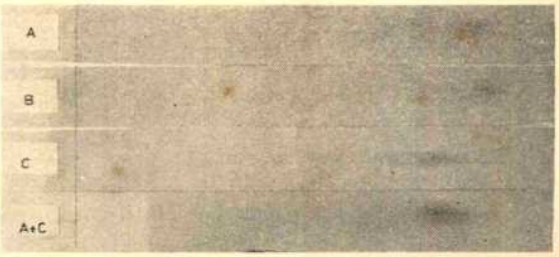


Fig. 1. Paper ionophoresis of chondroitin sulphate *A* (*A*), chondroitin sulphate *B* (*B*), chondroitin sulphate *C* (*C*) and a mixture of isomers *A* and *C* in 0·05 *M* sodium phosphate, *p*H 6·0, at 9·7 V./cm. for 4·5 hr. 2·5 μl. of a 3 per cent w/v solution of each isomer applied to dry paper (Schleicher and Schull 2043*B*). Stained with toluidine blue

It has been shown previously that forms *A* and *C* can be synthesized by a cell-free extract of embryonic chick cartilage[3]. The extract is relatively saturated with chondroitin sulphate *A* and little effect on the incorporation of (sulphur-35) sulphate into chondroitin sulphate resulted when the *A* isomer was added to this extract and the mixture incubated with adenosine triphosphate and (sulphur-35) sulphate. Addition of the *C* isomer, however, caused a marked stimulation of incorporation of sulphate into chondroitin sulphate. A type-specific priming mechanism was evident. By removal of the normal content of acid mucopolysaccharides from the chick cartilage extract by treatment with protamine, the ability to synthesize chondroitin sulphate was lost but was restored by addition of the *A* or *C* forms. Chondroitin sulphate *B*, which does not occur in cartilage[5], could not replace the *A* or *C* isomers but did show some priming power which was perhaps due to small amounts of the *A* or *C* isomers possibly contained in the preparation. Addition of *A* or *C* isomers to the enzyme system treated with protamine should result in synthesis of the corresponding isomer if the type-specific mechanism of priming action is correct[3]. Since the pure isomers *A* and *C* of chondroitin sulphate have different ionophoretic mobilities, it is possible to test this theory. Results of such an experiment are shown in Fig. 2. The (sulphur-35) chond-

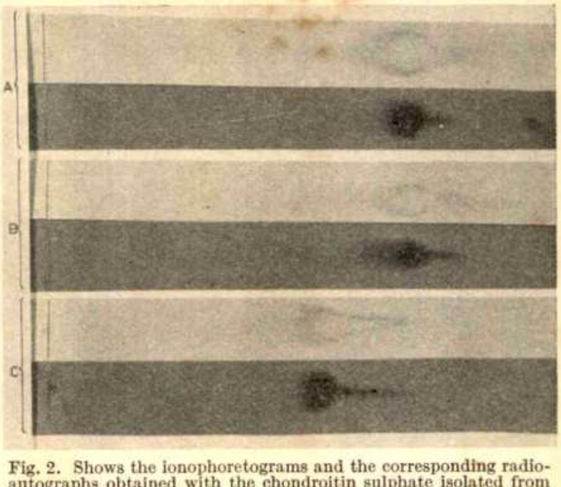


Fig. 2. Shows the ionophoretograms and the corresponding radioautographs obtained with the chondroitin sulphate isolated from normal incubations (ref. 3) in the presence of 10 μc. (sulphur-35) sodium sulphate, 0·4 ml. of protamine-treated chick cartilage extract and 2·1 mgm. of the sodium salts of each chondroitin sulphate isomer. After incubation, the tubes were heated at 100° for 1 min., cooled, centrifuged and the chondroitin sulphate isolated by precipitation with 'Cetavlon' in the presence of sodium sulphate. Each sample was dissolved in 0·5 ml. of 10 per cent w/v sodium chloride and the free chondroitin sulphate precipitated by the addition of alcohol (1·5 vol.). The precipitate was dissolved in 0·1 ml. of water and 10 μl. applied to paper for ionophoresis in 0·025 *M* citrate buffer, *p*H 5·5, at 9·7 V./cm. for 4 hr. The metachromatic zones are more diffuse as compared with Fig. 1, due to the larger amounts of material applied to the paper

roitin sulphate isomer synthesized by the enzyme extract is demonstrated by the radioautographs and these zones correspond to the isomer added to, and isolated from, the incubation mixture as shown by the metachromatic zones. This is conclusive proof for the specificity of the enzyme–substrate relationship.

One consequence of these results is applicable to the study of the types of chondroitin sulphates being actively formed by particular tissues. Rather than attempting to isolate, fractionate and identify the chondroitin sulphates from the relatively large amount of tissue normally required by this procedure, it should be possible to prepare an enzyme extract from small amounts of such tissue, free it of its constituent acid mucopolysaccharides and determine which type or types of chondroitin sulphate are synthesized by observing the effects of addition of the three isomers. Alternatively, to determine whether isomer *A* and/or *C* is synthesized, a crude preparation of the constituent acid mucopolysaccharides can be isolated from the tissue in question and tested with the embryonic chick cartilage extract in the presence and absence of excess amounts of the *A* and *C* isomers. It is intended to apply this type of investigation to the study of stromal elements associated with certain tumours.

J. B. Adams

Special Unit for Investigation and Treatment,
New South Wales State Cancer Council,
Prince of Wales Hospital,
Randwick, New South Wales.

[1] Hoffman, P., Linker, A., and Meyer, K., *Fed. Proc.*, **17**, 1078 (1958).

[2] Mathews, M. B., *Biochim. Biophys. Acta*, **35**, 9 (1959).

[3] Adams, J. B., *Biochem. J.* (in the press).

[4] Orr, S. F. D., *Biochim. Biophys. Acta*, **14**, 173 (1954).

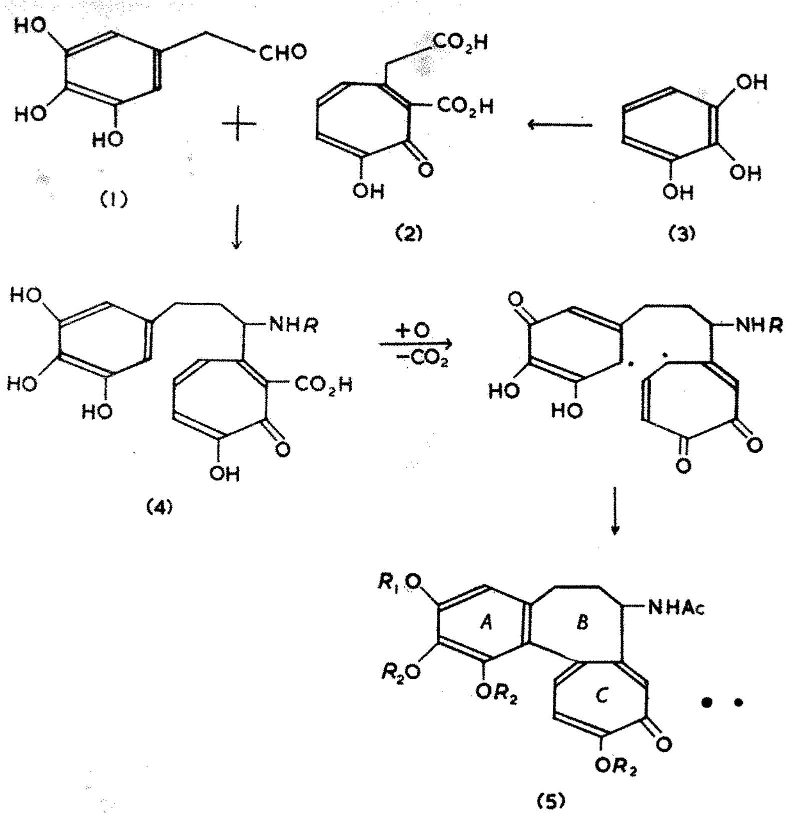
[5] Meyer, K., Davidson, E., Linker, A., and Hoffman, P., *Biochim. Biophys. Acta*, **21**, 506 (1956).

Biosynthesis of Colchicine

Of several proposals[1-4] concerning the biogenesis of the alkaloid colchicine (5 ; $R_1 = R_2 =$ Me), only that of Wenkert[4] involves the intervention of an intact tropolone ring prior to formation of ring *B*.

I now wish to suggest that a radical pairing reaction (4→5) involving one-electron oxidation of a tropolone ring might well represent the crucial stage in the elaboration of the tricyclic system. In support of this view I may mention that radical substitution has been observed in the case of diazotized 5-aminotropolone[5]. Also, the occurrence of partially methylated alkaloids[6,7] in *Colchicum* species (for example, 5 ; $R_1 =$ H ; $R_2 =$ Me) and the unlikely intervention of the $C_6{-}C_1 \rightarrow C_7$ change at aromatic level[4,8] would seem to be in accord with the present proposal.

It may also be conceivable that the genesis of purpurogallin from pyrogallol[3] involves a radical-pairing reaction[9]. The conversion of the former compound to the acid (2) takes place under biochemically acceptable conditions[10]. The biosynthesis of (4) has many possibilities of which only one is suggested herein. Experimental confirmation of this concept is being sought.



A. I. Scott

Chemistry Department,
The University,
Glasgow, W.2.

[1] Erdtman, H., and Wachtmeister, C. A., in "Festschrift Arthur Stoll", 144 (Basel, 1957).

[2] Belleau, B., *Experientia*, **9**, 178 (1953).

[3] Anet, F. A. L., quoted by Sir R. Robinson, *Proc. Roy. Soc.*, A, **206**, 16 (1951).

[4] Wenkert, E., *Experientia*, **15**, 165 (1959).

[5] Nozoe, T., in *Fortschritte Chem. Organ. Naturstoffe*, **13**, 232 (1956).

[6] Bellet, P., Amiard, G., Pesez, M., and Petit, A., *Ann. pharm. Franc.*, **10**, 241 (1952).

[7] Šantavý, F., and Reichstein, T., *Helv. Chim. Acta*, **33**, 1606 (1950), and later papers.

[8] Bentley, R., *Biochim. Biophys. Acta*, **29**, 666 (1958).

[9] Pauson, P. L., *Chem. Rev.*, **55**, 9 (1955).

[10] Critchlow, A., Haworth, R. D., and Pauson, P. L., *J. Chem. Soc.*, 1318 (1951).

Swelling of Fresh and Aged Liver Mitochondria as affected by Succinate, Adenine Nucleotides and Thyroxine

It has been observed previously[1] that isolated mitochondria from primary and transplanted hepatocellular hepatomas, in contrast to their normal counterparts from liver, do not swell to any marked extent in the presence of thyroxine. The increasing evidence[2-4] that both the spontaneous and thyroxine-induced swelling of liver mitochondria is actually dependent upon respiration (that is, when no oxidizable substrate is added, upon endogenous substrate and co-enzymes) has led us to re-examine the effect of thyroxine on the swelling of the tumour particles now incubated in the presence of succinate.

Previous investigators[2,5] reported that several oxidizable substrates, including succinate, markedly and instantaneously accelerated the swelling of fresh liver mitochondria from the rat. However, in our control experiments carried out with freshly isolated (0·3 *M* sucrose) mouse and rat liver mitochondria under similar conditions[2,3], the latter effect, as far as succinate (5×10^{-4} *M*) was concerned, has never been observed. On the contrary, in the suspensions (0·3 *M* sucrose containing 0·02 *M tris* (2-amino-2-hydroxymethylpropane-1 : 3-diol chloride), *p*H 7·4, 22 ± 1° C.) in which spontaneous swelling occurred, succinate prevented the latter completely during at least 40 min. Hereafter the protection changed into a sudden acceleration of the swelling so that in a relatively short time (approximately 20 min.) a decrease of 50 or more per cent in the $O.D._{520}$ ($O.D._{520}$, optical density at 520 mμ) took place. In addition to recording the decreases in $O.D._{520}$ as a measure of swelling, mitochondrial samples were examined under the phase contrast microscope and the fall in $O.D._{520}$ was always found to be accompanied by the typical signs of swelling. Obviously, then, in our hands the swelling of the liver mitochondria in the presence of succinate was conditioned by some 'change' occurring during the incubation at room temperature.

Since direct and indirect evidence[6-8] shows that phosphorylating or mitochondria containing adenosine triphosphate do not swell, it was thought likely, in view of the absence of magnesium and adenine nucleotides from the medium, that the above 'change' was related to the abolition (of one of the intermediate reactions[9]) of oxidative phosphorylation, perhaps as a result of the loss of endogenous adenine nucleotides. If this consideration contained an element of truth, the alleged change might be accelerated by subjecting the mitochondria to ageing[10] and, as long as it was not irreversible, counteracted by the addition of adenine nucleotides in a sufficiently low concentration (10^{-5} *M*) as to make any chelating effect of the latter unlikely. Keeping the mitochondria during 3 hr. at 0° C. in 0·3 *M* sucrose reduced the time of protection afforded by succinate against the spontaneous swelling on subsequent incubation in the 0·3 *M* sucrose–0·02 *M tris* medium to about half the value found for the fresh particles. The outburst of swelling which then set in, and also the later one occurring in the fresh preparations, could be prevented (or at least markedly delayed) by the simultaneous presence of adenosine monophosphate and adenosine triphosphate (10^{-5} *M* each). When, following the 3 hr. at 0° C., the mitochondria had in addition been held in 0·3 *M* sucrose at 37° C. during 10–15 min., succinate momentarily accelerated the swelling and the adenine nucleotides showed scarcely, if any, retarding effect on the latter process. The effects of succinate under the various experimental conditions were always abolished by malonate (10^{-3} *M*), pointing to the paramount role of succinate oxidation in the two kinds of effects, that is, the protection against and the acceleration of swelling.

If, as has been suggested[11,12], the induction of swelling by thyroxine *in vitro* represents an acceleration of a process which the particles are already inherently capable of undergoing spontaneously, it must be possible to counteract the thyroxine-induced swelling by addition of succinate and the adenine nucleotides. The onset of the swelling produced by thyroxine (3×10^{-5} *M*) in fresh mitochondria was indeed significantly delayed (10–15 min.) by succinate and still more by succinate and adenosine monophosphate and adenosine triphosphate (at least another 10 min.). Malonate, again, prevented this effect of succinate. The retardation of the onset of the thyroxine-induced swelling produced by succinate alone or together with the nucleotides was somewhat less pronounced in the suspensions which had been previously kept at 0° C. during 3 hr., but was completely missing in those preparations which had received another incubation at 37° C. during 10–15 min. In fact, the swelling produced by thyroxine in the latter preparations was frequently (not always) largely dependent upon the presence of succinate, which might have been due to the limiting amount of endogenous substrate still present[3]. By contrast, in the fresh and mildly aged mitochondria the extent of swelling ultimately reached in the presence of thyroxine (50 per cent decrease in $O.D._{520}$) was independent of the additions made. In view of the present observations it is of interest that Kaufman and Kaplan[13] have recently reported that, in contrast to the finding of previous investigators[3,14], succinate also inhibited the phosphate-induced swelling of the mitochondria.

The rats and mice used in the above experiments were fed *ad libitum* with the standard laboratory diet. Starvation during 24 hr. prior to the preparation of the mitochondria did not change the results. Rats which had been fed polished rice during several months yielded liver mitochondria of which the onset of swelling on incubation with thyroxine was very markedly retarded by succinate and by succinate plus the nucleotides, sometimes even for 40 and 60 min., respectively.

On account of all criteria set out above, freshly isolated liver mitochondria from rats, which had received an intravenous injection of a hepatoxic dose of the hepatocarcinogen dimethylnitrosamine (100 mgm./kgm. body-weight) 20 hr. earlier, have been found to resemble closely liver mitochondria from normal rats previously aged during 3 hr. at 0° C. followed by 15 min. at 37° C.

In view of the 'change' which has been postulated above as conditioning the swelling of mitochondria, it is of interest that the liver mitochondria from the dimethylnitrosamine-treated animals showed a partly uncoupled oxidative phosphorylation and an increase in adenosine triphosphatase activity, the manifestation of which was for the greater part dependent on magnesium. In the swelling experiments with normal liver mitochondria (fresh or after 3 hr. at 0° C.) several cases have been encountered in which adenosine monophosphate and adenosine triphosphate added in the absence of oxidizable substrate had scarcely, if any, effect on the patterns of the spontaneous and thyroxine-induced swelling (especially in suspensions containing mitochondria which had been kept at 0° C. during 3 hr.), or a smaller effect than when added in conjunction with succinate.

It may therefore be concluded that the process which prevented the entry of water into the mitochondria was dependent upon added oxidizable substrate and adenine nucleotides (as distinct from the situation in which a high concentration of adenosine triphosphate added singly may prevent or reverse swelling[9,14]), thus pointing to a role of oxidative phosphorylation[7,8] in the maintenance of mitochondrial structure. As regards the nature of the substrate, it appeared that succinate was (much) more effective than glutamate, α-ketoglutarate, pyruvate or β-hydroxybutyrate in counteracting the spontaneous and thyroxine-induced swelling.

Glutamate may, in fact, cause an immediate swelling of the fresh particles, especially when diphosphopyridine nucleotide was also present; diphosphopyridine nucleotide ($3 \times 10^{-4} M$) alone was sometimes similarly active[4].

The difference in effect of the various substrates might have been due to the fact that the phosphorylation accompanying succinate oxidation, or an intermediate reaction thereof, is especially involved in the contraction of the mitochondrial membranes[7] and/or to the fact that the corresponding processes of the diphosphopyridine nucleotide-linked oxidations are less stable[15], so that in the latter case the postulated 'change' may occur more readily under the conditions of the present experiments, which are certainly unfavourable to the maintenance of these integrated systems. It appears that the 'change' sets the trigger for swelling, while the actual swelling is dependent upon the presence of substrate, that is, on electron transport in (part of) the respiratory chain[2,3].

P. Emmelot
C. J. Bos
P. J. Brombacher
I. H. M. Reyers

Department of Biochemistry,
Antoni van Leeuwenhoek-Huis:
The Netherlands Cancer Institute,
Amsterdam.

[1] Emmelot, P., and Bos, C. J., *Exp. Cell Res.*, **12**, 191 (1957).

[2] Hunter, jun., F. E., Levy, J. F., Fink, J., Schutz, B., Guerra, F., and Hurwitz, A., *J. Biol. Chem.*, **234**, 2176 (1959).

[3] Chappell, J. B., and Greville, G. D., *Nature*, **182**, 813 (1958); **183**, 1525, 1737 (1959).

[4] Corwin, L. M., and Lipsett, M. W., *J. Biol. Chem.*, **234**, 2453 (1959).

[5] Raaflaub, J., *Helv. Physiol. Acta*, **11**, 142 (1953).

[6] Brenner-Holzach, O., and Raaflaub, J., *Helv. Physiol. Acta*, **12**, 242 (1954).

[7] diSabato, G., and Fonnesu, A., *Biochim. Biophys. Acta*, **35**, 358 (1959).

[8] Lipsett, M. W., and Corwin, L. M., *J. Biol. Chem.*, **234**, 2448 (1959).

[9] Lehninger, A. L., *J. Biol. Chem.*, **234**, 2187 (1959).

[10] Weinbach, E. C., *J. Biol. Chem.*, **234**, 1580 (1959).

[11] Lehninger, A. L., Ray, B. L., and Schneider, M., *J. Biophys. Biochem. Cytol.*, **5**, 79 (1959).

[12] Emmelot, P., and Bos, C. J., *Exp. Cell Res.*, **14**, 132 (1958).

[13] Kaufman, B. T., and Kaplan, N. O., *Biochim. Biophys. Acta*, **32**, 576 (1959).

[14] Tapley, D. F., *J. Biol. Chem.*, **222**, 325 (1956).

[15] Baltscheffsky, H., *Biochim. Biophys. Acta*, **20**, 434 (1956).

Presence of Protein in Some Serum Filtrates

In the determination of creatinine in plasma or serum the method of preparation of protein-free filtrates is known[1] to influence the total chromogen content of such fluids. Moreover, varying amounts of non-creatinine chromogen in such filtrates are known[2] to be partly responsible for differences in the total chromogen content.

It is generally assumed that a 1 : 5 'neutral' tungstic acid filtrate ($p\text{H} > 2{\cdot}5$), prepared as follows: 6 ml. distilled water, 2 ml. serum, 1 ml. 10 per cent sodium tungstate, 1 ml. $0{\cdot}66\ N$ sulphuric acid, and filtered through a Whatman No. 1 filter paper, is totally free of protein. Yet, it is well known that the precipitation of proteins by tungstic acid and other 'protein precipitants' consists of a series of changes in the protein molecule, which may, under certain conditions, be reversible. For it often happens that more than one denatured protein is formed by the action of these protein precipitants on a solution containing different amounts of albumins and globulins. Moreover, the isoelectric points of these proteins are different, so that a certain proportion of the metaprotein so formed may remain in solution at any given reaction. Further, these changes often consist in the opening up and extension of the highly organized coiled polypeptide chains of the native proteins which effect their viscosity, particle-size and solubility, etc.

Thus, a 'neutral' tungstate filtrate contains a small amount of protein (3·08 mgm./100 ml. serum) which can be precipitated by 5 per cent phosphotungstic acid in $2\ N$ hydrochloric acid (1 ml. to 5 ml. filtrate). A 1 : 10 tungstate filtrate, prepared as follows: 7 ml. distilled water, 1 ml. serum, 1 ml. 10 per cent sodium tungstate and 1 ml. $0{\cdot}66\ N$ sulphuric acid, contains no such detectable protein. It is evident, therefore, that a 1 : 5 'neutral' filtrate is not entirely 'protein-free' but contains some material which has escaped total precipitation or has been held in solution under the conditions of precipitation. Further, it is possible that other low molecular weight carbohydrate-containing proteins, particularly the mucopolysaccharides, may also be present in plasma or serum filtrates, as some of the acid mucopolysaccharides have a very acid isoelectric point.

The protein precipitated by phosphotungstic acid has a concentration of 0·08 mgm./100 ml. serum (in terms of creatinine) in normal pooled sera. Moreover, since protein is 'chromogenic' to alkaline picrate solution, it is possible that some filtrates may contain small amounts of protein which may be related to the so-called 'interfering material' (non-creatinine chromogen) in the determination of creatinine by the Jaffé reaction in biological fluids. For this figure is in fairly good agreement with that found by Owen, Iggo, Scandrett and Stewart[3] using the *NC*-creatinine destroying bacteria of Miller and Dubos[4] for a 'neutral' tungstate filtrate (1 : 5). Further, Lloyd's reagent, which is used to remove the 'interfering material' from a serum filtrate[3], is also widely used for removing proteins at a $p\text{H}\ 2{\cdot}0$–$3{\cdot}0$ from protein-containing solutions.

Thus, it should be remembered that the various protein precipitants differ in their ability to produce a plasma or serum filtrate which is completely free of protein, and of low molecular weight protein fragments (proteoses and peptones, etc.) which can react and interfere with the Jaffé reaction.

F. J. Scandrett

Clinical Research Laboratory,
Department of Obstetrics and Gynaecology,
University of Edinburgh.

Feb. 11.

[1] Ferro-Luzzi, G., *Z. ges. exp. Med.*, **94**, 708 (1934).

[2] Miller, B. F., and Miller, Z., *Proc. Soc. Exp. Biol. N.Y.*, **78**, 471 (1951).

[3] Owen, J. A., Iggo, B., Scandrett, F. J., and Stewart, C. P., *Biochem. J.*, **58**, 427 (1954).

[4] Miller, B. F., and Dubos, R. J., *Biol. Chem.*, **121**, 447 (1937).

PHYSIOLOGY

Endocrine Control of Sexual Reproduction in *Opalina ranarum* Parasitic in *Rana temporaria*

It is well known that opalinids parasitizing the recta of Amphibia multiply asexually by binary fission during most of the year. During the breeding season, however, the reproductive pattern changes to a sexual one, the preliminary stages of which are marked by an increase in the multiplication-rate and the production of small forms and minute individuals. The latter eventually encyst and are passed out with the fæces of the frog. If ingested by tadpoles, they excyst, form micro- and macro-gametes, and the resulting zygotes give rise to the multinucleated opalinids in the newly metamorphosed frogs.

It has long been suspected that the stimulus for inducing the change in the reproductive pattern of the opalinids was related to the endocrine behaviour of the host. Bieniarz[1] found that when male *Rana esculenta* were given injections of human pregnancy urine, the opalinids changed to a sexual pattern of reproduction resulting in the production of cysts. He suggested that the change might be initiated by the human chorionic gonadotrophin present. Cehovic[2] injected *R. esculenta* and *R. temporaria* with pregnancy urine, chorionic gonadotrophin or frog pituitaries, and obtained cyst formation. He concluded that the correlation between host and parasite life-cycles was due to pituitary activity and probably due to the production of gonadotrophin.

We have recently carried out a series of experiments on normal, hypophysectomized and gonadectomized *R. temporaria* with the following results.

(*a*) Injection of œstrone or gonadotrophic substances (concentrated or untreated pregnancy urine, chorionic gonadotrophin, serum gonadotrophin, suspension of frog hypophyses) to male and female frogs induced the sexual reproduction pattern of development in the opalinids—as evidenced by cyst production—but only in the period just prior to the breeding season (that is, during November–February in Europe) and not at other times of the year.

(*b*) Testosterone propionate and adrenaline injected into male and female frogs induced the sexual cycle of reproduction in the parasites during any time of the year.

(*c*) In gonadectomized animals, only injections of testosterone propionate were effective in inducing the sexual reproductive cycle in the parasites ; adrenalin was ineffective.

(*d*) *In vitro*, gonadotrophic hormones gave negative results in all cases ; but some positive results were obtained with untreated pregnancy urine. Some cultures treated with œstrone or hydrosoluble testis extract produced dividing stages and small forms, but cysts were never produced.

(*e*) In frogs prevented from copulating, the sexual reproductive cycle of the opalinids occurred in female frogs 77 days later than those which had copulated, and in the males, 82 days later.

These results clearly suggest that the induction of a sexual reproductive pattern in the opalinids is related, not to the levels of gonadotrophic hormones, but to the levels of gonadal hormones present in the host. In the male frog, the evidence shows that testosterone is implicated. In the female frog, in which the origin and nature of the gonadal hormone are obscure[3], the situation is not clear, for œstrone has been found only to induce cyst formation during the period just prior to the breeding season.

There is no evidence, as yet, to indicate whether the gonadal hormones exert their effect on these Protozoa directly or whether it is their breakdown products which are involved, or whether either of these exert their effect indirectly through some other aspect of the host's metabolism.

The effects of adrenalin injections in Amphibia are complex[4,5], and its action in inducing sexual reproduction in opalinids during any time of the year cannot be simply explained at the present phase of this work. The fact that it failed to induce cyst formation in gonadectomized frogs suggests that its action in some way induces the release of sex hormones, even when, in the male outside the breeding season, interstitial cells are absent from the testes.

Just prior to the breeding season, keeping the frogs at 8–12° C. induced cyst formation. That this result is attributable to the induction of early sexual maturity in the host and the subsequent release of the gonadal hormones may be shown by the fact that, during the summer, maintaining frogs at 20° C. failed to induce cyst formation, although injections of testosterone propionate induced the sexual cycle in the Protozoa, as at other times of the year.

Dr. Elspeth McConnachie[6] has kindly sent us the text of manuscript (in the press) in which she describes the induction of cyst production in *Opalina* by injection of frogs with chorionic gonadotrophin and frog pituitary extract. Although no experiments were carried out with the gonadal hormones, she concludes on theoretical grounds that the factors provoking encystation are probably the gonadal hormones.

M. El Mofty

Department of Zoology,
Alexandria University,
Egypt.

J. D. Smyth

Department of Zoology,
Canberra University College,
Canberra,
Australia.

[1] Bieniarz, B., *Nature*, **165**, 650 (1950).
[2] Cehovic, G., *C.R. Acad. Sci., Paris*, **242**, 2176 (1956).
[3] Smith, C. L., *Mem. Soc. Endocrinol.*, **4**, Part 1, 39 (1955).
[4] Robbins, S. L., and Parker, F., *Endocrinol.*, **44**, 384 (1949).
[5] Oordt, G. J. V., *et al.*, *Acta Endocrinol.*, **17**, 294 (1954).
[6] McConnachie, E., *Parasitology* (in the press).

Dipeptidase Activity of Brain

Available knowledge on the dipeptidase activity of brain is limited to the enzymatic hydrolysis of DL-alanyl-glycine[1-3]. Detailed studies by Pope *et al.* have dealt with the intralaminar distribution of dipeptidase activity towards DL-alanyl-glycine in the cerebral cortex of rat[1,2] and man[3]. Our own studies on proteolytic activity of brain led to a systematic inquiry into the existence of any selective or preferential dipeptidase activity of brain towards any particular dipeptidase structure. The present preliminary report deals with the systematic quantitative differences observed in the hydrolysis of the series of N-glycyl-dipeptides by mouse brain.

Freshly removed brains of adult Swiss albino mice were frozen on a glass slide placed on dry-ice, and immediately trimmed with a razor to remove the olfactory pole and the occipital poles (at the superior collicular level) to yield a standard-size block which was then cut into frontal sections of 75μ thickness on a freezing-microtome. Alternate sections were collected for total dry weight. Sections were immediately transferred to a chilled weighing-bottle containing 30 per cent glycerol in 4 per cent phosphate buffer at *p*H 6·97, and extracted overnight at 2° C. with occasional gentle stirring. This extraction procedure, similar to that used by Pope *et al.*[3], yielded a viscous, clear solution after centrifugation and filtration through sintered-glass micro-filters. To 50 μl. of extract in micro test-tubes 50 μl. of peptide solution (1·25–5·0 μmoles in 0·003 *N* sodium hydroxide) was added. After mixing by 'buzzing' on the shaft of a high-speed micro-motor, the tubes were incubated at 34° C. for 2 hr. together with separate tubes containing the same concentrations of the different peptides with only glycerol-phosphate buffer. After the incubation period, all tubes were chilled, 50 μl. of neutralized (phenolphthalein) 37 per cent formaldehyde and 4 μl. of 0·1 per cent phenolphthalein in 50 per cent ethanol were added to each tube. The formol titration was carried out against 0·1 *N* sodium hydroxide in a titration apparatus similar to that described by Linderstrøm-Lang and Holter[4]. The peptide and tissue blanks were subtracted from the enzyme-test values. The results are expressed in Fig. 1 and Table 1. The hydrolysis curve for DL-alanyl-glycine under the same conditions is presented for comparison in Fig. 1. Our observations indicate that the presence of a lipophilic aliphatic or aromatic side-chain is essential for dipeptidase activity in this category of dipeptides. Thus diglycine shows minimal splitting while all other glycyl-L-amino-acid dipeptides are maximally split. In keeping with the systematic difference, glycyl-γ-aminobutyric acid showed no splitting (Fig. 1), while the enzymatic hydrolysis of the glycyl-DL-α-aminobutyric acid was of the same order as the other dipeptides with a C-terminal DL-aliphatic or aromatic α-amino-acid residue. Similarly, glycyl-L-proline showed minimal hydrolysis under these conditions.

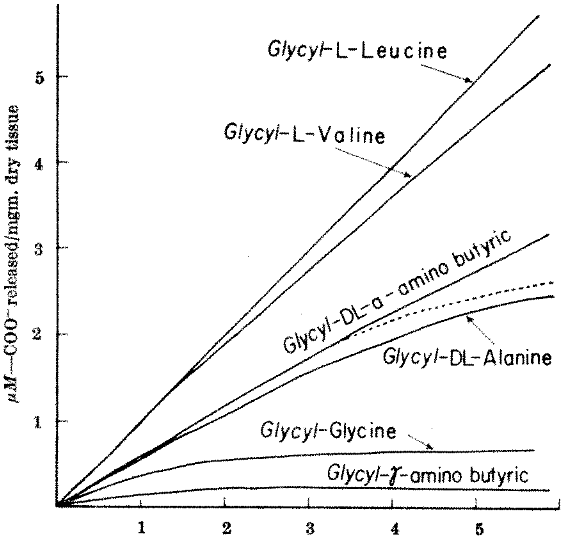


Fig. 1. Differences in peptidase activity of mouse brain dependent on presence of aliphatic side-chain of N-glycyl-dipeptides. The hydrolysis curve of DL-alanyl glycine at different peptide concentrations (dotted line merging with curve for glycyl-DL-α-aminobutyric acid) is included for comparison

Table 1

μM Peptide added/mgm. dry weight of brain	*μM*—COO⁻ released/mgm. dry weight of brain		
	1·5	2·5	5·0
Glycyl-glycine	0·50	0·55	0·72
Glycyl-L-alanine	1·45	2·40	4·47
Glycyl-L-valine	1·48	2·32	4·50
Glycyl-L-*iso*leucine	1·30	2·19	4·32
Glycyl-L-leucine	1·50	2·50	4·95
Glycyl-L-tyrosine	1·50	2·30	4·32*
Glycyl-L-phenylalanine	1·42	2·40	4·82
Glycyl-DL-alanine	0·82	1·34	2·30
Glycyl-DL-α-aminobutyric	0·90	1·45	2·78
Glycyl-DL-valine	1·04	1·60	2·73
Glycyl-DL-phenylalanine	0·80	1·26	2·20
Glycyl-L-proline†	0·40	0·40	0·40

* At this concentration the enzymatically released L-tyrosine precipitates out but redissolves during the formol titration.

† L-Proline in free form gives only 50 per cent of expected molar value in formol titration.

To our knowledge the existence of such structural requirements in the substrate was unsuspected for brain dipeptidase activity.

The same quantitative differences were observed when freeze-dried sections of mouse brain were extracted with 30 per cent glycerol in phosphate buffer, as well as when the peptides were incubated in the presence of fresh brain tissue slices in the glycerol-phosphate buffer solution without centrifuging off the slices to obtain a clear extract. In each instance the hydrolytic cleavage of each dipeptide, or lack of splitting, into component amino-acids was confirmed by paper chromatography. Incubation at 37° C. gave results identical with results of experiments carried out at 34° C.

Studies on a wide spectrum of related di- and tripeptides will be published in detail elsewhere.

This research was supported by a grant (*B*–712 *C*5) from the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.

L. LAHUT UZMAN
MARILYNN K. RUMLEY
STANLEY VAN DEN NOORT

Neurological Unit,
Boston City Hospital, and
Department of Neurology,
Harvard Medical School,
Boston,
Massachusetts.

[1] Pope, A., and Anfinsen, C. B., *J. Biol. Chem.*, **173**, 305 (1948).
[2] Pope, A., *J. Neurophysiol.*, **15**, 115 (1952).
[3] Pope, A., *J. Neurochem.*, **4**, 31 (1959).
[4] Linderstrøm-Lang, K., and Holter, H., *C.R. Trav. Carlsberg, Série Chim.*, **20**, 42 (1935).

Methane Exhalation in Sheep

IN view of the statements by Brody[1], Ritzman and Benedict[2], and Blaxter[3] to the effect that the ruminant exhales methane, it was deemed necessary to investigate the amount of methane which might be accumulated in the oxygen spirometer during indirect calorimetry experiments with sheep on full rations.

Appropriate arrangements were therefore made for gas analyses to be carried out by the Dominion Physical Laboratory at Wellington. On March 3, 1957, seven animals maintained on hay, crushed oats, and peas were chosen at random and each in turn was attached to the oxygen spirometer in the normal manner until it had exhausted one half the reservoir capacity—a period of about 10 min. The gas remaining in the spirometer was then collected and analysed. The results of the analysis of these samples are presented in Table 1.

Table 1. RESULTS OF ANALYSES OF GAS SAMPLES DRAWN AFTER THE SHEEP HAD EXHAUSTED HALF THE RESERVOIR CAPACITY OF A CLOSED CIRCUIT OXYGEN SPIROMETER*

Sheep No.	7	8	10	20	2	5	*X*
Methane	0·30%	0·05%	0·15%	0·20%	0·15%	0·15%	0·05%
Hydrogen	(0·02% or less)		(not found)				

* Hydrogen was included by the Dominion Physical Laboratory and is presented here for general interest.

There was no possible way in which the methane could have entered the spirometer other than from the lungs of the sheep. However, in view of the fact that in tracheotomized sheep some of the eructated gases flow back down the trachea—this was believed to be an original observation—the presence of traces of methane in the pulmonary system may have been due to residues from previous eructations. As the spirometer graphs used cannot be ruled to a greater accuracy than 0·05 l., a possible volume error of at the most 3 ml. of methane per 5 min. is considered to be low enough to be ignored in these experiments.

This work was supported by the Research Committee of the University of New Zealand. Particular thanks are due to the Director of the Dominion Physical Laboratory, Wellington, for offering the necessary laboratory staff and facilities.

E. CRESSWELL*

Massey Agricultural College,
New Zealand.

* Present address: The Rowett Research Institute, Bucksburn, Aberdeen, Scotland.

[1] Brody, S., "Bioenergetics and Growth", 315 (Reinhold, New York, 1945).

[2] Ritzman, E. G., and Benedict, F. G., *Carn. Inst. Wash. Pub.*, **494**, 25 (1938), citing Klein, W., *Biochem. Zeitsch.*, **72**, 169 (1916).

[3] Blaxter, K. L., cited from Hammond, J., "Progress in the Physiology of Farm Animals", 26 (Butterworths, London, 1954).

[4] Cresswell, E., *Nature*, **179**, 1139 (1957); Ph.D. thesis (1958), Massey Agricultural College Library, New Zealand.

Erythropoietine Production in the Dog

AN erythropoiesis-stimulating factor has been reported present in the plasma of numerous animals including the dog[1]. The dog, although readily available and a convenient source of relatively large volumes of plasma, has been utilized sparingly[2]. The present study was made in order that the hæmopoietic factor might be determined in the dog following exposure of the animal to various experimental procedures which are known to affect production of the factor in other species.

Five normal adult mongrel female dogs were placed in each of the following donor groups and subjected to the procedure indicated: group 1, untreated, healthy animals used as controls; group 2, hæmorrhage, 20 ml./kgm./day for 4 days; group 3, phenylhydrazine hydrochloride, 2·5 per cent, adjusted to *p*H 7·0, administered subcutaneously, 7·5 mgm./kgm./day, until the hæmoglobin concentration declined to 3·5–5·0 gm./100 ml.; group 4, the dog maintained in a closed chamber, in which the gases were mixed by a fan, with carbon dioxide being absorbed by soda lime. A mixture of 9 per cent oxygen–91 per cent nitrogen was admitted at a rate of 6 litres/min. for 24 hr.

At the end of the experimental period, each animal was bled, and 'protein-free' plasma prepared by the methods of Borsook[3], and Gordon[4]. This plasma preparation, pooled from each group, was injected intraperitoneally, in doses of 1·0 ml./100 gm./day, for 7–9 days into 200-gm. female Sprague–Dawley rats the hæmatological values of which had been determined. Terminally blood was removed by cardiac puncture from the 20 rats in each recipient group for determination of hæmoglobin, hæmatocrit, erythrocyte and reticulocyte values. The results in Table 1 indicate that the plasma from all donor groups, excepting that of the control animals, produced erythropoietic stimulation in the recipients. Additionally, the plasma of the phenylhydrazine-treated group stimulated erythrocyte production. In no case was reticulocyte percentage increased. The dog, like other animals, responds to appropriate stimuli by increased production of the erythropoietic-stimulating factor.

Table 1. EFFECT OF 'PROTEIN-FREE' PLASMA OF DOG ON RED CELL VALUES IN RATS

(Mean ± *S.E.*)	Hæmoglobin (gm./100 ml.)	Hæmatocrit (per cent)	Red blood count (mill./c.mm.)	Retics. (per cent)
Donors: (1) Control, normal dogs				
Rats: Before	14·9±0·15	45·0±0·30	8·4±0·26	1·1±0·17
After	14·6±0·18	44·4±0·18	8·7±0·13	1·3±0·21
(2) Hæmorrhaged dogs				
Rats: Before	13·8±0·19	40·8±0·88	7·8±0·23	2·2±0·21
After	14·9±0·16*	45·1±0·46*	7·9±0·14	1·7±0·19
(3) Phenylhydrazine-treated dogs				
Rats: Before	14·5±0·19	44·0±0·63	8·1±0·23	1·5±0·27
After	15·7±0·15*	47·3±0·35*	9·5±0·23*	1·4±0·18
(4) Hypoxic dogs				
Rats: Before	13·5±0·17	41·5±0·51	8·0±0·19	2·3±0·21
After	15·0±0·17*	45·5±0·56*	8·3±0·15	2·9±0·26

* Indicates probability value, $P < 0{\cdot}01$ for means 'after' as compared to those 'before'.

This investigation was supported in part by a grant from the National Institutes of Health, U.S. Public Health Service.

F. W. KINARD
F. F. GRIFFIN, JUN.
F. W. KINARD, JUN.

Medical College of South Carolina,
Charleston,
South Carolina.

[1] Linman, J. W., Bethell, F. H., and Long, M. J., *J. Lab. and Clin. Med.*, **51**, 8 (1958).

[2] Gibelli, C., *Arch. Exp. Path. Pharmakol.*, **65**, 284 (1911).

[3] Borsook, H., Graybiel, A., Keighley, G., and Windsor, E., *Blood*, **9**, 734 (1954).

[4] Gordon, A. S., Piliero, S. J., Kleinberg, W., and Freedman, H., *Proc. Soc. Exp. Biol. and Med.*, **86**, 255 (1954).

Ackee Toxin: a Riboflavin Antimetabolite?

THERE has occurred in Jamaica an illness known as 'vomiting sickness', characterized by vomiting, coma and death, which has been attributed to a toxin present in the ackee (*Blighia sapida*)[1-3]. In the course of routine assay for the protein values of human diets, a Jamaican meal containing this fruit was prepared, fed to rats, and the animals lost 26 per cent of their initial body-weight in 10 days. On a dry-weight basis, the meal contained 39 per cent green banana, 26 per cent salted cod-fish, 9 per cent coco-nut oil, 6 per cent salted pork fat, and 20 per cent ackee. Despite the high total protein content (17 per cent) of this mixture, it has a net dietary-protein value[4] of zero.

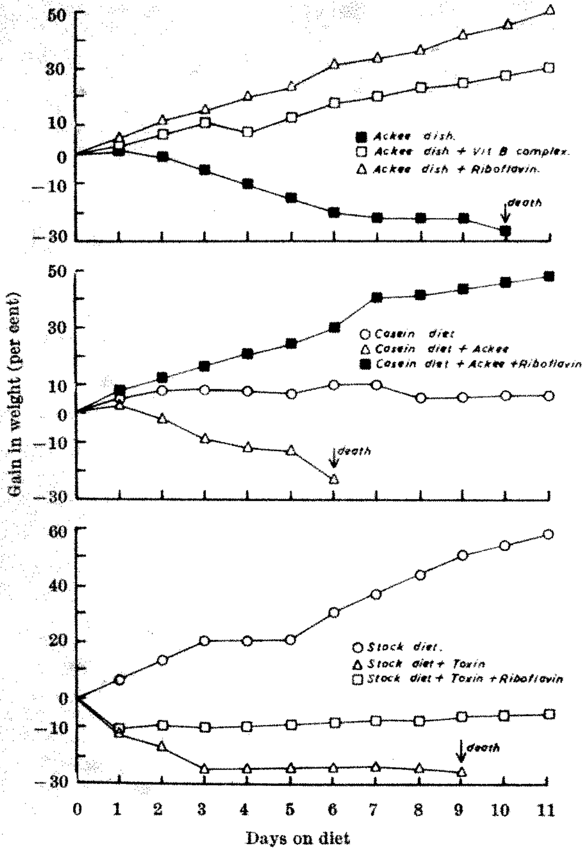


Fig. 1

By feeding each of the components of the meal separately in diets adequate in all nutrients, all were found to be innocuous, and the losses in weight on the complete meal were only prevented by supplementation with B vitamins, or more particularly with riboflavin (see Fig. 1). However, it is evident that simple riboflavin deficiency would not result in such an immediate and severe loss of weight[5] and, furthermore, analysis showed the diet to contain 0·28 mgm. riboflavin per 100 gm., which would supply the daily requirement for the rat[6]. This suggests that the meal contained an antimetabolite of riboflavin.

In another experiment the ackee was added to a synthetic, low-vitamin diet and was shown to produce a severe depression in growth-rate compared with a control. The addition of B-vitamins overcame both the adverse effect of the ackee and the low vitamin content of the diet: this is in agreement with the finding described above, where the toxic effects of the fruit could not be demonstrated with a diet containing 1 mgm. riboflavin per 100 gm.

Feng and Kean[7] have reported a protective action of protein to rats injected with a toxic material extracted from the ackee, but this work does not support their finding; in fact, 17 per cent casein in the absence of riboflavin was unable to prevent severe loss of weight and death when ackee was present in the diet. In addition, animals fed a low-protein diet adequate in B-vitamins lost 20 per cent of their weight in 10 days, whether or not ackee was added to the diet. These authors may have inadvertently added riboflavin concomitantly with protein in raising the level of nitrogen in the diet.

Finally we were able to obtain a sample of hypoglycin *A* extracted from ackees and have demonstrated that, when given subcutaneously (60 μgm./gm. body-weight), its toxic effects may be alleviated by simultaneous injection (120 μgm./gm. body-weight) with riboflavin. De Renzo *et al.*[8] have suggested from their studies with rat liver mitochondria that hypoglycin *A* is metabolized to the true toxic agent, and it is of interest that our sample did not interfere with the microbiological assay of riboflavin.

This work is supported by two clinical observations. Hill[2] has reported that many medical officers in charge of districts and hospitals throughout Jamaica noticed severe signs of riboflavin deficiency in the majority of cases of illness in which the ackee was implicated, and confirmed this view during the epidemic of 1951. Secondly, the incidence of the condition has been less frequent in recent years, during which there has been a rising consumption of wheat flour[9], a relatively good source of riboflavin.

This work formed part of an M.Sc. thesis by one of us[10] and is being continued with the view of establishing the mode of action of the antimetabolite. We are indebted to Prof. C. H. Hassall and Dr. S. J. Patrick for samples of hypoglycin *A*.

H. C. Fox
D. S. Miller

Human Nutrition Research Unit,
National Institute for Medical Research,
London, N.W.7.

[1] Scott, H. H., *Ann. Trop. Med. Parasit.*, **10**, 1 (1916).
[2] Hill, K. R., *W. Indian Med. J.*, **1**, 243 (1952).
[3] Hassall, C. H., Reyle, K., and Feng, P. C., *Nature*, **173**, 356 (1954).
[4] Platt, B. S., and Miller, D. S., *Proc. Nutr. Soc.*, **18**, vii (1959).
[5] Sure, J. H., and Phillips, P. H., *J. Nutr.*, **22**, 345 (1941).
[6] Folley, S. J., Henry, K. M., and Kon, S. K., *Brit. J. Nutr.*, **1**, 39 (1947).
[7] Feng, P. C., and Kean, E. A., *Brit. J. Nutr.*, **9**, 368 (1955).
[8] De Renzo, E. C., McKerns, K. W., Bird, H. H., Cekleniak, W. P., Coulomb, B., and Kaleita, E., *Biochem. Pharmacol.*, **1**, 236 (1959).
[9] "Handbook of Jamaica" (Govt. Printer, Jamaica, 1958).
[10] Fox, H. C., M.Sc. thesis, Univ. of London (1959).

RADIOBIOLOGY

Cæsium-137 in Spray-dried Danish Milk

The cæsium-137 content in Danish spray-dried milk has been measured in some fifty samples ranging in production time from 1949 to December 1959.

The measurements are carried out by γ-scintillation spectrometry using a Harshaw sodium iodide (thallium) crystal, 1½ in. diameter by 1½ in. thick, mounted in an electrolytic pure copper housing incorporating a quartz window. The 99-channel analyser used is of the analogue-to-digital conversion type built at this Laboratory and described elsewhere[1]. The resolution at 662 keV. is 8·3 per cent measured with a point source and approximately 10 per cent when a 800-gm. sample is counted. Fig. 1 shows sample container and detector in position inside the lead shield. The dried milk is measured without ashing or chemical treatment.

In Fig. 2 the upper curve shows a typical spectrum after subtraction of background. The potassium-40 peak at 1,460 keV. and cæsium-137 peak at 662 keV. are well resolved. No other peaks are significant. Sugar was used as background medium. The lower curve in Fig. 2 is that obtained with the cæsium-137 standard, while the points with their standard deviations are obtained from the upper curve by

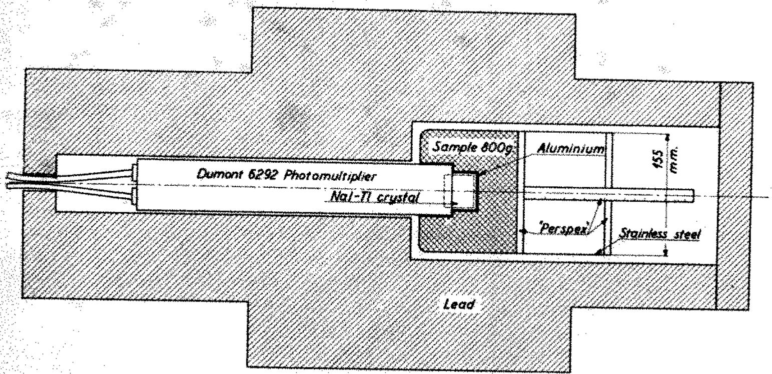


Fig. 1. Sample container and detector

subtracting the potassium-40 contribution. The points are seen to follow the cæsium-137 standard fairly well. 1 count/min. under the potassium-40 photopeak corresponds to 2·1 gm. of potassium in an 800-gm. sample, and 1 count/min. in the cæsium-137 photopeak corresponds to 98·1 μμc. of cæsium-137 in an 800-gm. sample.

The results are shown graphically in Fig. 3.

The peak value up to 1959 is about 20 μμc. cæsium-137/gm. potassium, which is rather low compared to figures given by E. C. Anderson *et al.*[2], who have measured two samples from Denmark and found 52 and 74 μμc. cæsium-137/gm. potassium respectively. Their samples were manufactured in June and September 1958. Our figures seem to correspond fairly well with those given by K. Løw and K. Edwarson[3] for Swedish milk but they are lower than the values quoted by Mayneord *et al.*[4] and by Booker[5].

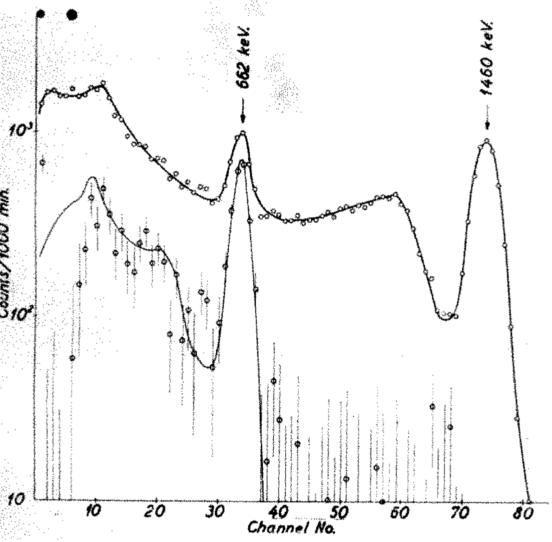


Fig. 2. Upper curve: spectrum of specimen after subtraction of background. Lower curve: spectrum of cæsium-137 standard

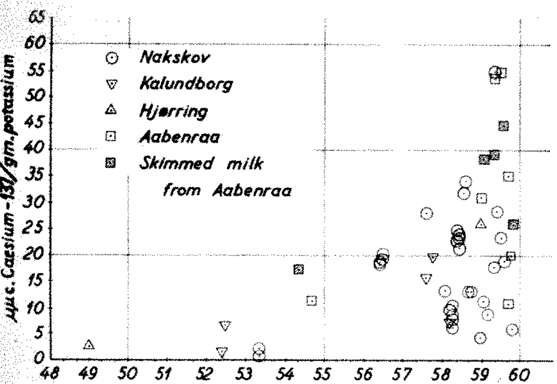


Fig. 3. Ratio of μμc. cæsium-137/gm. potassium in dried milk as a function of date of production

Maybe the relatively low content of cæsium-137 in Danish milk is due partly to the large amount of fertilizer used in Denmark. On the average, 3·2 gm. potassium is used per m.^{2} per annum. The average rainfall is 750 mm. in Aabenraa and 600 mm. in Hjørring per annum. No strontium determinations have so far been carried out on our samples.

PER GERT JENSEN

Finsenlaboratory, Copenhagen.

[1] Jensen, P. G., *et al.*, *Nucleonics*, **16**, 100 (1958).

[2] Anderson, E. C., Clinton, B., and Shields, I. L., *LASL* Report in *LA*-2296 (April 1959).

[3] Løw, K., and Edwarson, K., *Nature*, **183**, 1104 (1959).

[4] Mayneord, W. V., *et al.*, *Nature*, **182**, 1473 (1958).

[5] Booker, D. V., *Nature*, **183**, 921 (1959).

Mechanism of the Radiation Effect on the Synthesis of Deoxyribonucleic Acid

WORK on the mechanism of the radiation effect upon the synthesis of deoxyribonucleic acid in human bone marrow cells *in vitro* indicated a biphasic X-ray dose-response curve[1]. To test the applicability of these findings to other mammalian cell systems, similar work has been carried out with mouse Ehrlich ascites tumour cells; this system also has the advantage of being a more homogeneous cell population than bone marrow.

Seven- to ten-day-old tumour was used; the ascitic fluid was immediately aspirated by syringe, suspended in heparinized supplemented Hanks's solution and centrifuged at 1,200 rev./min. for 10 min. The supernatant was discarded and the cells re-suspended in a medium consisting of 50 per cent supplemented Hanks's solution and 50 per cent human serum to a concentration of 10^7 cells/ml. Aliquots of 1 ml. were then placed in 16 screw-cap culture vessels, of which four served as controls and four for each X-ray dose-level. X-rays were produced by a 300 kVp. resonant transformer, 1·9 mm. copper half-value layer at a dose rate of 475 rads/min. Irradiation was so arranged that all the doses were completed simultaneously. ^{14}C–thymidine, 0·5 μc./ml. culture, was added immediately after irradiation and the vessels incubated for 2 hr. at 37° C. Synthesis of deoxyribonucleic acid was measured by counting the total radioactivity of washed cells on planchettes prepared by the method of Lajtha *et al.*[2]; the number of cells per planchette was checked by ultra-violet absorption spectrometry. The results are shown in Fig. 1; each point represents the mean of eight experiments.

As in human bone marrow, the curve is at least biphasic, though less clear-cut. A steep initial depression (S_1) is again followed by a shallower slope at higher doses (S_2). The mechanism by which

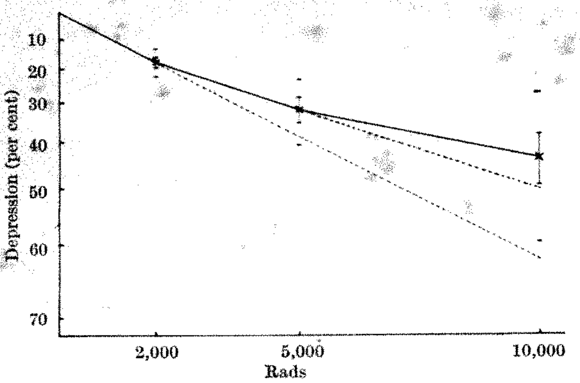


Fig. 1. X-ray dose-response curve, Ehrlich ascites cells *in vitro*. Each point represents the mean of eight experiments. Vertical bars indicate standard error of mean; standard deviation of individual experiments indicated by the short horizontal bars. Interrupted line from 2,000 to 10,000 rads indicates extrapolation of S_1 slope, that between 5,000 and 10,000 rads indicates dubious break in S_2 slope

irradiation inhibits synthesis of deoxyribonucleic acid is still unexplained; possibly S_1 represents some enzymatic inhibition[3] and S_2 the inhibition of the template replication of the deoxyribonucleic acid molecule. Variation in the radiosensitivity of the cells sufficient to explain the curve is unlikely, as autoradiographic work with ^{3}H-thymidine in similar experiments indicates a general shift of the grain counts to lower levels.

The effect of oxygen on the inhibition of synthesis of deoxyribonucleic acid by X-irradiation has been investigated for the initial (S_1) slope of the dose-response curve. Ehrlich ascites cells were suspended as before and placed in flat glass Petri dishes within a pressure vessel. The cell suspensions were equilibrated for 5 min. at room temperature with either 100 per cent oxygen or oxygen-free nitrogen and then rotated for 15 min. on an inclined turntable to ensure full equilibration of all cells with the gas phase. Irradiation was carried out while the cell suspensions were thus being rotated (300 kVp., 0·5 mm. copper + 1 mm. aluminium added filtration, dose-rate 280 r./min.). The cells were then incubated with ^{14}C–thymidine and planchettes were prepared as before. The results are shown in Fig. 2; at doses of both 800 and 2,000 rads (measured by ferrous sulphate), there was a markedly greater inhibition of the incorporation of ^{14}C–thymidine in the oxygenated suspensions. The ratio oxygen/nitrogen averaged 2·9.

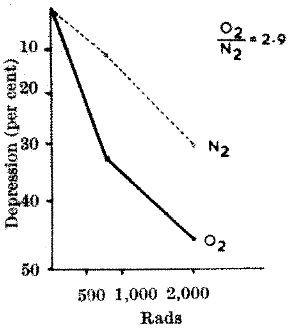


Fig. 2

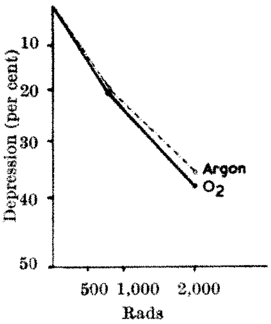


Fig. 3

Fig. 2. 'Oxygen effect', radiosensitivity of S_1 component. Each point at a given X-ray dose-level represents an experiment with quadruplicate controls

Fig. 3. Inability of 37 atm. argon + 1 atm. air to simulate anoxic conditions in modifying radiosensitivity of S_1 component. Each point at a given X-ray dose-level represents an experiment with quadruplicate controls

Ebert, Hornsey and Howard[4] noted that inert gases under pressure in the presence of normal atmospheric concentration of oxygen could simulate anoxic conditions in modifying radiosensitivity of several cell systems, including the production of abnormal anaphases in Ehrlich ascites cells. These cells show an 'oxygen effect' of a factor of 2·7–3·1 as demonstrated by Deschner and Gray[5]. To test an inert gas in this system, argon at 37 atm. + 1 atm. air was introduced over normally aerated cell suspensions in a pressure vessel and the vessel then rotated on the inclined turntable for 15 min. The control (oxygen) suspension was equilibrated for 5 min. with 100 per cent oxygen bubbled through water, then the vessel was rotated as before. The suspensions were irradiated and incubated as above. The results are shown in Fig. 3; the radiosensitivity in air + argon did not differ from that in oxygen at either dose-level.

The difference in the absolute values of the depression of deoxyribonucleic acid synthesis in oxygen between these experiments and those of Fig. 2 may be ascribed partly to the fact that the earlier experiments were performed with dry gas (permitting additional damage to the cells by dehydration and consequent hypertonicity of the medium), whereas in the latter water-saturated gas was used. It is significant, however, that in each experiment where both oxygenated and nitrogenated suspensions of the same tumour received identical treatment with the exception of the gas used, there was a marked difference between radiosensitivity in the two gases. By contrast, in the experiments in which oxygen and air + argon were used, there was no difference in radiosensitivity at either dose-level. The degree of depression shown in the dose-response curve in Fig. 1 suggests that the cell system was 'anoxic', as would be expected from the findings of Deschner and Gray[5], and that due to the closed system (rather than open Petri dishes) the cells were not additionally damaged by dehydration of the medium.

These experiments re-affirm the multiphasic (S_1, S_2) X-ray dose-response curve for the synthesis of deoxyribonucleic acid. They also indicate the dependence on oxygen of the radiosensitivity of the S_1 process; experiments to determine whether the S_2 process is similarly dependent on oxygen are in progress. The failure of inert gases to modify this response suggests that it is not due to effects at an intranuclear lipid interface where the inert gases have been postulated to act[4].

These experiments were supported by a grant from the Medical Research Council; one of us (R. J. B.) is British-American Exchange Fellow of the American Cancer Society.

R. J. Berry
E. Hell
L. G. Lajtha

Radiobiology Laboratory,
Department of Radiotherapy,
Churchill Hospital, Oxford.

M. Ebert

Medical Research Council
Experimental Radiopathology Unit,
Hammersmith Hospital, London.

[1] Lajtha, L. G., Oliver, R., Berry, R., and Noyes, W. D., *Nature*, **182**, 1788 (1958).

[2] Lajtha, L. G., Oliver, R., Kumatori, T., and Ellis, F., *Rad. Res.*, **8**, 1 (1958).

[3] Ord, M. G., and Stocken, L. A., *Nature*, **182**, 1787 (1958).

[4] Ebert, M., Hornsey, S., and Howard, A., *Nature*, **181**, 613 (1958).

[5] Deschner, E., and Gray, L. H., *Rad. Res.*, **11**, 115 (1959).

BIOLOGY

Golgi Bodies and Golgi Zones in Molluscan Oocytes

In the cytoplasm of the oocytes of *Aplysia depilans* L. (Mollusca, Opistobranchia), during the first phases of growth, a large quantity of Golgi bodies or dictyosomes can be found. Such bodies can be observed with the optical microscope with the silver impregnation methods and they are generally arranged along a bent line (Fig. 1). The same bodies can also be observed with the electron microscope (Fig. 2), and in this instance they show a closed system of double parallel membranes (Fig. 5) and not an open system, as generally observed by previous authors. Inside these bodies[1] there are vacuoles with a clear content and vesicles with a dark content, which correspond to similar structures of the open system. In the oocytes of *Aplysia* vitellogenesis takes place following a radical transformation of Golgi bodies into yolk globules, as already observed by Parat[2] in *Aplysia punctata*.

Electron microscope observations showed that the following growth stages of such globules take place by means of peculiar particles which are characterized by a central clear zone and by a peripheral zone, that is, composed of dark granulations with a diameter of about 300 Å. The particles arrange themselves around each globule in the shape of a half-moon (Fig. 4), which is evident also in silver method preparations as observed with the optical microscope (Fig. 3). When the globules have reached their maximum in growth, these particles are no longer present, but a semi-lunar globule can still be observed (Fig. 6). It differs, however, from the previously cited half-moon as it cannot be impregnated by silver methods and it shows different ultrastructural peculiarities (Fig. 6). The further phases of vitellogenesis in *Aplysia* have been reported in earlier communications[3,4].

In the oocytes of *Patella coerulea* L. (Mollusca, Prosobranchia) dictyosomes like those of *Aplysia* cannot be found. The formation of yolk globules takes place from the beginning in direct connexion with the ergastoplasm[4,5]. This is formed by filaments of a thickness of about 200 Å., which carry dark granulations measuring about 300 Å. in diameter. The presence of a semi-lunar formation around growing yolk globules can be observed both with the silver impregnation methods with the optical microscope (Fig. 7) and with the electron microscope. This formation disappears when the globules have attained their full development. Such formation clearly corresponds to that formed by the dark granulations of 300 Å. in diameter, which are attached to the filaments.

The above results demonstrate, with reference to the Golgi apparatus, that it is possible to distinguish two types of elements which are both evidenced through the silver impregnation. The first elements have been found only in *Aplysia*, and they correspond, from the ultrastructural point of view, to typical Golgi bodies; the second elements, which have been found both in *Aplysia* and in *Patella*, show totally different characters. It is therefore highly probable that the semi-lunar zones, which surround the developing yolk globules, are the expression of peculiar physico-chemical conditions, that are connected with intense synthetic processes and favour silver precipitations at their level. When such synthetic processes come to an end, silver is no longer precipitated. This allows the distinction of two different aspects of the Golgi apparatus: one is represented by typical Golgi bodies or dictyosomes according to Grassé, Carasso and Favard[6], and another is represented by Golgi zones, which have a different constitution and are connected with intense synthetic processes.

Contrasting views regarding the different elements of the Golgi apparatus can thus be reconciled. Such solution was already foreshadowed by conclusions reached by a few authors, such as Levi[7] and Dalton[8]. Grassé's[9] contention that the Golgi zone has no reality and that the Golgi apparatus is a definite organelle present in any cell appears thus to be highly restrictive from this point of view.

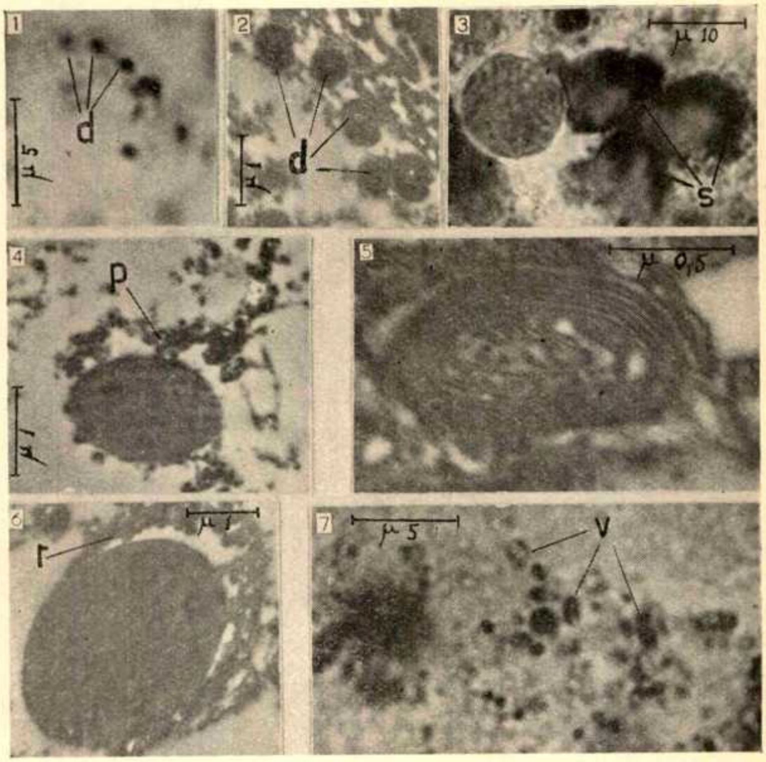


Fig. 1. Dictyosomes (*d*) of *Aplysia depilans* oocyte at the optical microscope; Da Fano silver impregnation. Fig. 2. The same dictyosomes (*d*) at the electron microscope. Fig. 3. Yolk globules of *Aplysia* oocyte at the optical microscope. Three of them are partly surrounded by a silver-impregnated semi-lunar zone (*s*). Fig. 4. Yolk globule of *Aplysia* oocyte at the electron microscope with particles (*p*) grouped into a semi-lunar arrangement. Fig. 5. Dictyosomes of *Aplysia* oocyte at the electron microscope. Fig. 6. Yolk globule of *Aplysia* oocyte with a very dense semi-lunar network (*r*) at the electron microscope. Fig. 7. Developing yolk globules in a *Patella coerulea* oocyte at the optical microscope. Some of them show a silver-impregnated half-moon (*V*). Observations at the electron microscope were carried out with a Siemens' Elmiskop I*a* of the Centre for Electron Microscopy at the University of Padua

This work has been supported by Consiglio Nazionale delle Ricerche, Roma.

A. BOLOGNARI

Istituto di Zoologia e di Anatomia comparata,
Università di Messina.

[1] Bolognari, A., *Boll. Soc. Ital. Biol. Sper.*, **35**, 474 (1959).
[2] Parat, M., *Arch. Anat. Micr.*, **24**, 73 (1928).
[3] Bolognari, A., *Boll. Zool.*, **25**, 171 (1958).
[4] Bolognari, A., *Nature* (in the press).
[5] Bolognari, A., *Boll. Zool.*, **25**, 155 (1958).
[6] Grassé, P. P., Carasso, N., and Favard, P., *C.R. Acad. Sci., Paris*, **241**, 1243 (1955).
[7] Levi, G., "Trattato di Istologia" (Torino, 1954).
[8] Dalton, A. J., *Z. Zellforsch.*, **36**, 522 (1952).
[9] Grassé, P. P., *C.R. Acad. Sci., Paris*, **242**, 858 (1956).

Structure of the Outer Secondary Wall on Unbleached Spruce Sulphite Fibres

NUMEROUS investigators, in particular Emerton[1], Wardrop[2] and one of us[3], have reported on the structure of the outer secondary wall, S_1, of coniferous fibres. In all cases, these investigations were carried out on fragments which had been freed from the fibres by some form of mechanical action. Although the evidence that these fragments originated from the S_1 wall is excellent, the S_1 wall has never been seen intact on the surface of a fibre.

We are at present carrying out investigations on some properties of unbleached spruce sulphite fibres. The fibres discussed here were mechanically treated in a 2-litre disintegrator for 80 min. at a consistency of 1 per cent. After the disintegration, the fibres were screened thoroughly twice to remove the fine fragments released by stirring. Samples of the screened fibres were dried on to slides and without further treatment examined in a microscope under reflected light. (Zeiss microscope, model *W*, epi-illumination *IIB*.) We found attached to many fibres typical S_1 fragments. In a few cases such as that shown in Fig. 1, the S_1 structure was clearly visible on the surfaces of the fibres. The alternate dark and bright lines between the fibre and the upper fragment are interference fringes (Newton's rings) formed in the wedge-shaped gap between the partially unravelled S_1 fragment and the slide[4] (see cross-sectional view of fibre in Fig. 2). The presence of the interference fringes is strong evidence that the unravelled S_1 fragment is attached to the top surface of the fibre.

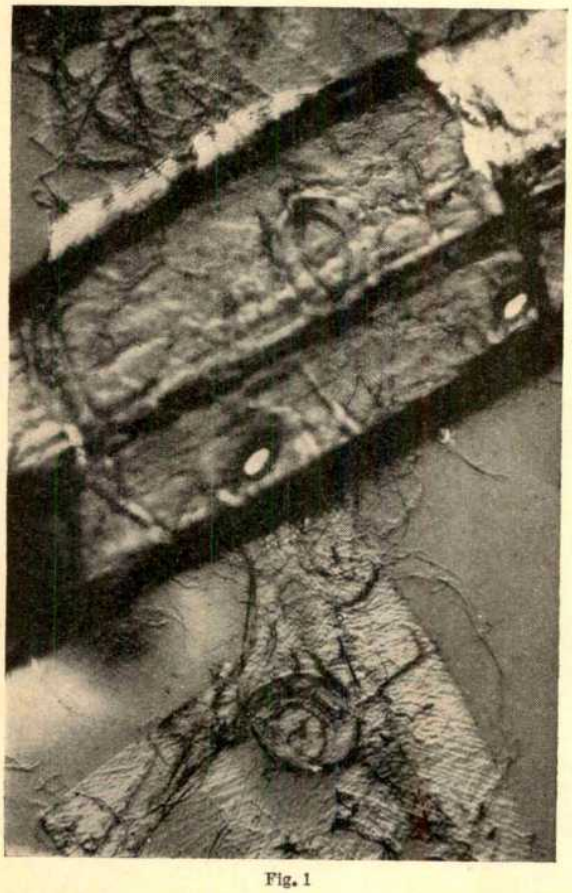


Fig. 1

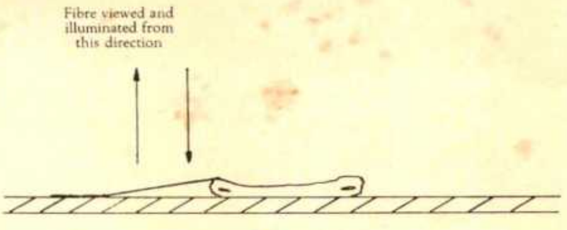


Fig. 2

The angle between each of the two sets of fibrils and the fibre axis (fibrillar angle) is about 50° (five measurements). The same value was obtained for the S_1 fragment in the upper portion of Fig. 1. Assuming that the longitudinal fibre axis of the other fragment is perpendicular to that of the fibre, its fibrillar angle is about 60°. These values agree well with those reported in refs. 1, 2 and 3.

We wish to thank the Directors of Wiggins Teape and Co., Ltd., for permission to publish this communication.

O. KALLMES
J. A. S. NEWMAN

Wiggins Teape Group Research
Organization,
Butler's Court,
Beaconsfield, Bucks.
Nov. 10.

[1] Emerton, H. W., and Goldsmith, V., *Holzforschung*, **10**, 108 (1956).
[2] Wardrop, A. B., *Holzforschung*, **11**, 102 (1957).
[3] Kallmes, O. J., *Tappi*, **43**, No. 2 (Feb. 1960).
[4] Emerton, H. W., *British Paper and Board Makers' Assoc. Proc., Tech. Sect.*, **36**, 595 (1958).

Occurrence of *Falkenbergia rufolanosa* on the West Coast of Scotland

PERIODIC reports during the past twenty years[1-4] have noted the appearance of *Asparagopsis armata* and its associated form, *Falkenbergia rufolanosa*, in a number of localities in western Ireland and the south and south-west coasts of England. Although the southern records reported the two forms appearing almost simultaneously, recent evidence suggests that *Falkenbergia* is spreading round the British coasts more widely than *Asparagopsis*[5-7]; and this would seem to confirm the suggestion of Thomas[8] that the two differ in their ecological requirements.

Further evidence of the spread of *Falkenbergia* is seen in its appearance on the coast of Scotland. During a survey of the inter-tidal zone of the coasts of the Hebridian island of Colonsay at the time of very low tides early in September 1959, filaments of a small polysiphonous alga showing three pericentral cells around each cell of the central filament were found on two shores: (*a*) intermingled with other small drift algae collected from the Strand between Colonsay and Oransay, and (*b*) as quite large, bright pink 'pom-poms' growing on *Cladophora rupestris* in Cable Bay, a small sandy bay at the south-east of Colonsay, where, again, it occurred much intermingled with other small epiphytic algae such as *Ceramium rubrum*, *Sphacelaria bipinnata*, *Lomentaria articulata* and *Achrochaetium* sp. This alga agrees with descriptions given for the vegetative state of *Falkenbergia rufolanosa*[8,9]. The filaments forming the well-marked 'pom-poms' were short and not much branched except towards the tips: they had the appearance of young, developing axes with markedly active apical cells. All the plants examined were sterile. On several filaments, propagules of *Sphacelaria bipinnata* were attached and were developing as epiphytes of the *Falkenbergia*.

It is hoped that other marine ecologists will keep a watch for further appearances of *Falkenbergia* in northern waters: it will be of considerable interest to see if it is followed in the Hebrides by *Asparagopsis*, or if the different distribution pattern of the two forms receives further confirmation.

ELSIE CONWAY

Department of Botany,
University of Glasgow.

[1] de Valera, M., *Irish Nat. J.*, 8, 30 (1942).
[2] Harvey, C. C., and Drew, K. M., *Nature*, **164**, 542 (1949).
[3] Drew, K. M., *Nature*, **166**, 873 (1950).
[4] Kerslake, J., *Nature*, **172**, 874 (1953).
[5] Walker, M. L., Burrows, E. M., and Lodge, S. M., *Nature*, **174**, 315 (1954).
[6] de Valera, M., "Guide to the Seaweed of Galway Bay" (Dublin, 1958).
[7] de Valera, M., *Coll. bot. Barcinone*, 5, 377 (1957).
[8] Thomas, L., *Coll. bot. Barcinone*, 4, 399 (1955).
[9] Feldmann, J., and Feldmann, G., *Ann. Sci. Nat. Bot.*, 11 (3), 75 (1942).

Perfect Stage of *Sclerotium rolfsii* Sacc.

THE perfect stage of *Sclerotium rolfsii* Sacc. has been reported by several workers[1-6]; however, the conditions under which its development takes place have not been investigated thoroughly. An attempt was therefore made to find out the various nutritional and environmental factors which affect the development of the perfect stage.

The fungus was isolated from rotted potato tubers and grown on different media; also under different conditions of temperature, hydrogen-ion concentrations, and relative humidities. Different sources of carbon and nitrogen, as well as different concentrations of their best sources, were also tried, but no success was met with, until one day a plate of standard Brown's agar medium containing cultures of *S. rolfsii* and lying in the cupboard for 1½ months was seen developing the fruiting body. An experiment was set up with seven agar media, namely, potato-dextrose, oatmeal, maize meal, host extract, Richard's, Czapek's and Brown's. Three plates of each were incubated at 25° C. and at room temperature in the cupboard.

The fruiting body developed only in the three plates containing Brown's agar medium incubated at room temperature during a period of 33–39 days. The mean maximum and minimum room temperatures for the period under observation were 19·9° C. and 14·4° C. respectively. This experiment was again repeated when the mean maximum and minimum room temperatures were 23·5° C. and 17·3° C. respectively, and similar results were obtained.

The descriptions and measurements of the fruiting body, basidium, and basidiospores resembled those reported earlier[2,4]. Basidiospores, when planted on potato dextrose agar, germinated and grew to form a mycelial mat and sclerotia. The mycelial, sclerotial, and growth characters of the basidiosporal cultures resembled those of the parent culture.

Brown's agar medium which developed the perfect stage is poor in nutrients as compared to the rest of the media. The special medium used with success by Mundkur[4] was also poor in nutrient. Curzi[2] also reported that sporulation in *S. rolfsii* took place earlier and was more abundant in media poor in nutrients as compared with media rich in nutrients. Reports of various workers[2,4,5] also indicate wide variation in the temperature requirement for the development of the perfect stage.

The development of perfect stage in *S. rolfsii* thus seems to depend both upon nutrient and temperature, and Brown's agar medium incubated at room temperature ranging between a mean maximum and minimum of 21·7° C. and 15·9° C. for 33–39 days is suitable for the development of the perfect stage.

A. P. MISRA
S. Q. HAQUE

Division of Mycology and Plant Pathology,
Bihar Agricultural College, Sabour,
Bihar. Dec. 11.

[1] Barret, J. T., *Phytopath.*, **24**, 1137 (1934)
[2] Curzi, M., *Bull. R. Staz. Pat. Veg.*, N.S., **11**, 306 (1932).
[3] Ghosh, T., and George, K. V., *Ind. J. Agric. Sci.*, **25**, 171 (1955).
[4] Mundkur, B. B., *Ind. J. Agric. Sci.*, **4**, 779 (1934).
[5] Venkatakrishnaiya, N. S., *Curr. Sci.*, **15**, 259 (1946).
[6] West, E., *Phytopath.*, **37**, 67 (1947).

BACTERIOLOGY

Isolation of Mutants of *Bacillus subtilis* requiring D-Glutamic Acid

ALTHOUGH synthetic pathways of the L series of amino-acids have been studied extensively by the use of biochemical mutants of micro-organisms, there appears to be no published account of the synthesis of the D series of amino-acids using similar experimental techniques. Meanwhile, because D-glutamic acid is known to be an essential component of the cell wall and capsular fractions of a certain kind of bacteria[1,2], an attempt to obtain mutants requiring D-glutamic acid for growth is still valuable. With this idea, induction and isolation of mutants from a wild strain of *Bacillus subtilis K* requiring D-glutamic acid was attempted.

Minimal medium was prepared as prescribed by Gray and Tatum[3] (L-asparagine was eliminated), adding 0·1 per cent glucose for liquid medium and 0·5 per cent for solid medium. To allow the growth of mutants requiring D-glutamic acid, if any existed, a special medium (*DG*) consisting of 100 μgm./ml. of D-glutamic acid and the components in the minimal medium was prepared and used in place of the so-called complete medium. Spores of the wild strain were harvested from a 10-day culture on Burkholder's nutrient agar slant[4], and a suspension

Table 1. Response Pattern of the Five Mutants Isolated

Amino-acids (100 μgm./ml.)	Mutant strains 1*a*	2*a*	3*a*	4*a*	3*d*
D-Glutamic acid	+	+	+	+	+
D-Aspartic acid	+	+	+	+	+
D-Alanine	+	+	−	−	+
L-Glutamic acid	−	−	+	+	−
L-Aspartic acid	−	−	+	+	−
L-Alanine	+	+	−	−	−
DL-Glutamic acid	+	+	+	+	+
DL-Aspartic acid	+	+	+	+	+
DL-Alanine	+	+	−	−	+
Minimal medium	−	−	−	−	−
Casein hydrolysate plus D-glutamic acid	+	+	+	+	−

containing 10^6–10^7 spores in 2 ml. of sterile saline was exposed to X-rays. The survival ratio at a dose of 144,000 röntgens was 20 per cent. After appropriate dilution, the cells were plated on *DG* medium. The replica plating method devised by Lederberg and Lederberg[5] was applied to the colonies that appeared on the plates, and such colonies which showed positive response to the *DG* medium, but not to minimal medium, were selected.

As a result, four out of about ten thousand colonies tested were proved to be mutants requiring D-glutamic acid. These mutants, 1*a*, 2*a*, 3*d* and 4*a*, are fairly stable though 3*d* gave rise to a new mutant, 3*a*, spontaneously. Growth response of these strains to D and L amino-acids was judged by shake culture method using about 10^6 cells/ml. as inocula. As seen in Table 1, all of them require D-glutamic acid for growth, but response to D-aspartic acid, D-alanine, L-glutamic acid, L-aspartic acid and L-alanine is different from strain to strain. For example, strain 3*d* grows on a medium containing either D-glutamic acid, D-aspartic acid or D-alanine, while strains 3*a* and 4*a* grow on either a D-glutamic acid, D-aspartic acid, L-glutamic acid or L-aspartic acid supplemented medium. It is strange that strain 3*d* cannot grow on a medium consisting of casein hydrolysate and D-glutamic acid; but this phenomenon may be due to a mutual effect between D-glutamic acid and other amino-acids.

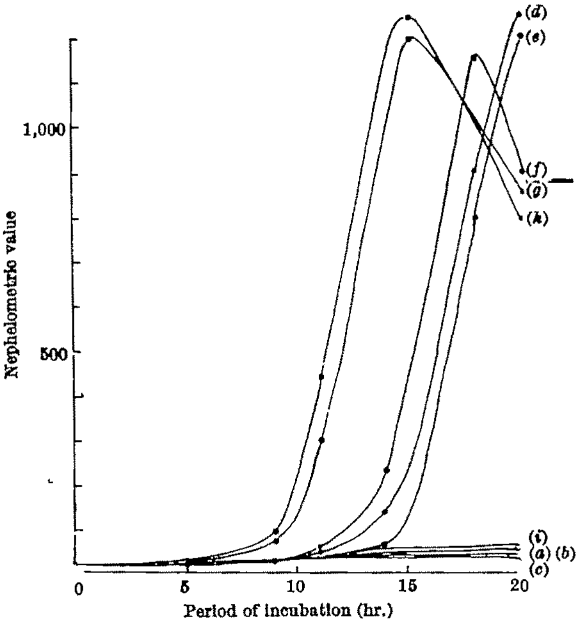


Fig. 1. Growth of strain 3*d* in media supplemented with (*a*) L-glutamic acid, (*b*) L-aspartic acid, (*c*) L-alanine, (*d*) D-glutamic acid, (*e*) D-aspartic acid, (*f*) D-alanine, (*g*) DL-glutamic acid, or (*h*) DL-aspartic acid. (*i*) is minimal medium

Fig. 1 shows growth-curves of strain 3*d* in media supplemented with 100 μgm./ml. of D, L or DL amino-acids, where cultivation was carried out in Monod tubes on a shaking machine at 37° C. Moreover, the minimal amount of D-glutamic acid sufficient to achieve full growth of strain 3*d* was determined to be 5–10 μgm./ml. The number of viable cells decreased rapidly when strain 3*d* was placed in a medium devoid of D-glutamic acid.

Haruo Momose
Yônosuke Ikeda

Institute of Applied Microbiology,
University of Tokyo.

[1] Work, E., *Nature*, **179**, 841 (1957).
[2] Thorne, C. B., "Bacterial Anatomy", 68 (Cambridge University Press, 1956).
[3] Gray, C. H., and Tatum, E. L., *Proc. U.S. Nat. Acad. Sci.*, **30**, 404 (1944).
[4] Burkholder, P. R., and Giles, N. H., *Amer. J. Bot.*, **34**, 345 (1947).
[5] Lederberg, J., and Lederberg, E. M., *J. Bact.*, **63**, 399 (1952).

T_6 and λ Phage Adsorption on Protoplast-like Bodies of *Escherichia coli*

During the past few years, methods have been developed for preparing spherical units of Gram-negative bacteria such as *E. coli*, which have often been described as 'large bodies' or 'protoplasts'. Unlike the protoplasts of Gram-positive bacteria, these spherical forms are also very sensitive to osmotic change. Whereas it can be shown by various methods that the cell wall is removed in the case of *B. megatherium*, this has not been proved conclusively for the spherical forms of *E. coli*. Since the cell wall of *E. coli*, unlike that of Gram-positive bacteria, contains a lipoprotein component as well as lipopolysaccharide[1] and at least four of five methods of preparation for spherical forms involve only polysaccharides, it is very probable that the spherical forms of *E. coli* are surrounded by cell-wall remains. If this is really the case, we may assume that these forms adsorb at least some of those phages, towards which the rod-shaped, normal cell is sensitive.

We have therefore investigated the adsorption of the T_6 and λ phages on spherical forms of *E. coli* strains.

This communication deals with the adsorption of phages T_2, T_6 and λ_{hc} on spherical forms of *E. coli*[2], strains *B*, 173–25 or *S*, which have been produced either with lysozyme[2a], penicillin[2b], phage enzyme[2c], glycine[2d] or by deprival of diaminopimelic acid[2e].

In general, the standard phage techniques, as described by Adams[3], have been used. Special techniques will be published in detail elsewhere. Normally, *E. coli* cells grown up to 2–5 × 10^8/ml. or dilutions 1 : 3–1 : 50 of overnight cultures were used. The conversion to spherical forms was made in media containing 12 per cent sucrose. Such conditions were chosen that at least 99 per cent of the cells were changed to the spherical form, that is, the survival rate after an osmotic shock (dilution 1 : 100 in phosphate-buffer 0·1 *M*, *p*H 7·0) was never higher than 1 per cent.

The adsorption of phages was studied in sucrose-broth (~100 gm. sucrose, 11 gm. peptone, 5·8 gm. sodium chloride/l.) over a period of 10 min. (phage T_2) or 15 min. (phages T_6 and λ_{hc}) at 37° C. Non-adsorbed phage was recovered after killing of the infected complexes with chloroform. The micro-

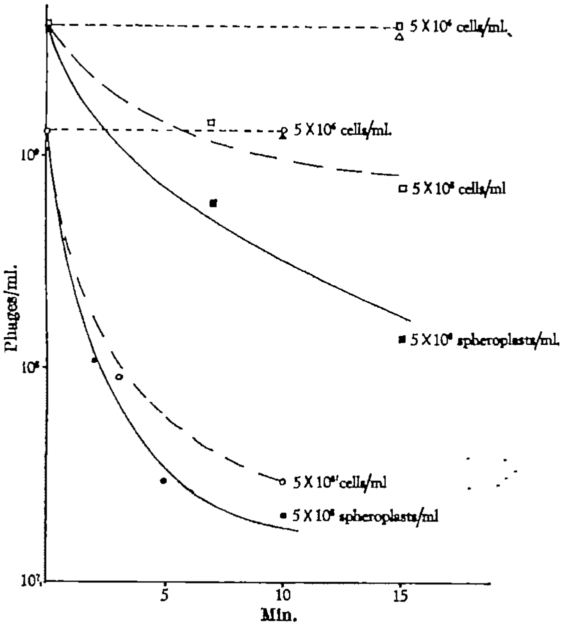


Fig. 1. Adsorption of phages T_2 and T_5 (● and ■) to spheroplasts obtained by treatment with 1,000 U./ml. penicillin in aerated culture at 37° C. during 75 min. (full symbols), to *E. coli* cells (empty symbols) and inactivation by cell-free supernatant of conversion medium (△)

scopically determined titre of the washed spherical forms was $\sim 5 \times 10^8$/ml. in experiments with phages T_2, T_5 and $\sim 10^5$/ml. in experiments with phage λ_{hc}.

Glycine treatment was also carried out in normal broth without addition of sucrose. In this case the conversion was only controlled by phase-contrast microscopy and the adsorption was measured in a sucrose-free medium.

As controls we used the conversion medium from which the cells had been removed by centrifugation, as well as normal *E. coli* cells of the same concentration as the spheroplasts and in a dilution 1 : 100. In this way we were able to take into account a possible adsorption on rod-shaped, non-converted bacteria and the inactivation of phage by soluble cell-wall material.

The comparison of adsorption by normal rod-shaped cells and spherical forms of equal titre should, under certain conditions, allow quantitative conclusions concerning the proportion of receptor substance still remaining.

A typical result is shown in Fig. 1. Phages T_2 and T_5 are adsorbed at the same rate on to *E. coli* cells as on to spherical forms (obtained by treatment with 1,000 U./ml. penicillin in aerated broth–sucrose medium during 75 min. at 37° C.).

The same rate of adsorption of the phages on both normal cells and spherical forms makes the assumption possible that the receptor substances for T_2 and T_5 phages remain quantitatively on the spheroplasts. But this assumption must be verified by further investigations in which a comparison between the highest possible number of adsorbed phages per spheroplast and per rod-shaped bacterium is made.

Similar results were obtained in parallel experiments with *E. coli* converted by phage-enzyme, lysozyme, glycine or by deprival of diaminopimelic acid and phages T_2 or T_5 and λ_{hc}. These results provide strong evidence that *E. coli* cells, after conversion in liquid suspension, are not true protoplasts since these are defined as being the protoplasm completely depleted of the cell wall. Indeed, the receptors for the phage T_2 have been shown to be situated in the cell wall. It seems to be obvious, in general, that the receptors should be at the surface of the wall. In these circumstances the term 'spheroplast' is preferable to protoplast as suggested by S. Brenner and others[4].

We are now studying the adsorption of the other T_i phages. This may be another way to investigate the localization of phage receptors in the cell-wall components.

On the completion of this work we read the paper by G. Dénes and L. Polgár[5] on T_2 phage multiplication in 'protoplasts' obtained by penicillin treatment, and found it in close agreement with our results.

These investigations were started in the Laboratoire de Biophysique, Geneva. We wish to thank Prof. E. Kellenberger and his collaborators for their many suggestions and for the courtesy of providing us with phage and bacterial strains. We also thank Dr. McQuillen, Cambridge, from whom we received *E. coli* strain 17325 and a sample of diaminopimelic acid.

We are also indebted to Prof. A. Butenandt for his encouragement throughout the course of this work, and for making the studies in Geneva possible.

P. H. HOFSCHNEIDER

Max-Planck-Institut für Biochemie,
München.

[1] Weidel, W., and Primosigh, J., *Z. Naturforsch.*, 11, *b*, 200 (1956).

[2] Weibull, C., "Ann. Rev. Microbiol.", 13, 1 (1958) (see also ref. 4). (*a*) Mahler, H. R., and Fraser, D., *Biochim. Biophys. Acta*, 22, 197 (1956). Repaske, R., *ibid.*, 22, 189 (1956). (*b*) Lederberg, J., *Proc. U.S. Nat. Acad. Sci.*, 42, 574 (1956). Liebermeister, K., and Kellenberger, E., *Z. Naturforsch.*, 11, *b*, 200 (1956). Lederberg, J., and Clair, J. St., *J. Bact.*, 75, 143 (1958). (*c*) Phage-enzyme preparation according to Weidel, W., and Primosigh, J., *Z. Naturforsch.*, 12, *b*, 421 (1957). (*d*) Jognes, M. H., *Nature*, 180, 867 (1957). (*e*) McQuillen, K., *Biochim. Biophys. Acta*, 27, 410 (1958).

[3] Adams, M. H., "Bacteriophages" (New York, 1959).

[4] Brenner, S., *et al.*, *Nature*, 181, 1713 (1958).

[5] Dénes, G., and Polgár, L., *Nature*, 183, 696 (1959).

The a–z–z_{35} Group of *Salmonella* Antigens

IN the course of establishing the antigenic formula for a new *Salmonella* serotype, *S.* greenside, its specific-phase flagellar antigen (*z*) was found to differ from the usual type as seen in *S.* poona, but to be identical to that of *S.* bulawayo[1]. Taylor, in describing the antigen z_{34} of *S.* chittagong, mentioned its relationship to both *z* of *S.* poona and *a* of *S.* paratyphi A.[2]. Common factors between *a*, *z*, and the antigen z_{35} of *S.* cairina were also described by Kauffmann[3], although z_{35} in this case was found to be slightly different from that of *S.* chittagong.

In view of these findings, an attempt has been made to clarify the relationships between these antigens by means of a series of agglutinin-absorption tests.

Rabbit antisera preserved with 50 per cent glycerine were used throughout these experiments. Sera prepared from biphasic *Salmonellae* were given an initial absorption with packed bacterial cells containing antigens corresponding to the unwanted flagellar phase.

Absorption tests were done by emulsifying packed cells in 5-ml. volumes of each serum, incubating at 37° C. for 18 hr., and removing the supernatant fluid after centrifugation. This procedure was repeated

Table 1. FLAGELLAR AGGLUTINATION REACTIONS BEFORE AND AFTER ABSORPTION

Agglutinable suspensions	Antisera											
	z (poona)	z (poona) absorbed with		z (bulawayo)	z (bulawayo) absorbed with		z_{35}	z_{35} absorbed with			a	a absorbed with z_{35}
		z (bulawayo)	z_{35}		z (poona)	z_{35}		a	z (poona)	$a + z$ (poona)		
S. poona (z)	2,560	160	1,280	2,560	0	320	640	160	0	0	0	0
S bulawayo (z)	640	0	160	2,560	80	640	320	160	0	0	0	0
S. chittagong (z_{35})	640	0	0	640	0	0	2,560	1,280	1,280	320	40	0
S. paratyphi A. (a)	0	0	0	0	0	0	1,280	0	640	0	2,560	2,560

Note 0 equals negative at 1/10 dilution. Figures indicate reciprocals of titres.

until no more agglutinins against the absorbing antigen could be demonstrated.

Agglutination tests were carried out in a 52° C. water-bath for 2 hr., using dilutions of serum in 0·85 per cent saline, and equal volumes of formalinized antigenic suspensions adjusted to approximately 1×10^9 bacilli per ml. The final serum dilutions ranged from 1/10 to 1/5120.

Comparison of the reactions before and after absorption shows that although a and z bear no direct antigenic relationship to each other, they each contain a fraction in common with z_{35} (Table 1).

The z complex can also be subdivided into two types, each of which has a specific factor and a factor common to both types, which includes the component shared with z_{35}.

Cross-absorption tests with z_{35} of *S.* cairina confirmed that it was not completely identical to z_{35} of *S.* chittagong, but showed that it shared the same factors with a and z.

Cultures of all z-containing *Salmonellae* described in the Kauffmann–White scheme were acquired from the National Collection of Type Cultures in London, or from the International Salmonella Centre in Copenhagen. Each culture was tested against specific factor sera prepared by saturating z (poona) and z (bulawayo) antisera with their heterologous antigens. All the cultures were agglutinated by one or other of the specific sera, thus forming two distinct groups (Table 2). It is of interest that the majority of the z_b group originated in central and southern Africa, including three first described from these laboratories (*S.* alexander, *S.* greenside, and *S.* rand).

Table 2. *Salmonellae* CONTAINING THE ANTIGEN z

z_p factor
S. bristol
S. businga
S. clerkenwell
S. entebbe
S. ezra
S. homosassa
S. indiana
S. kaolack
S. kiambu
S. poona
S. preston
S. schoeneberg
S. shubra
S. sundsvall
S. worthington

z_b factor
S. alexander
S. angola
S. bulawayo
S. carno
S. detroit
S. greenside
S. haarlem
S. nachshonim
S. nordenham
S. rand
S. tosamanga

Table 3. RELATIONSHIPS BETWEEN THE FLAGELLAR ANTIGENS a AND z_{35}

Agglutinable suspensions	Antisera			
	(a_2) *S.* miami absorbed with *S.* durban	(a_3) *S.* miami absorbed with *S.* paratyphi A.	(a_4) *S.* paratyphi A absorbed with *S.* miami	*S.* paratyphi A. absorbed with *S.* chittagong
S. paratyphi A. (a_1,a_3,a_4)	160	0	40	2,560
S. durban (a_1,a_3)	0	40	0	640
S. miami (a_1,a_2,a_3)	320	80	0	640
S. chittagong (z_{35})	0	0	0	0

le Minor[4] has shown that the a antigen is a complex one, divisible into four components, of which *S.* paratyphi A. possesses three (a_1, a_3, and a_4). Further tests were now undertaken to see which, if any, of these factors was the one shared with z_{35}.

The results (Table 3) confirm le Minor's findings, and show that the antigen shared with z_{35} is a part of the a_1 fraction. This is proved by the inagglutinability of z_{35} in specific factor sera for a_2, a_3, and a_4, and by the fact that an a antiserum (*S.* paratyphi A.), after absorption with z_{35}, still contains agglutinins for the antigens of *S.* paratyphi A., *S.* miami, and *S.* durban.

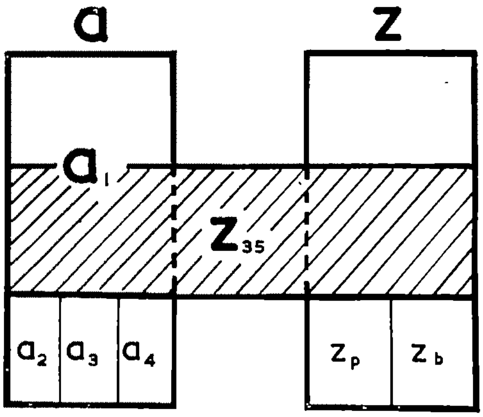


Fig. 1. Diagrammatic illustration of the relationships between the flagellar antigens a, z and z_{35}

The results of this series of experiments are summarized diagrammatically in Fig. 1. It will be seen that both the a and z antigens occur in different forms, each consisting of a common major fraction and one or more specific minor fractions. z_{35} shares one component with part of a_1, and a different component with part of the major fraction of z.

LEONARD SCHRIRE

South African Institute for Medical Research,
Johannesburg.

---

[1] Schrire, L., Kauffmann, F., and Edwards, P. R., *Acta Path. Microbiol. Scand.*, **41**, 156 (1957).

[2] Taylor, J., Hayes, W., Freeman, J., and Anderson, E. S., *J. Path. and Bact.*, **60**, 35 (1948).

[3] Kauffmann, F., Fain, A., and Schoetter, M., *Acta Path. Microbiol. Scand.*, **31**, 383 (1952).

[4] le Minor, L., *Ann. Inst. Pasteur*, **88**, 76 (1955).

VIROLOGY

Antigenic Structure of Non-Infectious Adenovirus Materials

HeLa cells infected with adenovirus type 5 produce, in addition to virus particles, three non-infectious materials previously named antigens *A*, *B* and *C*[1]. These antigens can be separated by electrophoresis[1] and by chromatography on diethylaminoethyl cellulose columns[2]. Antigen *B* corresponds to the protein factor responsible for the early cytopathic action of adenoviruses in HeLa cell cultures[3,4] and possibly also to the cell-detaching factor described by Rowe *et al.*[5]. Antigens *A* and *C*, but not antigen *B*, contain deoxyribonucleic acid[6]. A comparison of these three antigens by gel-diffusion precipitation tests revealed a partial identity of antigens *B* and *C* and absence of antigenic relationship of either of these two materials with antigen *A* [1].

In the present investigation, an attempt was made to establish more precisely the relationship between antigens *B* and *C*. The virus material used was obtained from HeLa cells infected with the prototype strain of adenovirus type 5. A partially purified antigen was prepared by treatment of the infected cells with the fluorocarbon compound 'Arcton 63' (Imperial Chemical Industries, Ltd., London, S.W.1) as described by Pereira and Valentine[7]. Chromatographic fractionation was carried out on diethylaminoethyl cellulose columns at *p*H 6·5, using stepwise elution with sodium chloride concentrations varying from 0·01 to 0·35 *M* in 0 05 *M* steps. The antiserum used throughout was from a rabbit immunized with the unfractionated virus material.

The complex nature of antigen *B* was first suggested by the fact that digestion of this antigen by 0·1 per cent crystalline trypsin at *p*H 7·4 for 1 hr. at 37° C. resulted in complete abolition of its cytopathic action for HeLa cells while its complement-fixing activity remained practically unchanged. The effect of trypsin on the behaviour of antigen *B* in gel-diffusion precipitation tests was next investigated. The results of a representative test are shown diagrammatically in Fig. 1. The reaction between antiserum and unfractionated antigen gives three precipitation lines corresponding to antigens *A*, *B* and *C* as indicated. Antigen *B* isolated by chromatography gives a single precipitation line continuous with the corresponding line of the original antigen and showing reactions of partial identity with antigen *C* and of non-identity with antigen *A*. After trypsin digestion, the same antigen *B* preparation gives a single precipitation line showing reactions of identity with antigen *C* and non-identity with antigen *A*. This result suggests that antigen *B* is a complex of a trypsin-sensitive protein with the trypsin-resistant antigen *C*.

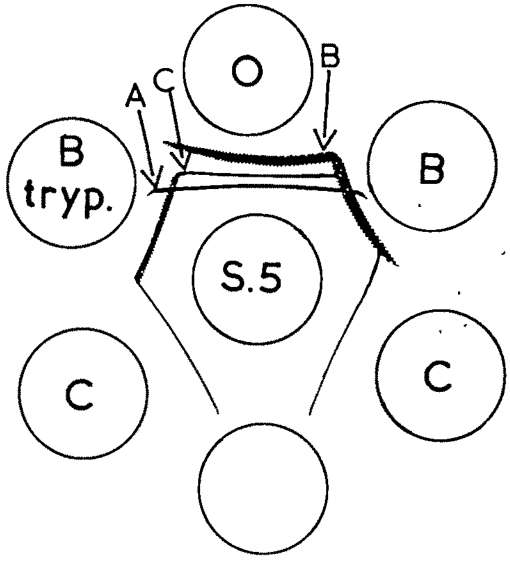


Fig. 1. Gel-diffusion precipitation test between adenovirus type 5 antiserum (*S* 5) and homologous antigens. *O*, Unfractionated antigen; *B*, antigen *B* isolated by chromatography; *B* tryp., the same antigen *B* preparation digested by trypsin; *C*, antigen *C* isolated by chromatography

This suggestion is supported by chromatographic studies shown in Fig. 2. The upper curve in this figure shows the fractionation of the original virus material into three antigenic components previously shown by Klemperer and Pereira[2] to correspond to antigens *A*, *B* and *C* with elution peaks at 0·275, 0·15 and 0·05–0·075 *M* sodium chloride respectively. The two eluates with highest complement-fixing titres in the band corresponding to antigen *B*, namely, the 0·15 and 0·175 *M* eluates, were pooled and divided into two equal parts, one of which was digested by trypsin under the conditions mentioned above. Both parts were dialysed against 0·01 *M* phosphate buffer at *p*H 6·5 and re-chromatographed under the same conditions as those used for the original antigen. Complement-fixation titres of the eluates are shown in the middle and lower curves of Fig. 2 for untreated and trypsinized materials respectively. The untreated antigen was eluted essentially in a single band with a peak at 0·2 *M* sodium chloride. The difference in position of this elution band as compared with that of the corresponding antigen in the original run is difficult to understand; it could be due to displacement effects caused by antigens or other components present in the starting material. The trypsinized antigen, in contrast, was eluted at lower concentrations of sodium chloride, with a peak corresponding closely in position to that of antigen *C* in the original run.

The nature of the antigenic component common to antigens *B* and *C* was further investigated by staining the gel-diffusion precipitation lines with acridine orange following the technique developed by Allison and Armstrong[8]. It had been previously shown by this technique[6] that antigen *C* present in unfractionated virus materials was stained by acridine orange, giving a strong yellow-green fluorescence; this indicates the presence of deoxyribonucleic acid in this antigen. No such staining reaction was, however, obtained with precipitation lines of antigen *B*. Identical results were obtained with antigens fractionated by chromatography, and no deoxyribonucleic acid could be detected by this method either in untreated or in trypsinized antigen *B*. The antigenic component common to antigens *B* and *C* is shown, therefore, to be free of deoxyribonucleic acid.

For convenience, we will designate the trypsin-sensitive component of the *B* complex as antigen β and the trypsin-resistant component common to *B* and *C* as antigen γ. The antigenic factor so far identified in *A* will be designated antigen α. The various components of non-infectious adenovirus type 5 antigens are shown in Table 1. It should be pointed out that the components listed there may account

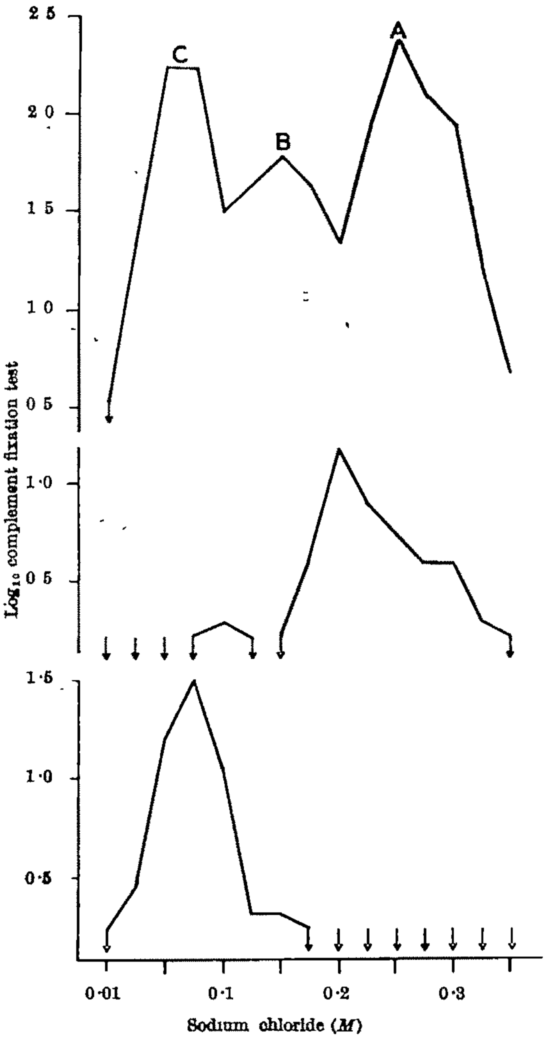


Fig. 2. Chromatography of adenovirus type 5 antigens on '*DEAE*-cellulose' columns. Stepwise elution with increasing concentrations of sodium chloride at constant *p*H (6·5). Eluates tested by complement fixation against adenovirus type 5 antiserum. Top curve, original virus material; middle curve, rechromatography of antigen *B* fractions (0·15 and 0·175 *M* eluates); lower curve, same as above, rechromatographed after trypsin digestion

for only part of the structure of antigens *A*, *B* and *C*. It is possible that the deoxyribonucleic acid components of antigens *A* and *C* may be nucleoproteins rather than pure deoxyribonucleic acid. This or additional factors not detected by the methods used in the present study might explain some anomalies apparent in the chromatographic behaviour of the antigens studied. A complex of antigen γ with deoxyribonucleic acid would be expected to elute from diethylaminoethyl cellulose at higher molarities than a complex of the same γ with another protein. The fact that antigen *C* is eluted from the columns before antigen *B* (Fig. 2) suggests, therefore, a higher complexity of the system.

The present findings might help to explain the possible relations of the antigens under study with virus particles and with the protein crystals free of deoxyribonucleic acid observed by Leuchtenberger and Boyer[9] and by Morgan *et al.*[10] in nuclei of HeLa cells infected with adenovirus type 5. It is tempting to speculate, for example, that complexes of antigen γ with nucleic acid or nucleoprotein would tend to aggregate to form virus particles whereas complexes of the same antigen with protein β would form the protein crystals free of deoxyribonucleic acid.

Table 1. Components Identified in Non-infectious Adenovirus Type 5 Antigens

Antigen	Component
A	α deoxyribonucleic acid
B	γ β
C	γ deoxyribonucleic acid

I am indebted to Drs. A. C. Allison, H. G. Klemperer and R. Porter for valuable suggestions and criticism.

H. G. Pereira

National Institute for Medical Research,
Mill Hill, London, N.W.7.

[1] Pereira, H. G., Allison, A. C., and Farthing, C. P., *Nature*, 183, 895 (1959).

[2] Klemperer, H. G., and Pereira, H. G., *Virology*, 9, 536 (1959).

[3] Pereira, H. G., *Virology*, 6, 601 (1958).

[4] Everett, S. F., and Ginsberg, H. S., *Virology*, 6, 770 (1958).

[5] Rowe, W. P., Hartley, J. W., Roizman, B., and Levy, H. B., *J. Exp. Med.*, 108, 713 (1958).

[6] Allison, A. C., Pereira, H. G., and Farthing, C. P., *Virology*, 10, 316 (1960).

[7] Pereira, H. G., and Valentine, R. C., *J. Gen. Microbiol.*, 19, 178 (1958).

[8] Allison, A. C., and Armstrong, J. A. (to be published).

[9] Leuchtenberger, C., and Boyer, G. S., *J. Biochem. Biophys. Cytol.*, 3, 323 (1957).

[10] Morgan, C., Godman, G. C., Rose, H. M., Howe, C., and Huang, J. S., *J. Biophys. Biochem. Cytol.*, 3, 505 (1957).

SOIL SCIENCE

Capillary Movement of Nitrate towards Tropical Soil Surfaces

As in many other parts of the tropics, accumulation of nitrate in the top inch of soil during the dry season has been observed at Katherine, Northern Territory, Australia, on a red sandy clay loam. The accumulation could be caused by a complex of processes of a physico-chemical, photo-chemical, biological or physical nature. Experiments at Katherine have shown that capillary movement has been obscured, rather than overlooked, as the main cause.

During the 1959 dry season, changes in chloride and nitrate content in the top soil of a clean fallow were followed in the 0–1, 1–2, 2–3, 3–6, 6–9 and 9–12 in. layers from April 20 onwards, that is, one day after the last rain in April. Normally, the rains end in April and are followed by a five-months rainless period. However, in 1959, 0·95 in. fell between May 18 and 24.

Chloride was applied to the soil surface on March 2 in the form of sodium chloride at the rate of 2,000 lb./acre. Leaching of this ion by the subsequent 13 in. of rain resulted on April 20 in a chloride distribution over the top 12 in. of soil as is given in Fig. 1. Comparative fallow plots receiving no salt were sampled for nitrate. Its distribution over the top 12 in. on the first sampling date is given in Fig. 2.

The progress of accumulation of chloride and nitrate near the soil surface is shown in Figs. 1 and 2. Chloride content in the top inch increased significantly from 950 p.p.m. on April 20 to 2,977 p.p.m. chloride on June 22, and nitrate significantly from 38 to 229 p.p.m. nitrate over the same period. Chloride content at this level decreased temporarily after the rain in May, but increased again in the following dry weather. Nitrate content in the top inch did not decrease after the May rain, due presumably to a short period of nitrification at adequate moisture content, but showed a concentration pattern similar to that of chloride in the 12 in. profile throughout the sampling period.

More detailed sampling of the top 1¾ in. of the soil, in ¼ in. layers, revealed that the level of maximum accumulation is not at the surface but at a depth determined by the bottom of the soil crust. At this level the soil has an open and loose structure, and below it the soil is hard and compacted. A typical nitrate stratification in the top 1¾ in. of the soil, measured in August at one point, is given in Fig. 3. The level of maximum nitrate accumulation has consistently been found to coincide with the bottom of the soil crust and is not related to actual soil depth. Chloride accumulation shows an exactly similar relationship with the crust.

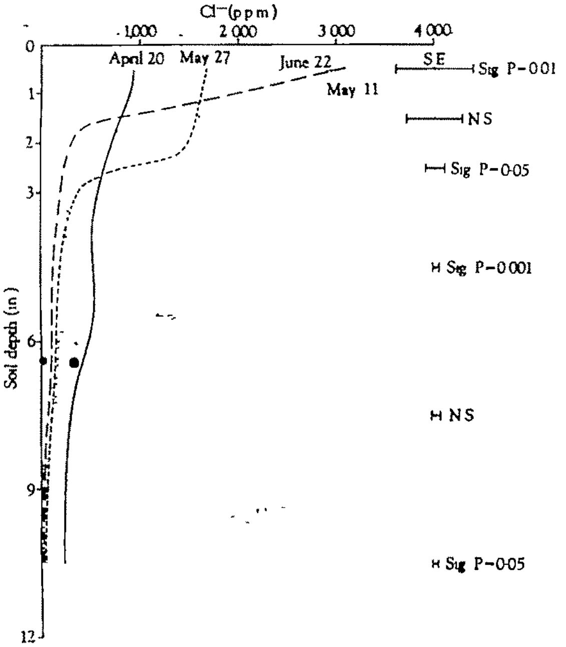


Fig. 1

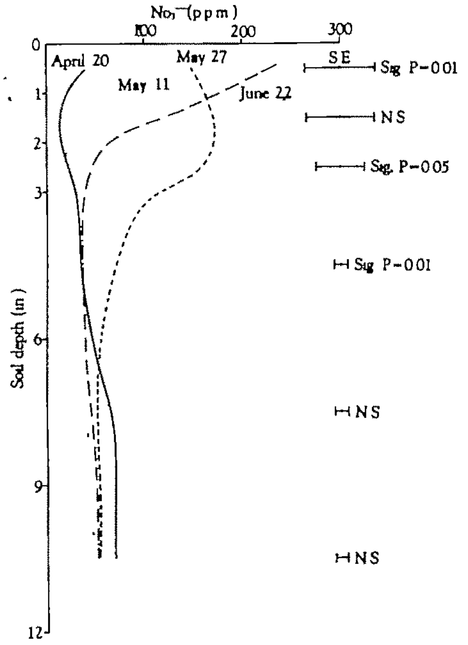


Fig. 2

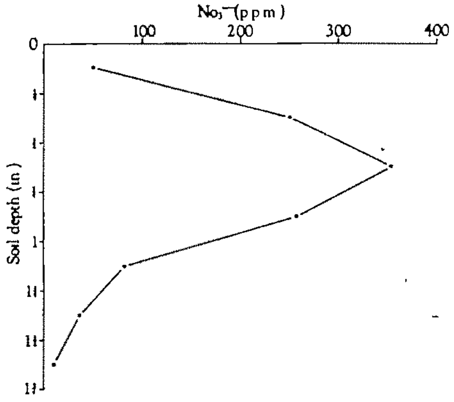


Fig. 3

This relationship and the fact that nitrate and chloride stratifications are affected in similar ways by rain and a following dry period indicate strongly that the main cause of nitrate accumulation near the surface of the soil is a physical one, for which capillary movement is the only acceptable explanation.

Further details will be published elsewhere.

R. Wetselaar

Division of Land Research and Regional Survey,
Commonwealth Scientific and Industrial Research
Organization,
Canberra.

Complexes of Calcium-Montmorillonite with Polymers

Various types of polymers have been used to stabilize soil crumbs[1-5], the polymers linking together the domains of clay crystals within the crumbs[6]. To obtain further information on the nature of clay–polymer bonds, the interaction of calcium-montmorillonite with a wide range of polymers has been studied.

A neutral suspension of calcium-montmorillonite in 2×10^{-3} *M* calcium chloride was prepared from the $< 2\mu$ fraction of Wyoming bentonite (Volclay). To an aliquot of this suspension a known amount of organic material was added as a neutral solution. The calcium chloride present ensured that complexes formed rapidly after mixing, large flocs appearing within a few seconds. The clay was then filtered through a sintered glass funnel and later dried over phosphorus pentoxide to form an orientated disk 0·02 mm. thick.

Flakes about 4 mm. square were cut from the disk and their thickness measured with a travelling microscope reading to 0·002 mm. The swelling of the flake was determined after immersion in *M* calcium chloride and then in progressively more dilute calcium chloride solutions. The effect of adding 1·0 per cent of various materials on the swelling of calcium-montmorillonite is shown in Fig. 1, the ordinate being the ratio of the increase in thickness of the

Table 1. EFFECT OF LEACHING ON THE DISPERSION OF CALCIUM-MONTMORILLONITE COMPLEXES

Leaching treatment	Dispersion medium	Addition			
		None	1·0 per cent		
			Group 1	Group 2	Group 3
			Sodium alginate Sodium pectinate Sodium carboxy-butyl cellulose Sodium humate (from soil)	Sodium polyacrylate Polyacrylamide	Polyvinyl alcohol Polyglucosans Polyfructosans
N sodium chloride	*N*/100 sodium chloride	Dispersed in 2–3 hr.	Dispersed in 2–3 hr.	No dispersion	No dispersion
Neutralized 0·15 *M* sodium pyrophosphate	*N*/10 sodium chloride	Dispersed in 2–3 hr.	Dispersed in 2–3 hr.	Dispersed in 2–3 hr.	No dispersion

flake $(h-h_0)$ to its initial thickness (h_0) over phosphorus pentoxide.

The expansion of the clay in *M* calcium chloride is predominantly intra-crystalline, the d_{001} spacing increasing from 10·0 Å. (over phosphorus pentoxide) to 18·9 Å. In the more dilute calcium chloride solutions the swelling of the untreated clay is due to increasing separation of the clay crystals, as the d_{001} spacing in water is almost unchanged at 19·2 Å. A similar spacing in water has been reported previously[7-9]. As shown in Fig. 1, the inter-crystalline expansion was prevented by the addition of 1 per cent of cetyltrimethyl ammonium bromide or polyvinyl alcohol and largely suppressed by the same quantity of sodium alginate or polyacrylamide. Of these materials, cetyltrimethyl ammonium bromide, an organic cation and polyvinyl alcohol have been found to react with the basal surfaces of montmorillonite, for with increasing concentration they penetrate between the individual silicate sheets forming inter-lamellar complexes[10,11].

The similarity in the swelling pattern of the various complexes suggests that all four materials are reducing the expansion of the clay by linking together the basal surfaces of the clay crystals.

Further information on the nature of the clay–polymer bonds was obtained by trying to replace the exchangeable calcium ions on the clay by sodium ions. Flakes of calcium-montmorillonite with and without 1·0 per cent of polymer added were leached with *N* sodium chloride or 0·15 *M* sodium pyrophosphate adjusted to *p*H 7·0. Afterwards, the behaviour of the flakes was observed in dilute sodium chloride solutions. The results for a range of polymers are given in Table 1. Dispersion of the clay plus polymer flake at the same concentration of sodium chloride as the untreated clay indicates that the polymer has been removed.

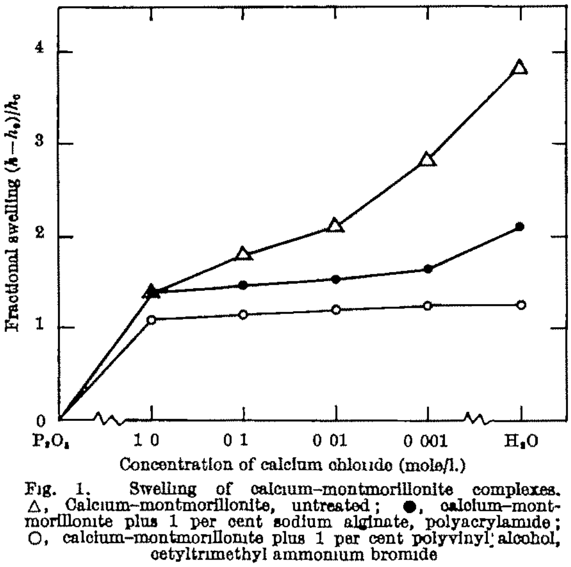


Fig. 1. Swelling of calcium–montmorillonite complexes. △, Calcium–montmorillonite, untreated; ●, calcium–montmorillonite plus 1 per cent sodium alginate, polyacrylamide; ○, calcium–montmorillonite plus 1 per cent polyvinyl alcohol, cetyltrimethyl ammonium bromide

The polymers have been divided into three groups according to their ease of displacement. Polymers of group 1 were readily removed by *N* sodium chloride. This indicates that the complexes were formed by precipitation with the exchangeable calcium ions near the basal surfaces of the clay crystals. The second group was only removed by a strong solution of sodium pyrophosphate. From this, it is inferred that the polymers formed co-ordination compounds with the exchangeable calcium ions, but that these calcium ions could be displaced by a strong sequestering agent. The remaining group of polymers was unaffected by either treatment. Here, the bonding, therefore, is independent of the valency of the exchangeable cation. It is inferred that these polymers are linked by a series of hydrogen bonds between the polymer hydroxyl groups and the surface oxygens of the silicate sheets.

The complex with humic acid extracted from soil is of interest. Previously it has been shown that the clay in soil crumbs from old grassland is still held together after leaching with neutralized sodium pyrophosphate[12]. It follows from the above results that although humic acid can link clay crystals together, it is too easily removed to be the important polymer in soil organic matter for stabilizing soil crumbs.

I wish to thank Dr. K. Norrish for determining the X-ray spacings and Dr. R. Swaby for the sample of humic acid.

W. W. EMERSON

Division of Soils,
Commonwealth Scientific and
Industrial Research Organization,
Adelaide.

[1] Quastel, J. H., *Soil Sci.*, 73, 419 (1952).
[2] Hedrick, R. M., and Mowry, D. T., *Soil Sci*, 73, 427 (1952).
[3] "Soil Stabilization Research Sponsored by Industrial Funds" (Mass. Inst. Tech, 1952).
[4] Montgomery, R. S., and Hebbard, B. B., *Soil Sci.*, 79, 283 (1955).
[5] Emerson, W. W., *J. Agric. Sci.*, 47, 117 (1956).
[6] Emerson, W. W., *J. Soil Sci.*, 219, 10 (1959).
[7] Hofmann, U., and Bilke, W., *Koll. Z*, 77, 238 (1936).
[8] Barshad, I., *Amer. Min.*, 34, 675 (1950).
[9] Quirk, J. P, and Norrish, K., *Nature*, 173, 255 (1954).
[10] Jordan, J. W., *J. Phys. and Colloid Chem.*, 53, 294 (1949)
[11] Emerson, W. W., *Nature*, 176, 461 (1955).
[12] Emerson, W. W., *J. Agric. Sci.*, 47, 122 (1956).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 16

UNIVERSITY OF LONDON (at the Wright-Fleming Institute of Microbiology, St. Mary's Hospital Medical School, Norfolk Place, London, W.2), at 5 p.m.—Prof. R. R. Porter: "The Structure of Gamma Globulin and Antibodies". (Third of four Almroth Wright Lectures. Further lecture on May 23.)

BRITISH SOCIETY FOR THE PHILOSOPHY OF SCIENCE (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Marjorie Grene: "Adaptation and Evolution".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. F. H. S. Brown: "The Power System". (Second of Three Cantor Lectures on "Energy".)

Tuesday, May 17

LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE (at Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Prof. C. H. Waddington, F.R.S.: "Evolutionary Wisdom and Ethical Value"* (Fourth Auguste Comte Memorial Lecture).

ROYAL AERONAUTICAL SOCIETY, HISTORICAL GROUP (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Sir Thomas Sopwith, C.B.E.: "My First Ten Years" (Inaugural Lecture).

Wednesday, May 18

INSTITUTION OF ELECTRICAL ENGINEERS (at the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1), at 10 a.m.—Symposium on "Electronic Equipment Reliability—Field Experience and Methods of Assessing and Predicting Reliability".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. F. K. Hare: "The Summer Circulation of the Arctic Stratosphere Below 30 km.", Mr. J. L. P. Jones and Mr. F. Pasquill: "An Experimental System for Directly Recording Statistics of the Intensity of Atmospheric Turbulence"; Mr. J. L. Monteith: "The Reflection of Short-Wave Radiation by Vegetation".

WOMEN'S ENGINEERING SOCIETY (at "Hope House", 45 Great Peter Street, London, S.W.1), at 7 p.m.—Miss R. Winslade: "Electronic Weighing".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. David Lack, F.R.S.: "A Survey of the Conflict Between Evolution Theory and Christian Belief".

Thursday, May 19

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 4 p.m.—Annual General Meeting. Prof. David Williams: "Progress in Mining Geology—Education Research and Employment" (Presidential Address).

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. J. M. Aronson and Prof. R. D. Preston, F.R.S.: "An Electron Microscope and X-ray Analysis of the Walls of Selected Lower Phycomycetes"; Mr. H. G. Callan and Mr. L. Lloyd: "The Lampbrush Chromosomes of Crested Newts *Triturus cristatus* (Laurenti)".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Annual General Meeting, followed by Dr. A. M. Spooner: "Technical Features of a New Television Studio at Wembley".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. M. J. Lighthill, F.R.S.: "Mathematics and Aeronautics" (48th Wilbur Wright Memorial Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. G. S. Nelson: "Schistosomes as Zoonoses in Africa".

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 7.30 p.m.—Annual General Meeting. 8 p.m.—Dr. V. E. Cosslett: "X-Ray Microscopy—Retrospect and Prospect" (Thirty-ninth Silvanus Thompson Memorial Lecture).

Friday, May 20

ROYAL SOCIETY OF MEDICINE, EPIDEMIOLOGY AND PREVENTIVE MEDICINE and COMPARATIVE MEDICINE SECTIONS (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Discussion on "Myxomatosis in Britain"., Speakers: Dr. C. H. Andrewes, Mr. H. V. Thompson and the Hon. Miriam Rothschild.

Friday, May 20—Saturday, May 21

BRITISH SOCIETY FOR IMMUNOLOGY (in the Hall of the London Hospital Medical College, Ashfield Street, London, E.1)—Spring Meeting.

Friday, May 20

At 10 a.m.—Symposium on "Immunological Aspects of Diseases of Connective Tissue". Chairman: Dr. L. E. Glynn.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (with special qualifications in palæontology) IN GEOLOGY—The Secretary, The University, Belfast (May 20).

ASSISTANT LECTURER IN ZOOLOGY—The Registrar, The University, Manchester 13 (May 21).

LECTURER IN THE DEPARTMENT OF NATURAL PHILOSOPHY—The Secretary, The University, Edinburgh (May 21).

EXPERIMENTAL PHYSICIST to work for a D.Phil. degree on high temperature physics, plasma physics, ionization in gases or nuclear gas reactions at very low kinetic energy—T. C. Keeley, Esq., C.B.E., M.A., The Clarendon Laboratory, The University, Parks Road, Oxford (May 21).

READERS IN NUCLEAR PHYSICS; MATHEMATICS (preferably Mathematical Physics); MATHEMATICS (Electronic Digital Computers); and CHEMICAL ENGINEERING—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (May 21).

LECTURER (Grade II) IN STATISTICS within the Department of Mathematics—The Registrar, The University, Bristol (May 23).

READER (with outstanding research ability) IN PHYSICS; a SENIOR LECTURER (with a good honours degree together with research and/or industrial experience, and preferably an interest in nuclear physics) IN PHYSICS; and an ASSISTANT LECTURER, Grade "B" (with a good honours degree) IN PHYSICS—The Registrar, Royal Technical College, Salford 5, Lancs (May 23).

TECHNICAL OFFICER (with a specialized knowledge of optical design and appropriate experience, and preferably mathematics and physics to G.C.E. "O" level) IN OPTICAL DESIGN, at the Weapons Research Establishment, Salisbury, South Australia, to be responsible for the design of optical lenses and systems, under the general guidance of the professional staff—Senior Representative (AV. 60/3), Department of Supply, Australia House, Strand, London, W.C.2 (May 23).

INSTRUMENT TECHNICIAN (Experimental Officer grade, with H.N.C. or equivalent), for the development, adaptation and maintenance of instruments used by research departments—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (May 24).

KEEPER IN BOTANY (with a good honours degree in botany and/or a Museums Diploma, and preferably museum experience)—The Director, Liverpool Public Museums, Carnatic Hall, Elmswood Road, Liverpool 18 (May 24).

LECTURER, Grade II, IN CHEMICAL PHYSIOLOGY—The Registrar and Secretary, The University, Bristol (May 24).

NEMATOLOGIST; and a GENETICIST (Plant Breeder) (Scientific Officer grade, with an honours degree in an appropriate scientific subject, and preferably postgraduate experience)—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (May 24).

ASSISTANT EXPERIMENTAL OFFICER (graduate, with a degree in zoology and/or botany and an interest in biochemistry, also those graduating in 1960 considered) IN THE NEMATOLOGY DEPARTMENT—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (May 28).

ASSISTANT LECTURER IN PHILOSOPHY—The Registrar, University College of Wales, Aberystwyth (May 30).

ASSISTANT LECTURER (preferably with a special interest in inorganic chemistry) IN CHEMISTRY—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (May 30).

ASSISTANT LECTURERS (2) IN PHYSICS—The Principal, Royal Holloway College, Englefield Green, Surrey (May 31).

CHAIR OF BOTANY—Joint Clerk to the University Court, The University, St. Andrews (May 31).

FELLOW, for research on factors influencing flowering and seed production in herbage grasses—The Registrar (Room 22, O.R.B.), The University, Reading (May 31).

LECTURER or SENIOR LECTURER IN GENETICS AND PLANT BREEDING; an ASSISTANT LECTURER IN BOTANY; and a DEMONSTRATOR IN ZOOLOGY in the Department of Biological Sciences—The Registrar, Wye College (University of London), near Ashford, Kent (May 31).

RESEARCH ASSISTANT (preferably candidate with either a degree in geology with good subsidiary zoology or a good degree in zoology with subsidiary geology) IN VERTEBRATE PALÆONTOLOGY IN THE DEPARTMENT OF GEOLOGY—The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (May 31).

ESSO RESEARCH FELLOW IN PHYSICAL CHEMISTRY, to work in the field of heterogeneous catalysis—The Registrar, The University, Nottingham (June 1).

RESEARCH FELLOW (post-doctoral chemist or biochemist) IN THE DEPARTMENT OF CHEMISTRY of the Faculty of Science, to take part in work on the synthesis of nucleotide analogues and the study of their metabolism—The Registrar, The University, Manchester (June 1).

ASSISTANT DIRECTOR OF GRADUATE STUDIES IN THE DEPARTMENT OF PHYSICAL CHEMISTRY—The Registrar, The University, Leeds 2 (June 7).

ASSISTANT LECTURER or LECTURER (with special qualifications in pure mathematics) IN MATHEMATICS—The Registrar (Room 22, O.R.B.), The University, Reading (June 7).

BOTANIST, Scientific Officer grade (with a good honours degree and preferably postgraduate training or research experience), to study the development and anatomy of apples in relation to storage behaviour—The Secretary, East Malling Research Station, near Maidstone, Kent (June 11).

PLANT PHYSIOLOGIST (honours graduate in science or agricultural science with appropriate postgraduate research experience) IN THE DIVISION OF PLANT INDUSTRY, Commonwealth Scientific and Industrial Research Organization, Canberra, A.C.T., Australia, to initiate studies on the physiology of growth in pastures and pasture plants with the ultimate aim of understanding more fully the determination of pasture yield—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 130/418 (June 11).

Senior Lecturer (with research experience) in Physiology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 11).

Associate Professor in Mathematics; a Senior Lecturer or Lecturer in Mathematics; a Senior Lecturer or Lecturer in Statistics; a Senior Lecturer or Lecturer in Botany; a Senior Lecturer or Lecturer in Chemistry; a Senior Lecturer or Lecturer in Geology; a Senior Lecturer or Lecturer in Physics; and a Senior Lecturer or Lecturer in Zoology at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 15).

Lecturer (graduate in science, preferably with honours in physiology, or with a higher degree, or graduate in medicine or veterinary science, and preferably with experience in research in, or teaching of, physiology) in Physiology at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 15).

Lecturer in the Department of Chemical Engineering, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, June 15).

Senior Lecturer in Physics; Lecturers (2) in Chemistry; a Lecturer in Civil Engineering; and Lecturers (2) in Mathematics at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, June 15).

Lecturer and a Senior Lecturer in Applied Mathematics at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 18).

Lecturer (honours graduate in either physics or electrical engineering, and preferably with an interest in audiofrequency acoustics associated with human communication) in Acoustics in the Department of Physics—The Registrar, The University, Liverpool, quoting Ref. No. CV/N (June 18).

Senior Lecturer or Lecturer in Physics at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, June 18).

Lecturer (qualified and interested in any of the following research topics: solid state studies, X-ray spectrography of solids and gases, radio investigations of the upper atmosphere such as meteorite distribution, auroral zone detection and studies of the lower ionosphere); and an Assistant Lecturer (with an honours degree in physics) in the Department of Physics, University of Canterbury, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, June 30).

Senior Technician in the Department of Physiology; and a Scientific Instrument Mechanic, to take charge of the Faculty of Science Workshop, Makerere College, The University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 30).

Mental Health Research Fund Fellows (suitably qualified persons wishing to pursue full-time research work bearing on problems of mental health, whether in clinical psychiatry, or one of its supporting sciences)—The Secretary, Research Committee, Mental Health Research Fund, 39 Queen Anne Street, London, W.1 (October 1).

Biochemist, Basic grade (graduate in chemistry or Associate or Graduate Member of the Royal Institute of Chemistry), in the Department of Pathology—The Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

Biochemist, or an Organic or Physical Chemist (university graduate with first- or second-class honours), to work at Millport on organic matter in sea water in its relation to marine organisms—The Director, Scottish Marine Biological Association, Marine Station, Millport, Isle of Cumbrae, Scotland.

Biochemist (Senior or Basic grade), to the Rochdale Group of Hospitals, to work under the Consultant Pathologist and to carry out biochemical work for the hospitals and clinics of the Group—The Group Secretary, Rochdale and District Hospital Management Committee, Central Offices, Birch Hill Hospital, Rochdale, Lancs

Head (medical graduate or science graduate with a higher degree) of the Division of Virology, for duties which will include the supervision of diagnostic services and the carrying out of special investigations on, and research into, virus diseases—The Director, Institute of Medical and Veterinary Science, P.O. Box 14, Rundle Street, Adelaide, South Australia.

Lecturer (male, single, preferably specializing in entomology and/or animal physiology) in Agricultural Zoology and Assistant Warden—The Clerk to the Governors, Essex Institute of Agriculture, Writtle, near Chelmsford.

Lecturer (with a good honours degree in mathematics with teaching and/or industrial and research experience) in Mathematics—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham, Essex.

Research Assistant (man or woman) in Zoology, to assist Prof. T. A. Stephenson, F.R.S., with the completion of a book on the seashore ecology of the world—The Registrar, University College of Wales, Aberystwyth.

Senior Lecturer and a Lecturer (with an honours degree in physics, industrial and/or research experience in some branch of applied physics, and teaching experience) in the Department of Physics—The Registrar, College of Science and Technology, Ashley Down, Bristol 7.

Senior Technician or Technician for duty in the Clinical Isotope Laboratory—The House Governor, St. Mary's Hospital, Paddington, London, W.2.

Technical Editor (preferably with a pass degree, H.N.C., or equivalent qualification, and appropriate experience in a related field of work), to be employed on editing, proof-reading, indexing and distribution of scientific reports, technical specifications, etc., and the handling of information inquiries relating thereto—The Senior Recruitment Officer, United Kingdom Atomic Energy Authority, A.W.R.E., Aldermaston, Berks, quoting Ref. No. A.2493/34.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Genetical Research, Vol. 1, No. 1 (February 1960). Pp. 172+5 plates. Published in February, July and November. Subscription rate: 100*s.* net (including postage) for an annual volume of three parts (17.50 dollars, U.S.A.). Separate parts 40*s.* or 7 dollars (plus postage). (London and New York: Cambridge University Press, 1960.) [252

Bulletin of the British Museum (Natural History). Zoology. Vol. 6, No. 2: A Revision of the Platyseiinae (Mesostigmata: Aceosejidae) based on Material in the Collections of the British Museum (Natural History). Pp. 25–101. (London: British Museum (Natural History), 1960.) 24*s.* [252

Liverpool Observatory and Tidal Institute. Annual Report, 1959. Pp. 19. (Liverpool: Liverpool Observatory and Tidal Institute, 1960.) [252

Discovery Reports, Vol. 30: Ascidiacea. Pp. 1–160+plates 1–6. (Cambridge: At the University Press, 1960.) 70*s.* net. [252

The Christian Approach in Teaching Science. By Dr. R. Hooykaas. Pp. 20. (London: The Tyndale Press, 1960. Published for the Research Scientists' Christian Fellowship.) 1*s.* 6*d.* [262

Department of Scientific and Industrial Research. Factory Building Studies No. 4: Structural Loading in Factories. By H. V. Apcar. Pp. iv+21. (London: H.M. Stationery Office, 1960.) 1*s.* 9*d.* net. [262

Titles of Dissertations approved for the Ph.D., M.Sc., and M.Litt. Degrees in the University of Cambridge during the academical year 1958–1959. Pp. iii+21. (Cambridge: Board of Research Studies, The University, 1959.) [262

The Engineer Buyers Guide, 1960. Pp. 976. (London: *The Engineer* Buyers Guide, 1960.) 7*s.* 6*d.* [272

Other Countries

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 41 (January 1960): Marked Population Growth in United States and Canada. Frequency of Overweight and Underweight. The Accident Toll of 1959. Chances of Having a Plural Birth. Pp. 12. (New York: Metropolitan Life Insurance Company, 1960.) [192

Suomen Geodeettisen Laitoksen Julkaisuja. Veröffentlichungen des Finnischen Geodätischen Institutes. No. 52: Vergleichende Azimutbeobachtungen mit vier Instrumenten. Von V. R. Ölander. Pp. 46. (Helsinki: Finnischen Geodätischen Institutes, 1959.) [222

Somaliland Protectorate. Annual Report of the Geological Survey Department for period April 1958–March 1959. Pp. ii+22. (Hargeisa: Stationery Office; London Crown Agents for Oversea Governments and Administrations, 1959.) 2*s.* [222

Geological Survey of Canada. Bulletin No. 55: Fossil Bibionidae (Diptera) from British Columbia. By H. M. A. Rice. Pp. x+37+4 plates. (Ottawa: Queen's Printer, 1959.) 1 dollar. [252

The Pasteur Institute of Southern India, Coonoor. Annual Report of the Director, 1959, and Scientific Report, 1959. Pp. 104. (Coonoor: Pasteur Institute of Southern India, 1959.) [252

Records of the Botanical Survey of India. Vol. 17, No. 1: Monograph on Indian Cucurbitaceae (Taxonomy and Distribution). By H. L. Chakravarty. Pp. iii+234. (Delhi: Manager of Publications, 1959.) Rs. 17.00; 26*s.* 6*d.* [252

Durban Museum and Art Gallery. Annual Report for the Municipal Year 1958–1959. Pp. 19. Durban Museum Novitates. Vol. 5, Part 16: Miscellaneous Taxonomic Notes on African Birds, XIII. By P. A. Clancey. Pp. 197–218. 5*s.* net. Vol. 5, Part 17: The Genitalia and Food-Plants of the South African Hesperiidae (Lepidoptera: Rhopalocera). By The Rev. Desmond Murray. Pp. 219–230 (3 plates). 2*s.* 6*d.* net. Vol. 5, Part 18: Miscellaneous Taxonomic Notes on African Birds, XIV. By P. A. Clancey. Pp. 231–259. 5*s.* net. [252

East Africa High Commission. East African Trypanosomiasis Research Organisation Report, January—December, 1958. Pp. ii+91. (Nairobi: Government Printer, 1959.) Sh. 7/50. [252

Indian Forest Records (New Series). Timber Mechanics. Vol. 1, No. 10: Physical and Mechanical Properties of Woods tested at the Forest Research Institute, Dehra Dun, Report IX. By A. C. Sekhar and R. S. Rana. Pp. 163–170. (Delhi: Manager of Publications, 1959.) Rs. 1.12 nP.; 1*s.* 9*d.* [252

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lasquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2.
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

EDUCATION AND THE YOUTH OF GREAT BRITAIN

THE debates on the Crowther Report, in the House of Commons on March 21 and in the House of Lords on March 23, were noteworthy for the statements of Government policy made by the Minister of Education and the Minister for Science, although the Government had already indicated its acceptance in principle of the recommendations both of the Crowther Report and of the Albemarle Report on the youth service in England and Wales. The debates, moreover, brought out the way in which, to some extent, the recommendations of the two reports are interlocked; and, particularly in conjunction with earlier debates in the House of Lords on the problems and opportunities of leisure, on March 2, and on adult education, on March 16, they also helped to clarify a number of the main issues involved and the points at which action is imperative. Moreover, appropriate action is not solely the responsibility of the Government; speaking in the debate of March 2, Lord Hailsham, referring to the acceptance of those recommendations of the Albemarle Report which require Government action, said that the Government would as soon as possible be discussing with the local education authorities the part they should play, and that the Minister of Education desired him to lay great stress on the need for voluntary effort.

So far as leisure is concerned, Lord Hailsham himself believes that the vital role of education is in the inculcation of right standards, and that here the critical battleground is in the home, with the school as an invaluable ally. In this he thinks the technical colleges as well as the schools have an important part to play: full-time education gives the best opportunity of instruction in the art of using leisure, and the key place now occupied by scientists and technologists in modern life makes it imperative to seek to increase their awareness of the economic and social importance of their work. Here Lord Hailsham referred incidentally to the value of educational research—a topic that received a remarkable amount of attention in the later debates on the Crowther Report. For the rest, however, on this occasion Lord Hailsham was concerned to stress the limitations placed on Government initiative in a free society if the use by the individual of his faculties is to be encouraged and not undermined.

While the Crowther Report and its recommendations have already been discussed in these columns, beyond the general acceptance of these recommendations in principle little was known of the Government's intentions. These have been made much clearer by Sir David Eccles's speech on March 21, in asking the House of Commons to welcome the Report. Sir David said at once that the Government accepts its major recommendation that the school-leaving age should be raised to sixteen provided the extra year in full-time education can be spent either in school or in a technical college, but he questioned the desirability of fixing the date now before we have ensured that the necessary conditions can be fulfilled, particularly as there is already a strong tendency for more children voluntarily to stay on after the age of fifteen.

The four pre-conditions specified by Sir David are, first, school buildings adequate to accommodate the extra pupils; competence to hold the interest of the 15–16-year-olds; sufficient teachers; and a public opinion which fully supports this step. As regards the first, he believes that if the resources were made available, we could provide the total building requirement of about £80 million for England and Wales in four years before the date suggested for raising the age. In many secondary schools the teaching staff has not yet had a fair chance to provide satisfying courses for the *C* and *D* streams in their last year, and while the Crowther Council is confident that the schools could be so much improved by the late 1960's that Government need not be afraid to name the date now, Sir David said that the public reaction to the Report indicates great misgivings about doing so now.

Dealing more fully with the question of teachers, which he regards as the heart of the problem, Sir David said that about 18,000 teachers would be needed to raise the school-leaving age; but before we can spare these teachers, we must reduce the number of over-size classes and so give the teachers in them the chance of doing their job really well. No other single reform, in his opinion, would so raise the standard of education in Britain. Four factors have postponed the removal of this handicap to good teaching: the unexpected increases in the birth-rate; the very welcome increase in numbers of those voluntarily staying at school beyond the age of fifteen; a considerably greater wastage of teachers than was expected; and the introduction of the three-year training course for teachers in place of the two-year course. This last reform, the only factor under Government control, involves the loss in 1962 of more than 10,000 new teachers coming from the training colleges, and because of it, while agreeing with the Crowther Committee that one or at most two leaving dates during the year would be sound educationally, Sir David said that because of the employment implications, he would be discussing that aspect with the Minister of Labour and others concerned before reporting to the House the Government's conclusions.

As regards the actual supply of teachers, Sir David Eccles said that the output of teachers from the 39,000 places in the training colleges could not exceed 13,000 a year if over-crowding is to be avoided and reasonable provision reserved for overseas students. The Government has accepted in principle the recommendation in the Crowther Report to add a further 8,000 places, but Sir David could not say how soon this could be achieved; if all went well, he thought by 1970 that over-size classes could be eliminated and at the same time the school-leaving age raised. Dealing next with the introduction of county colleges, he said that the Government agrees with the Crowther Committee that the raising of the school-leaving age should come first for three basic reasons stated in its Report. Nevertheless, the Government intends to press on with the voluntary further education of the sixteen- and seventeen-year-olds, and he believes that the technical college programme, which has progressed so much in the past three or four years, provides the opportunities for a big advance. First, the 300 local colleges, well spaced in England and Wales, a few of which are already running courses of the county college type, form a natural focus for the development of county college work. Secondly, as the Parliamentary Secretary to the Ministry, Mr. K. Thompson, said in replying on the debate, the Ministry has plans for much-improved arrangements for courses in technical colleges to expand further education on a voluntary basis. Some 400 projects have been authorized for the establishment of new colleges or the improvement of existing colleges.

Sir David did not refer to one important point made in the Crowther Report regarding the staff of the sixth form in schools—the fact that the schools have not yet experienced anything like the full effects of the decline in the quality of recruitment in recent years, nor did other speakers in the debate refer to the serious risk of a still worse crisis in science-teaching as the older men and women retire. Besides, however, touching on the question of finance, Sir David concluded by emphasizing two other important matters, both of which were also stressed by Lord Hailsham. As regards finance, Sir David estimates that, making no allowance for any of the Crowther recommendations, the annual cost of education for England and Wales would have risen from the present £700 million by one half by the end of the decade, and by four-fifths in the middle 1970's. Nevertheless, the Government believes it right to find this £1,400 or £1,500 million a year for education, even if it means sacrifices in other directions.

The first of Sir David's two points is that of educational research. The Crowther Committee commented that the present expenditure on educational research, in view of the large annual expenditure on education, can only be regarded as pitiable, and that if there is to be a consistent programme of educational development, almost the first step should be to review the provision for statistics and research. Sir David had referred to some specific examples where more information is needed before stating that action is already being taken to increase the amount of such research undertaken by the Ministry and to strengthen its statistical services; this action was warmly welcomed by several speakers in the debate, notably Mr. I. J. Pitman, Mr. F. Blackburn and Sir Hubert Ashton.

Lord Hailsham did not touch on this question of research in his speech in the House of Lords on March 23, but generally he followed the line taken by Sir David Eccles. Even more explicitly, he gave first priority to the elimination of over-size classes, which he thought should be possible by the end of the present decade; and in referring to the plans for more teachers, he urged that the number of graduates among teachers should be substantially increased. He also referred particularly to the provision of graduate teachers of science and mathematics. To maintain 1959 staffing standards in 1970, we shall need to increase the present 12,800 graduates in science by about 400 a year net, and ideally we should at least double the average net annual increase; though Lord Hailsham does not think we are likely to achieve this even with the proposed expansion of the universities and a significant contribution from the training colleges, where a number of specialist science wings have been attached to general colleges with a capacity of about 1,200 places. The four hundred science specialists expected from these wings should provide an invaluable supply of teachers to the schools, especially those with General Certificate of Education 'Ordinary' Level courses which at present employ 3,250 non-graduate science teachers. In March 1959 there were 5,100 mathematics graduates and 7,700 science graduates teaching senior pupils in maintained schools; but at the end of 1958 there were 505 such posts vacant and another 509 were said to be unsatisfactorily filled.

On finance, Lord Hailsham reiterated his view that we should spend at least 5 per cent of the gross national product on education. He also pointed out that even without the 8,000 additional places in teacher-training colleges, the cost of education in Britain will rise to £1,000 million by 1964, and with university education will then be more than 5 per cent of the estimated gross national product. He reminded the House that education will be in competition with claims on the national income from roads, railways, pensions and National Health Service, for example, and that it is imperative that investment in factories, transport, machinery and laboratories should keep pace with educational advance. He admitted that it is a great weakness in the educational system of Britain that so many children go out of full-time education at fifteen, but he emphasized the importance of first making sure that the curriculum is suitable to the needs of those who are thus compelled to remain at school.

Apart from a passing reference at this point to the county colleges and the experiment proceeding in some local colleges of further education, the most important remaining passages in Lord Hailsham's speech were those which took up the comment in the Crowther Report on the absence of any single body within the United Kingdom which looks at school and university education as a whole, and in which he urged that the schools and universities should come closer together. Sir David Eccles had already touched on this in referring to university entrance and to the helpful response he had had from the Committee of Vice-Chancellors and Principals, who, he said, are fully alive to the need for more university places to be available and the conditions of entrance to be modified to enable sixth-form teachers to find time to teach English thoroughly, and to provide more science for the arts specialists and more of the arts to the scientists.

On the question of university places, Sir David said that the University Grants Committee has already been authorized to discuss with the universities a further expansion of 35,000 to 40,000 places by about 1970 over and above the present target of 135,000 to be available by the late 1960's. Lord Hailsham commented that not long ago strong exception would have been taken to the Minister of Education showing such interest in the universities. He welcomed the change, and what Sir David had affirmed that these problems of university entrance, over-specialization and reform of the curriculum are now being vigorously attacked in concert by the universities, the schools and the Ministry. During the debate, Lord James of Rusholme urged that the raising of the school age is not so much a question of an extra school year as of an opportunity to provide a genuine course of secondary education, and has also both the importance of sixth-form work and the danger of over-emphasizing the gulf between science and human knowledge. In replying on the debate, Lord Hailsham dealt with what is probably the most vital issue in regard to the fixing of a date for raising the school-leaving age. He did not dispute the value of this step or deny the plea for timing which Lord James had reiterated. Conceding, however, the Crowther Committee's conclusion that the necessary measures should be worked out and adopted as a coherent, properly phased development programme, extending over as much as twenty years, it remains true, as Lord Hailsham pointed out, that we are dealing with parents and children who do not share that view as to the value of education after the age of fifteen. It is not simply a question of buildings and the supply of teachers or the development of appropriate curriculum, but of at what stage and in what circumstances we are to apply the principle of compulsion not only to laggards but also to a minority of children whose formal education might well have ceased at fourteen or even earlier.

There is, of course, a further point implicit in a speech of Mr. C. Curran in the House of Commons debate, in which he urged the raising of the school-leaving age to sixteen on the grounds of the social value of taking children of fifteen off the labour market as soon as we can, so as to deny the purchasing power largely responsible for many juvenile problems. From both aspects this question of an additional school year is related to the problem of leisure and to the development of youth services, and it should be clear that any phased programme of educational development in Britain must take account in its timing and other aspects of what is being done to meet the needs of youth generally and to deal with the problems of leisure. That much was indeed recognized by the Albemarle Committee itself; but Sir Geoffrey Crowther, in a speech in Manchester on March 22, challenged the idea of absolute priorities, and with regard to county colleges pressed the need for considerable experience before we commit ourselves to compulsory attendance. It may well be that ultimately the broad advance for which the Albemarle Report calls, and a generous return for the money expended on the youth service, will result from the effect of educational progress generally; it will also depend on the creation of an appropriate public opinion and the impetus given to the supply of teachers and youth leaders of high quality and clear vision and the professional ability to use to the full the opportunities which are now opening to them.

MANAGEMENT OF RESEARCH PERSONNEL

The Human Element In Research Management
By Dr. B. E. Noltingk. Pp. vii+91. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1959.) 9*s*. 6*d*.

I FOUND the title of this book somewhat misleading. It is really a book about research personnel management, rather than about the more restricted conception of the use of the word 'human'. It has chapters on scientists themselves, anatomy of a laboratory, physiology of a laboratory, seniors, juniors, strategy, output and ethics, but does not, for example, deal at any great length with the hopes and aspirations of research scientists, and does not attempt to analyse their motivations.

Despite the author's rather disarming statement in his preface of what "prompts me to the conceit of writing a book without many years' opportunities to put all its precepts into practice", I was left with the feeling that some greater experience on the part of the author and a deeper study of the existing literature on his subject might, when coupled with his own views, have produced a book of deeper significance. For example, the author gives some reasons for not having made himself familiar with all the published work in his field before venturing into print, but the works to which he does refer are, in the main, articles in journals the main interests of which lie in somewhat different directions, and which are summaries rather than the results of systematic observation and investigation.

I am, perhaps, somewhat biased on this matter because I am writing this review in the United States, where there is a considerable literature on Dr. Noltingk's subject. Much that has been written in the United States on this subject might never have achieved publication in Great Britain, but for all that the subject has received considerable systematic study, and the author should, I think, have shown that he was aware of this. This does not mean that on the whole I disagree with the author's views, but they are rather naive, and because his experience would appear to have been rather limited, he has not produced anything particularly novel.

The book is well written, and the biblical quotations at the chapter headings are apt. Dr. Noltingk does well, in my view, to stress greatly the importance of asking the right questions concerning research. Most of his generalized conclusions would be agreed by many research scientists who have had to give at least part of their attention to the organization and control of the work of others.

Some of the author's statements are, however, not in accord with past experience. For example, in dealing with the problem of the older scientist he states that if such an individual's project has perforce to be stopped, moving him outside the laboratory may well be the soundest policy. He then makes the common error of suggesting that perhaps laboratory administration is a good outlet for him. He goes on to say that "it is doubtful whether a deficiency of several years' experience could ever be remedied to fit him for the role of a senior scientist in a different field". For many scientists this may be true, but certainly for many more it is true that they can enter entirely new fields effectively and successfully, and experience during the Second World War showed that scientists could do first-class research in disciplines entirely different from those in which all their previous experience lay. I am one of those who believe that very few scientists are dedicated, in the sense that they can do effective work only in one field. I know from experience that some people with first-class paper qualifications will probably never do any effective original work in any field, but for the great majority of scientists I believe that a good man will be good in whatever he tackles.

In dealing with salaries, the author suggests that a time might arrive when "the man in authority could sometimes actually be paid less than those under him". This position has existed for many years in many large research organizations, if one accepts 'under' as meaning 'organizationally under'. In many research organizations in Great Britain and in the United States there are two avenues of promotion, one organizational and the other depending purely on scientific ability with no significant organizational responsibilities. The 'special merit' promotions in the Scientific Civil Service in Britain and the wide use of 'consultants' in the United States are examples of this.

In dealing with periodical reviews of staff for promotion, the author comes to the conclusion that "the simple solution of leaving him to be assessed by the boss, who will apportion accordingly the money he has available, is the best". This is a system which may work in a small organization, but concerning which there are very great difficulties where large numbers of staff have to be considered. Various bosses have various standards, and in any organization, if good staff relations are to be maintained, there must be reasonably common standards throughout it. Some systemization must therefore be attempted unless all the staff can be judged by one individual, and even then my experience is that the majority of junior staff dislike such a system. They feel that their careers depend too much on the whim of an individual, and that whether they get promotion or not may be almost fortuitous. The larger the organization the more this appears to be felt, and it is often not realized that in large organizations, such as the Civil Service, much of the apparent 'red tape', and even much of the apparent inflexibility, derives not from the wishes of the top people, but from the pressures from below. The era of 'the boss can't be wrong' has passed, and although all matters of advancement must to a great extent be the result of subjective assessment by others, modern systems can reduce considerably the element of chance.

In dealing with what he calls the physiology of the laboratory, Dr. Noltingk comes to the conclusion that it should not have a larger staff than about 300 if it is truly to be directed by one man. He thinks that if it is larger than this, then the divisional heads will become virtually directors of separate units. This is probably true, although there are many examples of larger organizations being directed by one man if the organization has grown up under him. On the other hand, it is a little doubtful whether one man can become director of an existing laboratory, even of the 300 size, and be effectively the director of the science as well as the director of the institution, but here much will depend on the nature—not the discipline—of the work. Very much larger organizations can be directed by one man if they are what the Americans call 'uni-purpose', that is to say if they have a convergent structure, and this is particularly the case when the scientific work is applied rather than fundamental. The size of the organization which can be directed by one man becomes much less when the organization is multi-purpose or divergent, that is to say where there is no close relationship between the objectives of the various subjects studied.

In one matter I cannot agree with Dr. Noltingk. In several chapters in the book he mentions the need for a laboratory to advertize its existence: for example, in one chapter he says, ". . . for research laboratories in the modern world, like detergents or beer, need to keep themselves in the public eye not so much by reasoned argument of their excellence as by frequent reminders of their existence". In a further chapter on output he again says about a laboratory, "A proportion of its activities should quite openly and admittedly be devoted to blowing its own trumpet, and betterment of the regard in which it is held should be recognized as part of its desired output".

Something of this sort may be necessary in the organization of which a laboratory is part, but I would have thought that the general principle of 'good wine needs no bush' applies very much to scientific research establishments. If they do good work they will become well known, and however large they are and whatever their publicity policy, unless they do good work their reputation will suffer. I particularly, therefore, disagree with the author when he says of a laboratory director, ". . . the need to approach problems scientifically should be, with the praises of his own laboratory, the twin stanzas of his signature tune". E. S. Hiscocks

MAYA HIEROGLYPHICS

Maya Hieroglyphic Writing

An introduction. By J. Eric S. Thompson. Second edition. Pp. xxii+347+64 figures. (Norman, Oklahoma: University of Oklahoma Press, 1960.) 10 dollars.

When this book first appeared in 1950 as one of the publications of the Carnegie Institution of Washington it was thought that it was only for specialists, but it was written with such a background of knowledge of the Maya, both those who survive and those long dead, that it has had a far wider appeal. It has been out of print for some time and the demand for it has proved so great that this new edition has been issued by the University of Oklahoma Press. Apart from a short preface reviewing progress since 1950, it is a facsimile reproduction of the first edition, with the welcome addition of a substantial binding. Experience has shown that a word of explanation about the title of this massive work will not come amiss; far from being a mere introduction to Maya hieroglyphics, it is a very profound study of this difficult subject, but it was also designed to introduce a dictionary of non-calendrical glyphs, a work which the author has only just finished. Eric Thompson has studied the Maya for the past thirty years or so, and has long been known as one of the foremost authorities on their hieroglyphic writing. This book has added greatly to his reputation.

It contains a wealth of detailed information about the various types of Maya inscription, those cut in wood and stone, and those painted in the manuscripts and to a lesser extent on wall or pot. Each of the great synchronized cycles which make up the calendar is considered, and new light is thrown on divinatory inscriptions. All this reveals the staggering complexity of the subject; but the treatment is lightened by the author's constant insistence on human and spiritual factors and by the happiness of his style. He says in effect that mathematics and astronomy have an essential part in this study, but that an understanding of Maya religion and mythology is as important, and he goes so far as to say that "Mysticism, religion and poetry completely dominate their hieroglyphic writing." It is emphasized that the whole of Maya religion revolved around the majestic conception of the eternal march of time, in which the periods into which the calendar is divided are borne along by the gods, who pause only to change their burdens over like relay runners at the appropriate period endings. This is graphically shown on the most elaborate form of inscription, the full-figure glyphs exemplified by Stela *D* at Copan, of which a free modern version forms the frontispiece.

The brevity of this notice is not a measure of the importance of the book, which is unsurpassed in its own field, but of the small number of those who concern themselves with the study of the Maya in Great Britain. It is pleasant to record that the author himself has returned to swell their number after living for many years in the New World, and it is to be hoped that his new Glyphic Dictionary will soon be published. G. H. S. BUSHNELL

WORLD DISTRIBUTION OF ABO BLOOD GROUPS

The ABO Blood Groups

Comprehensive Tables and Maps of World Distribution. By Dr. A. E. Mourant, Ada C. Kopeć and Kazimiera Domaniewska-Sobczak. (Occasional Publication No. 13 of the Royal Anthropological Institute.) Pp. viii+276. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas, Publisher, 1958.) 42*s*. net.

DR. MOURANT and his colleagues have brought together all the results published up to the end of 1957 on the frequency of the ABO blood groups in the human population; the figures are given for the majority of areas in the world. The result is a most comprehensive book on the distribution of these groups incorporating 1,056 references and 6 maps.

After a short introduction, the information is given in the form of tables. These show place, population, authors and numbers of samples examined, the frequencies of each of the groups, the calculated gene-frequency and, in the last column, the figure D/σ. The vast bulk of the material has been published in the form of the groups O, A, B, and AB, but there are sections where the sub-groups of A have been wholly, or partially, classified. The authors say that "the classification adopted for the data is primarily topographical"; both place and population are well covered, and the population column includes racial or tribal names where appropriate.

In the largest section of the work, the gene-frequencies have been calculated according to Bernstein's formula, but in the section where the sub-groups of A are completely classified the maximum likelihood method is used. The figure D/σ in the last column is given in preference to the usual χ^2; it is a measure of the deficiency or excess of the group AB in the results as compared with the calculated frequency. The authors consider that this value allows the reader to make his own estimate of the reliability of the results with respect to genetical homogeneity or accuracy of testing. It is unfortunate that the authors did not write a more comprehensive introduction, giving details of the statistical calculations and more details of the factors which affect the value of D/σ, with a discourse upon the interpretation of the results; for the average reader this would have been most helpful. The claim of the authors that this single figure gives a general indication of the reliability of the results is probably valid, but others might well have need to consult the original paper to obtain an accurate estimate of a particular work.

The book is an excellent reference book, with good typography. It is easy to read and the tables are set out (and the book opened) in the long way, which makes them easy to see; but the book is not so easy to fit into a bookcase. To have all this information available in such a small compass is, indeed, valuable for all who are concerned with blood groups, whether they are hæmatologists, anthropologists or geneticists. Dr. Mourant and his colleagues are to be congratulated on the production of this extremely comprehensive and unique work. F. STRATTON

FACTORS AND CAUSES OF INFECTIVE DISEASES

The Aetiology of Infective Diseases

With Special Reference to the Subsidiary and Important Non-specific Factors. By Prof. Reginald Lovell. Pp. viii+136. (London: Angus and Robertson, Ltd., 1958.) 27*s*. 6*d*.

IN this book Prof. Lovell, whose experience and authority are well known, gives us the substance of lectures which he delivered in the Department of Microbiology and Public Health at Michigan State University in 1955. He intends the book to stimulate rather than to instruct, and hopes it will awaken interest in the philosophy of epidemiology; both of the aims are certainly achieved. Much knowledge of fact is also added in the author's clear and persuasive style. Though the text refers largely to diseases of domesticated and other animals, the relationship between these and the diseases of man is well brought out.

The book begins by pointing out that the nature of disease is always changing and that this constant change is part of our social history. An infective disease, once it is established, Prof. Lovell reminds us, may stay with us for good and he gives us evidence of this. Discussing next the normal bacterial flora of man and other animals, and the phenomena of resistance (immunity) to disease, he goes on to discuss the host-parasite relationship, which, like disease, is never stable, a fact which is, in spite of Lovell's view to the contrary, very well realized nowadays.

In Part 2 of the book the author discusses various subsidiary factors which play a part in infective disease. Thus the influence of age is illustrated by reference to white scours of calves, infantile diarrhœa, lamb dysentery, Johne's disease of cattle, meningitis in children, diphtheria, scarlet fever, leptospiral infections and various viral diseases, including poliomyelitis. The significance of sex is illustrated by reference to mastitis and pyelonephritis of cattle, trichomoniasis, tuberculosis, brucellosis and other infections. The effects of changes in the host's diet are illustrated by reference to botulism, food poisoning by *Salmonella*, enterotoxæmia of lambs and protein deficiencies and those due to changes in husbandry and environment, by tuberculosis, the slow pneumonia of sheep in Iceland called 'maedi' and by Johne's disease of cattle and braxy of sheep. Fungal infections are considered under the heading of the effects of the general health of the host. In an interesting section on the effects of trauma the author discusses tetanus, gas gangrene and infections with various species of *Clostridium* and those due to the bites of animals, such as rabies. The effects of stress and fatigue and the use of properdin and adrenocorticoids for the treatment of them are then considered, and a final section discusses infections which involve a living vector as well as a pathogen, the diseases here discussed including rickettsial and viral infections, influenza of man and swine, louping ill, foot and mouth disease, yellow fever, psittacosis, *Q* fever, distemper of dogs and the different distemper of cats and other infections. A brief bibliography gives references to standard works.

Both the veterinarian and the student of human disease will learn much from this book, and it will, as its author commendably intends, make him discard any tendency he may have to think of each disease as a separate entity. G. LAPAGE

A TREATISE ON STATICALLY INDETERMINATE STRUCTURES

Hyperstatic Structures

An Introduction to the Theory of Statically Indeterminate Structures, Vol. 1. By Prof. J. A. L. Matheson. With chapters by Dr. N. W. Murray and Dr. R. K. Livesley. Pp. xv+474. (London: Butterworths Scientific Publications, 1959.) 90*s*.

THE student of that branch of elasticity which deals with structural mechanics too often finds himself confused by the numerous 'theorems' and 'principles' which so liberally ornament the literature of the subject. This confusion is worse confounded by the use of various names for the same result, and even, on occasion, the appropriation of a well-established designation for something quite different.

In fact the number of independent principles which are of value to the engineer are surprisingly small, and even if the subject is approached from a purely academic point of view rather than from a more practical one, that number is not greatly increased. Many of the results which are so frequently stated as principles are in fact variations, often obvious ones, of fundamental theorems. These variations may, indeed, prove very useful in particular applications, but their isolation from the fundamentals on which they are based makes for an artificial elaboration of the subject and the consequent bedevilment of the student.

One of the avowed objects of the author of this book is to clarify this position and to show the inter-relationship of the many theorems and methods commonly quoted. The result will be of considerable interest to the reader who already has a working knowledge of the subject; but the word 'introduction' in the title may prove somewhat misleading and even disheartening to the real beginner.

In the preface the author says that the book is an attempt to produce the treatise (incidentally a much better description of the work than is indicated by the title) which his friends hoped that the late Prof. Cyril Batho would write. Batho had an extensive knowledge of German literature on theory of structures and a great admiration for the work of Mueller-Breslau in particular, and his friends will be in no doubt that he would have been pleased by Prof. Matheson's treatment. This comment, however, does only partial justice to Matheson; in addition to the careful presentation of the classical work of Clerk Maxwell, Mohr, Castigliano, Williot and Mueller-Breslau there is much which could not have been found in a book by Batho, for even in the few years since his death considerable advances have been made. References to the work of David Williams, E. H. Brown and others in clarifying the relationship between the different energy theorems, and the specialized chapters on the stability of struts and frameworks, and on matrix methods of analysis, by N. W. Murray and R. K. Livesley respectively, indicate the up-to-date character of the book.

In this connexion, too, the inclusion of a short account of the work of Prof. J. F. Baker and his colleagues at Cambridge is to be welcomed as an outline of the latest trends in steel structural design based on collapse loads; the possibility suggested by the author that this reference may be out of place in a work dealing with elastic structures surely need not be considered seriously. Elastic and plastic behaviour are both phenomena with which the engineer has to deal, and any attempt at a complete separation of their study can only lead to an unbalanced outlook.

A suggestion for future editions which might be offered is that the section of Chapter 1 which deals with intuitive methods for the approximate solution of statically indeterminate problems should be relegated to an appendix. It is undoubtedly true that a visualization of displacements can materially assist the analysis of a structure, but it is equally true that intuition can come only as a result of experience and knowledge, and to suggest some of the ideas contained in this section at such an early stage may prove a disservice to the student rather than a help.

The book is excellently produced, and with its companion volume of examples which is promised for a later date will add something distinctive to British literature in theory of structures. One wishes it the success which it merits. A. J. S. PIPPARD

A Guide-Book to Biochemistry

By Kenneth Harrison. Pp. viii+150. (Cambridge: At the University Press, 1959.) Cloth edition, 17*s*. 6*d*. net; Paper edition, 10*s*. 6*d*. net.

THERE are several good modern biochemistry books in the thousand-page category, but there is a real need for the introductory type of book of a hundred pages or so. Biochemistry has grown into such a vast subject that an author who is courageous enough to write a small book about it is sure to be criticized for what he decides to leave out, if not for what he puts in. The decision will, of course, depend on the type of reader the author has in mind. According to the dust cover (for which the author may not be responsible), this book is aimed not only at science students at the university, but also at boys and girls at school who may be thinking of taking up biochemistry later on. What will these potential biochemists find in the book? After a short introduction they will find chapters on energy, oxidation (including several pages on the *r*H scale), photosynthesis, metabolism of carbohydrates, fats and proteins, and a final chapter on control of metabolism. For good measure they will be able, in an appendix, to study the full structural formulæ of complex molecules such as coenzyme *A* or uroporphyrin-III. But they will find nothing about, say, hæmoglobin and its functions, and, as the author himself says, it is a far cry from the contents of this book to a dog or a cat or even a cabbage. One wonders whether the cry need have been quite so far as it is. No, the value of this book is not so much as an introductory guide to biochemistry for school children or for university students, but as a means of helping students to consolidate and summarize biochemical knowledge which they have gained from their lectures and text-books. Here it will fulfil a most useful purpose. The information, though so highly condensed, is clearly set out and is up to date. The book is well produced, and few misprints were noticed. The price is very moderate, and it was a good idea to make available a paper-backed edition at an even lower price.

D. C. HARRISON

Nuclear Electronics

Proceedings of the International Symposium on Nuclear Electronics organized by the French Society of Radioelectricians. (Sessions 1–5.) Pp. xii+452. (Vienna: International Atomic Energy Agency, 1959.) 84 schillings; 24*s*.; 4 dollars.

THIS volume contains the texts of fifty papers presented by delegates from the European countries and the United States at sessions 1–5 of the symposium on nuclear radiation detectors, associated pulse techniques and reactor control measurements and instrumentation. About a half of the papers are printed in English and the rest in French. A brief record of the discussion periods is given at the end of each of the five sections.

Session 1, on scintillation radiation detectors, includes a general review paper on the characteristics of phosphors and photo-multipliers developed during the past ten years and summarizes the important problems for future investigation. Separate papers deal with fast photo-multiplier tubes and with scintillation processes in phosphors, including variation of phosphor decay-time with specific ionization, and its application in differentiation of particle types. Session 2 is devoted to other types of radiation detectors used mainly in nuclear physics measurements, and includes short papers on ionization counters, scintillation in gases, a gas Cerenkov counter and semi-conductor radiation detectors. Three papers describe developments in gamma-ray spectrometry.

Session 3, on fast pulse techniques, includes a brief review of fast electronics in high-energy physics, and separate papers on trigger circuits, coincidence circuits, timing circuits and pulse generators for use in the nano-second time region. Session 4 on pulse techniques is devoted mainly to pulse-height analysers while Session 5 contains a short review on philosophy of reactor safety control in the United States, and several contributions on control systems and measurements in French reactors.

Much of the information has been published elsewhere in greater detail, but the collected papers will serve as a useful reference book on recent developments to designers and users of nuclear electronic equipment.

W. ABSON

Electromagnetic Radiation from Cylindrical Structures

By James R. Wait. Pp. ix+200. (London and New York: Pergamon Press, 1959.) 50*s*. net.

THE designer of aerials for aircraft and missiles must co-operate with the aerodynamicist and is therefore led to types of aerial which can be mounted on wings or fins without disturbing their aerodynamic properties. A satisfactory form of aerial is the slot, for which the behaviour in an ideal infinite conducting plane is well known. On an aircraft, however, the slot must be mounted on a relatively small conducting surface, which inevitably has an appreciable curvature. There is therefore a need to have information on the influence of curved surfaces on the radiation from slots and also from small dipoles mounted at right angles to the surface. The author of the present book has tackled this problem for those surfaces which admit the possibility of a formal electromagnetic solution. The surfaces include circular and elliptic cylinders, wedges and corner reflectors. In each case a detailed mathematical solution, usually in series form, is derived and comprehensive numerical results are given for the parameters likely to be of practical interest. These numerical results, which are given graphically, can be readily used by the practical designer even if he is not interested in the details of the theory.

The material is clearly presented and should be intelligible to the physics or electrical engineering graduate with a reasonable knowledge of electromagnetic theory. A useful appendix on the classical theory of radiation from current distributions serves as a revision of the fundamental results from which the main text is developed. An excellent feature is the frequent reference by the author to the similarity between radiation and scattering problems, and the reciprocity theorem is used to illustrate this. The volume is thus also of value to those interested in the theory of electromagnetic wave scattering. In particular, the short account of the work of Fock in this field provides an admirable introduction to the many original papers which use Fock's methods.

This book fills a gap in the existing literature and is strongly recommended to those with theoretical interests in aerials and electromagnetic scattering problems.

J. BROWN

USE OF LONG-LIVED NATURAL RADIOACTIVITY AS AN ATMOSPHERIC TRACER

By W. M. BURTON
Atomic Energy Research Establishment, Harwell
AND
N. G. STEWART
Dounreay Experimental Reactor Establishment

THE fission product activity in the atmosphere and in rain-water due to nuclear test explosions has been sampled in the United Kingdom and elsewhere for several years[1-3]. Studies of the distribution of some of the long-lived components of this activity, in particular, strontium-90 and cæsium-137, have revealed interesting seasonal variations and latitude distributions which have been interpreted as supporting the Dobson–Brewer model of atmospheric circulation deduced from measurements of ozone and water vapour[2]. Elements produced by cosmic rays have been proposed as possibly fruitful tracers for further studies of atmospheric movements[4].

A common feature of all such tracers, fission products, ozone and isotopes produced by cosmic rays is that their effective source lies in the stratosphere. They can consequently be used directly to study the mechanism of transport of air from stratosphere to troposphere, but not the complementary transport in the opposite direction. It seemed that a useful group of radioactive isotopes for this purpose would be the longer-lived, daughter products of radon—radium-D, -E and -F—which are naturally present in the atmosphere as a result of the leakage of radon from soils and rocks on the Earth's surface.

This article gives the results of an exploratory survey of the distribution of these isotopes in air and in rain-water, derives certain conclusions from these and points to the value of a more comprehensive programme.

Radon Decay Products

Radon is one of the elements formed by the radioactive decay of uranium which is present in greater or lesser degree in rocks and soils all over the world. Being a gas, radon can escape from the Earth's crust into the atmosphere, where it disintegrates radioactively to form a chain of solid daughter products, each of which is produced by the disintegration of the preceding one, the final element being lead, which is stable. The half-lives and radiation characteristics of the decay products are shown in Table 1, where for clarity minor branches of the decay series have been omitted.

Table 1. RADON AND ITS DECAY CHAIN

Chain member	Isotope	Half-life	Radiation
Radon	Radon-222	3·8 day	α
Radium-A	Polonium-218	3·1 min.	α
Radium-B	Lead-214	26·8 min.	$\beta\gamma$
Radium-C	Bismuth-214	19·7 min.	$\beta\gamma$
Radium-C′	Polonium-214	160 μsec.	α
Radium-D	Lead-210	19·4 yr.	$\beta\gamma$
Radium-E	Bismuth-210	5·0 day	β
Radium-F	Polonium-210	138·4 day	α
Radium-G	Lead-206	Stable	—

The daughter products are ultimately washed out of the atmosphere in rain after a mean period of residence in the troposphere of about 20 days (par. 2 of Discussion). The half-lives of the radium-A, -B, -C and -C′ are short compared with this mean residence time, and these isotopes are generally found to be in secular equilibrium with each other and with the parent radon[5]. Since radium-D takes some 80 years to reach equilibrium with radon, it is removed from the atmosphere by rain long before this state can be reached. Thus, typical values of the concentration of radon over land and sea are 200 d.p.m./kgm. (disintegrations per min. per kilogram of air) and 4 d.p.m./kgm., respectively[6], but the mean value of the radium-D concentration at ground-level reported by Blifford is only 0·03 d.p.m./kgm.[7]. For the same reason it is to be expected that the radium-E concentration will be less than that of radium-D, and radium-F less than radium-E. The low concentration of all these isotopes makes it necessary to pass large volumes of air through filters in order to obtain samples large enough for analysis, and complications can result from the collection of soot and other airborne dusts which may interfere with subsequent chemical separations.

Sampling Procedures

Air sampling programme. Ground-level air samples were collected at a height of 1 m. above the grass airfield at Harwell using cylindrical filters of esparto grass paper through which about 6,000 kgm. of air were passed at a mean linear speed of 140 cm./sec. during a normal 24-hr. period[1]. Above ground-level the samples were collected on filters attached to aircraft which were flown, primarily to collect fission products, at various fixed altitudes up to 48,000 ft. Some of these samples were obtained on disk filters fitted in a tube which carried an orifice plate for measuring airflow during flight. In general, the amount of air sampled in each such flight was too small for analysis; but by combining and analysing a batch of several filters from the same altitude it was possible to determine mean values of the specific activity at that altitude. On other occasions, a cylindrical filter was flown together with the disk, and the much larger amount of air thus sampled was determined from the ratio of the fission product activities of the two filters and the airflow through the disk. Typical linear sampling velocities were 460 cm./sec. at 18,000 ft. and 350 cm./sec. at 48,000 ft. The filters analysed were collected at various times between 1951 and 1957.

The efficiency of filtration is subject to uncertainty; but this is not considered to be serious. The radon daughter products are created as individual atoms in the decay process, and filtration efficiency is known to be high for such particles[8]. However, it has been demonstrated that the atoms can become attached to condensation nuclei in the atmosphere[9], and in this form filtration efficiency may be lower. Recent measurements made at Harwell[10] have shown that at sampling velocities in the region of 400 cm./sec. the sampling efficiency of esparto paper has a minimum value of 40 per cent for condensation nuclei of diameter 0·06 μ. The efficiency increases rapidly with diameter and has a value of about 70 per cent at 0·08μ. Mobility studies have shown that, when first formed, condensation nuclei have diameters in the region of 0·001μ, but they coagulate rapidly and reach 0·01μ in about 1 hr. and have increased to 0·08μ in about 30 hr. The atmospheric residence-time of daughter product atoms will be shown to be about 20 days, and during this period it is probable that the nuclei to which they are attached are larger than 0 08μ, and that the sampling efficiency is relatively high. A value of 100 per cent has been assumed in this article.

Rain-water sampling programme. Samples of rain-water were collected at Harwell in polythene bottles using two identical polythene funnels each with a 5-cm. rim and a collecting area of 2,000 cm.². Each funnel and storage bottle was cleaned and rinsed with distilled water before sampling began. To eliminate the possible effect of dry deposition on the funnel, the apparatus was only set up when a period of steady rain was beginning and it was taken in as soon as the rain stopped. The samples were acidified with nitric acid, carriers (lead and bismuth) added, and the volume measured before returning the samples to polythene bottles to await evaporation and chemical analysis. By independent analysis of the samples collected in the two units a check could be made on the reproducibility of the subsequent processing of two similar samples. Typical collections provided 2–6 litres of rain-water during a sampling period of a few days.

Chemical Separation Methods

The measurement of small quantities of radium-D, -E and -F in air and rain-water samples is complicated by the presence in the atmosphere of fission products from nuclear test explosions. During the course of the present experiments, the fission product concentration in air was very variable and generally exceeded the radium-D concentration by a factor of 100 at least. Trace-level experiments were carried out with solutions of radium-D, -E, -F and fission products and a complete separation procedure was worked out, based on solvent extraction of the dithizone complexes of lead and bismuth. Full details are given elsewhere[11]. The extracted isotopes were measured using standard low-background Geiger and scintillation counters.

The analytical method extracted at least 80 per cent of the radium-D, -E and -F from the samples and the limit of significant measurement was 2 d.p.m. The radiochemical purity of the separated isotopes was satisfactory, and in test extractions less than 0·01 per cent of the fission product activity initially present remained in the final radium-D fraction. In some cases, radium-D, -E and -F were measured on the same sample, but in most samples the analysis was limited to radium-D and radium-E or to radium-D and radium-F.

Results

Atmospheric concentration of radium-D. The concentration of radium-D in the airborne dust collected on air filters was estimated by two independent methods. In the first method, radium-F analyses were carried out on air filters which had been stored for several years after the dust samples had been collected. During this period the radium-F collected during sampling had almost completely decayed, while fresh radium-F had grown into equilibrium with the radium-D originally collected on the filter. Consequently, the radium-F content of the filters could be used to estimate the amount of radium-D collected by the filter at the time of sampling. In most cases, more than two years had elapsed between sampling and the chemical separation, so that the radium-F was at least 95 per cent of its final equilibrium concentration. In a few cases, the theoretical build-up was only 85 per cent, and a correction was added to the derived radium-D concentration. The results of these measurements are given in Table 2. Where more than one filter is specified in column 3, these were collected at different times during the stated periods but were combined for analysis. The standard deviation (*S.D.*) of each of the values in column 6, due to errors in air flow measurement, chemical analysis and counting, is estimated to be less than ± 15 per cent.

In the second method the samples were stored for about twenty days to allow the radium-E to come into equilibrium with the radium-D, and separate analysis of the two isotopes was carried out. The measured amounts generally agreed to within 20 per cent,

Table 2. ATMOSPHERIC CONCENTRATION OF RADIUM-D MEASURED BY ANALYSIS OF RADIUM-F IN OLD AIR FILTERS

Air filter sampling details					
Sampling altitude	Collection date	No of filters	Air mass sampled (kgm.)	Air concentration (10^{-8} d.p.m/kgm)	Average air concentration (10^{-8} d.p m./kgm.)
Ground-level	May 1954	1	4,800	7·3	7 0
Ground-level	May 1954	1	5,400	6 7	
11,000 ft.	July–August 1954	3	400	19	21
11,000 ft.	January–February 1955	2	270	22	
27,000 ft.	July–August 1954	5	390	30	
27,000 ft.	September 1954	2	130	30	28
27,000 ft.	January–February 1955	3	220	24	
40,000 ft.	July–August 1954	8	290	37	37
47,000 ft.	June 1955	4	105	55	55
48,000 ft.	January 1955	7	125	74	74

Table 3. ATMOSPHERIC CONCENTRATION OF RADIUM-D MEASURED BY ANALYSIS OF RADIUM-D–RADIUM-E IN AIR FILTERS

Air filter sampling details					
Sampling altitude	Collection date	No. of filters	Air mass sampled (kgm.)	Air concentration (10^{-3} d.p.m./kgm.)	Average air concentration (10^{-3} d.p.m./kgm.)
Ground-level	August 1954	1	6,000	6·7	
Ground-level	August 1954	1	18,300	6·0	
Ground-level	January 1955	1	5,900	8·5	
Ground-level	January 1956	1	5,300	6·4	
Ground-level	August 1956	1	6,000	3·2	7·1
Ground-level	November 1956	1	15,600	7·4	
Ground-level	December 1956	1	5,500	13	
Ground-level	January 1957	1	5,500	5·5	
11,000 ft.	July–August 1954	5	670	12	
11,000 ft.	January–February 1955	10	1,360	17	17
11,000 ft.	January–February 1955	11	1,470	23	
18,000 ft.	August–November 1955	11	1,330	18	
18,000 ft.	August–November 1955	11	1,150	22	18
18,000 ft.	January–February 1956	8	760	14	
27,000 ft.	July–September 1954	10	740	19	
27,000 ft.	August 1956	1	250	36	29
27,000 ft.	August 1956	2	350	32	
30,000 ft.	July 1956	1	730	32	32
30,000 ft.	July 1956	1	680	31	
35,000 ft.	September 1956	3	1,530	34	34
45,000 ft.	July–January 1955	19	520	50	50
47,000 ft.	July 1956	1	130	70	70

which is consistent with the estimated *S.D.* of ± 10 per cent on each individual determination. The results of these analyses are given in Table 3.

The averaged concentrations of radium-D determined by both methods are plotted against the altitude of sampling in Fig. 1 to give the vertical distribution of radium-D. The numbers in parentheses adjacent to each point refer to the number of separate samples used. It is clear that the two methods of measurement are in good agreement and that it is possible to draw a smooth curve through the experimental points. This agreement provides a measure of confidence in the sampling, separation and averaging procedures and suggests that the number of samples, although small, is adequate. There is, however, a systematic error inherent in the sampling procedure for radium-D arising from the fact that the filter paper collects the short-lived radon daughter products from the air, and these afterwards decay to form more radium-D on the paper after collection. This error is likely to be greatest at ground-level, where the concentration of radon is highest, but it can be shown to be small. Gale[5] has found that the mean concentration of radium-A, -B and -C in ground-level air at Harwell is 115 d.p.m./kgm. Collected on a filter paper, this would give rise to an apparent concentration of radium-D of $1 \cdot 2 \times 10^{-4}$ d.p.m./kgm., which is less than 2 per cent of the observed mean value of $7 \cdot 1 \times 10^{-3}$ d.p.m./kgm.

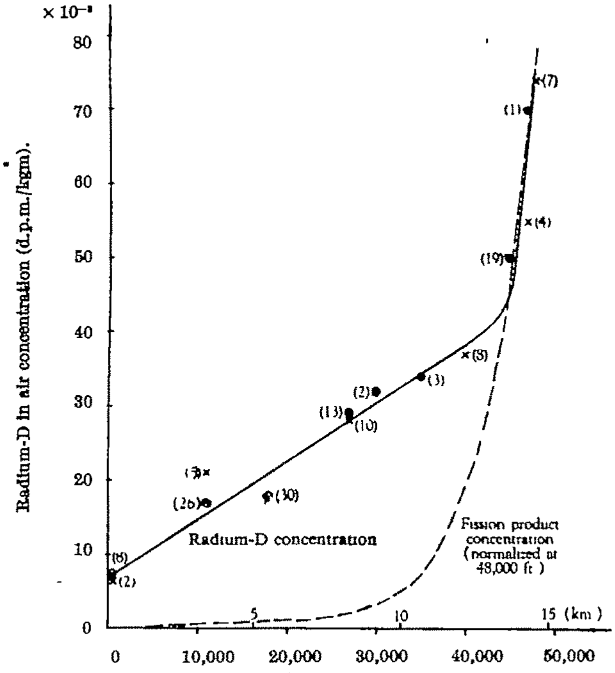


Fig. 1 Vertical concentration gradient of radium-D and fission products in the atmosphere above the United Kingdom. ○, radium-D from radium-D analysis; ×, radium-D from radium-F analysis. Numbers in brackets denote number of filters analysed

Atmospheric concentration of radium-F. Some analyses of radium-F were carried out on recently flown filters in which the measured radium-F concentration was practically the same as existed in the air during the sampling period. In a few cases the time-interval between sampling and analysis was long enough for the radium-F concentration to be affected, and in these cases a small correction was applied. The results of these measurements are shown in Table 4. The samples are grouped so as to average the radium-F concentration at three mean heights: ground-level, 27,000 ft. and 45,000 ft. The lack of data makes the form of the radium-F concentration curve uncertain, but it is clear that the concentration varies from a low value at ground-level to a high value in the lower stratosphere. The actual weighted mean values are $0 \cdot 9 \times 10^{-3}$ d.p.m./kgm. at ground-level and 30×10^{-3} d.p.m./kgm. at a weighted mean height of 45,000 ft. By comparing these values with those for radium-D in Fig. 1 it will be seen that the ratio of radium-F to radium-D is 0·13 at ground-level, increasing to 0·65 at 45,000 ft. This ratio in the lower stratosphere was also measured using a filter through which a large but unmeasured amount of air had been passed. The observed ratio of radium-F to radium-D in this case was 0·60, which is in good

Table 4. Atmospheric Concentration of Radium-F measured by Analysis of Radium-F in New Air Filters

Air filter sampling details					
Sampling altitude	Collection date	No. of filters	Air mass sampled (kgm.)	Air concentration (10^{-3} d.p.m./kgm.)	Average air concentration (10^{-3} d.p.m./kgm.)
Ground-level	May 1955	1	5,400	0·2	
Ground-level	November 1956	1	15,600	1·0	0·9
Ground-level	December 1956	1	5,500	1·4	
Ground level	January 1957	1	5,500	1·0	
27,000 ft.	August 1956	2	350	11	7
27,000 ft.	December 1956	1	190	4	
40,000 ft.	December 1956	1	70	35	
40,000 ft.	December 1956	1	56	29	30
47,000 ft.	October 1956	3	260	25	
47,000 ft.	December 1956	1	73	31	

agreement with the mean value of 0·65 determined above.

Concentration of radium-D and -F in rain-water. Each rain-water sample was analysed for both radium-D and -F and the results are given in Table 5. On two occasions duplicate chemical analyses were carried out on samples obtained from adjacent collectors In one case the results agreed to within ± 10 per cent and in the second case to ± 20 per cent, but the radium-F to radium-D ratios in each pair were in excellent agreement. The specific radium-D activity is seen to vary substantially from day to day, but the mean value of 5 d.p.m./litre over the period September–December 1956 is in good agreement with Blifford's value of 5·3 d.p.m./litre observed in Washington, D.C.[7]. The mean radium-F : radium-D ratio of 0·10 in the same period agrees with the ratio of 0·13 found in air at ground-level. This is to be expected since rain collects its dust from the lowest layers of the atmosphere.

Discussion

Radium-D in the stratosphere. The first striking feature of the results is that the concentration of radium-D in the atmosphere above the United Kingdom increases with height above ground and that the gradient increases sharply in the vicinity of the tropopause (Fig. 1). A similar discontinuity has been observed in the gradient of fission product dust from the thermonuclear explosions in Eniwetok in 1954 in which the dust clouds were injected high into the stratosphere[1]. A feature of the distribution of these fission products was that the stratospheric gradient had, within experimental error, the same value some 6 months, 12 months and 18 months after the explosions and this appeared to be a characteristic of the descending cloud. A normalized version of the fission product distribution curve is shown in Fig. 1. It will be noted that the stratospheric gradient of radium-D is very similar to the characteristic fission product gradient. This suggests that in the middle latitudes, where sampling was carried out, radium-D is descending from the stratosphere in a manner similar to the fission products. One possible source of this radium-D is in meteoric and volcanic dusts, which are known to diffuse into the troposphere from high altitudes. However, an approximate calculation indicates that the maximum contribution from these sources cannot account for more than about one millionth of the observed radium-D. We conclude that the radium-D has its origin in the tropopause and has entered the stratosphere at some earlier stage of its history.

Important features of the exchange processes between the stratosphere and the troposphere have been revealed by the work of Dobson and Brewer on the ozone and water vapour content of the atmosphere and a model of the general circulation based on their deductions is shown in Fig. 2. Dobson[12] explained the observed seasonal variations in total ozone by suggesting that the cold pool of air which forms above the winter pole when it is in shadow ultimately sinks and carries ozone-rich air to the lower levels of the stratosphere. In order to explain the form of the water-vapour curve in the stratosphere, Brewer[13] has suggested the circulation system shown in the model in which tropospheric air enters the stratosphere near the equator, travels to temperate and high latitudes and then sinks into the troposphere again. Fission product studies have supported this model. Thus, it has been shown that the rate at which fission products re-enter the troposphere from the stratosphere varies in the same seasonal manner as the total ozone[2]. Again, the concentration of fission products in air and in rain-water has a pronounced minimum in equatorial regions and a peak in the middle latitudes of the northern hemisphere, suggesting that this is where

Table 5. Analysis of Radium-D and -F in Rain-water

Rainwater sampling details			Radium-F activity (d.p.m./litre)	Radium-D activity (d.p.m./litre)	Ratio radium-F/radium-D
Collection date	Sample volume (litres)	Details			
September 27–28, 1956	2·4	duplicate samples	0·58	4·6	0·13
September 27–28, 1956	2·4		0·42	3·1	0·13
October 1–2, 1956	6·0		0·62	9·3	0·07
October 17–19, 1956	4·0		0·45	6·5	0·07
November 8–9, 1956	4·0		—	6·2	—
December 10–14, 1956	4·3	duplicate samples	0·63	1·7	0·37
December 10–14, 1956	4·3		0·50	1·4	0·36
December 14–16, 1956	5·6		0·43	2·4	0·18
	Average values		0·51	5·0	0·10

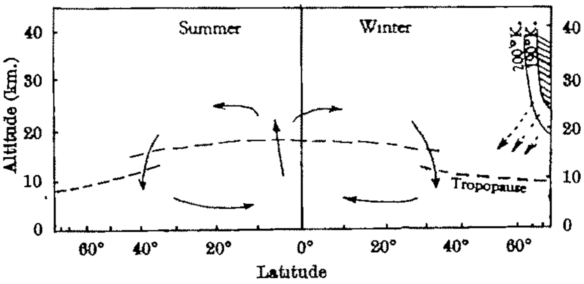


Fig. 2. Atmospheric circulation model (Dobson and Brewer)

the descending fission products re-enter the troposphere.

If this model is accepted, then the source of the radium-D in the stratosphere is the ascending air at the equator, which carries with it not only radium-D but also radon and its daughter products from which more radium-D will be formed.

Radium-D in the troposphere. The radium-D in the troposphere is a combination of two components, one of which is the radium-D descending from the stratosphere while the other is radium-D which was created and has remained in the troposphere. If we assume that the stratospheric component behaves similarly to fission products, then Fig. 1 shows that the tropospheric component predominates and that this component increases with height. At first sight this is surprising since the parent radon is known to originate at ground-level. The explanation is that the radium-D in the troposphere above the United Kingdom is characteristic of Atlantic air and is largely independent of any radium-D formed locally. In its passage across the Atlantic, the parent radon can diffuse above the rain-producing layer in the troposphere into a region where the radium-D formed is not subjected to washout. Radium-D at lower levels is subject to washout and the overall effect is to produce a positive concentration gradient in the troposphere.

It is possible from the results obtained to derive two independent estimates of the mean life of a radium-D atom in the troposphere. First, we can compare the radium-D content of a vertical column of air with the mean rate at which radium-D is deposited by rain. From Fig. 1 the radium-D content of 1 $m.^2$ column reaching from ground-level to the tropopause at 40,000 ft. is 167 d.p.m. The mean radium-D content of rainwater is 5 d.p.m./litre, so that an average rainfall of 2 mm./day (characteristic of the middle latitudes of the northern hemisphere[14]) deposits 10 d.p.m./$m.^2$/day. This points to a mean life of 17 days, a figure which would be proportionately higher if the efficiency of air sampling were less than the 100 per cent assumed.

A second rough estimate can be obtained from the ratio of radium-F to -D in the activity deposited in rain-water. If we make the reasonable assumption that the radium-D, -E and -F particles are washed out with equal efficiency by rain, then it can be shown that the radium-F to -D activity ratio is given by the expression:

$$\frac{\text{radium-F}}{\text{radium-D}} = \frac{T^2}{(Te + T)\,(Tf + T)} \qquad (1)$$

where Te = radioactive mean life of radium-E = 7·2 days; Tf = radioactive mean life of radium-F = 200 days; T = mean residence time of an individual atom in the atmosphere.

The mean ratio in the bulked rain-water collected was 0·10 and substitution in equation (1) gives T = 29 days. This figure, however, represents the mean residence time of the combined tropospheric and stratospheric components, and since the latter has been airborne for a longer time, it is high for the tropospheric component alone. Thus, if we assume that rain-water removes the activity from a mean height of 6,000 ft., then using Fig. 1 and the observed value of the radium-F/radium-D ratio in the stratospheric component, it can be calculated that the radium-F/radium-D ratio in the tropospheric component of rain-water is 0·075. This gives a value of T = 22 days for the mean residence time of those atoms the whole airborne life of which is spent in the troposphere.

Since each radon atom ultimately produces a radium-D atom, a final check on the consistency of the results can be made by comparing the amount of radon exhaled from the ground into the atmosphere with the amount of radium-D deposited by rain. Israel[9] has summarized the radon measurements made in many parts of the world and has shown that the mean rate of exhalation of radon from the Earth's surface, measured directly, is 7·7 × 10^4 d.p.m./$m.^2$/day, while the value derived from the measured concentration of radon in the atmosphere is 7 2 × 10^4 d.p.m./$m.^2$/day. Since land occupies 39·3 per cent of the surface of the northern hemisphere, we may take a mean radon exhalation-rate of 2·8 × 10^4 d.p.m./$m.^2$/day. This is equivalent to a production-rate of 15 d.p.m./$m.^2$/day of radium-D, which is in reasonable agreement with the measured deposition-rate of 10 d.p.m./$m.^2$/day computed above for a mean rainfall of 2 mm./day.

Circulation time of air entering the stratosphere from the troposphere. The ascending equatorial air shown in the model in Fig. 2 will carry with it radon, radium-D and -F together with the other less-important radon daughter products. Since the mean rainfall-rate is higher at low latitudes than in the middle latitudes it is possible that the radium-F will be even more deficient with respect to radium-D than it was in the troposphere above the United Kingdom. When the air enters the stratosphere, it becomes insulated from washout processes, and the radium-F can begin to build up towards its 'equilibrium' value with respect to radium-D, and consequently the radium-F : radium-D ratio in any mass of stratospheric air can be used as a measure of the length of time the air has been in the stratosphere. In particular, by comparing the ratio in equatorial air with that in air in the lower stratosphere above the United Kingdom the period of the circulation process depicted in Fig. 2 can be determined.

One unknown is the composition of equatorial air, but this does not have a major influence on the estimate. If the ascending air contained radium-D alone, then the observed radium-F : radium-D ratio of 0·65 at 45,000 ft. above the United Kingdom would correspond to a circulation time of 212 days. If pure radon was the original constituent, the time would be a little longer. These are upper-limit estimates and are highly unlikely in practice. Another assumption to make is that the ascending air has the same isotopic composition as the air near ground-level in the United Kingdom. This leads to an estimated circulation time of 177 days, which would be low if the radium-F : radium-D ratio in the equatorial troposphere were less than that in the middle latitudes. The true figure should be between these extremes and the best estimate is therefore of the order of six months.

Suggestions for Further Work

The radium-D, -E, -F measurements have been interpreted in terms of an atmospheric circulation model which appears to fit the facts. Other interpretations are possible, however, and future studies might be directed towards discriminating between the possibilities. L. Machta[15] has pointed out that the steep gradient in the stratosphere could be explained by an extension of the argument in par. 2 of the Discussion, which accounted for the positive gradient in the troposphere. In this 'diffusion' model, the source of the radium-D in the stratosphere is the radon and its daughters which diffuse through the tropopause into the stratosphere and afterwards decay into radium-D. The difference in gradient is due to differences in the diffusion constants appropriate to troposphere and stratosphere. This explanation would appear to require a greater value of the stratospheric diffusion constant than has hitherto been considered reasonable, but the matter might be settled by measuring the radon content of the lower stratosphere to establish if there was enough there to support this hypothesis. It would also be instructive to investigate the concentration of radium-D in the stratosphere in more detail than was possible here, to determine if it was subject to the seasonal variations observed with ozone and with fission products.

Conclusion

The development of a radiochemical separation procedure has enabled a preliminary study to be made of the distribution of radium-D and radium-F in the atmosphere. Systematic results have been obtained which suggest that radium-D is a valuable natural tracer for the further study of atmospheric processes.

The work described in this article was carried out in the Health Physics Division at the Atomic Energy Research Establishment, Harwell; we thank the Director of the Establishment for permission to publish this communication, and also the Royal Air Force for the collection of the airborne dust samples.

[1] Stewart, N. G., Crooks, R. N., and Fisher, Miss E. M. R., Atom. Energy Res. Est., *HP/R*.2017 (1956).

[2] Stewart, N. G., Crooks, R. N., Osmond, R. G. D., and Fisher, Miss E. M. R., Atom. Energy Res. Est., *HP/R*.2354 (1957).

[3] Stewart, N. G., Crooks, R. N., Osmond, R. G. D., Fisher, Miss E. M. R., and Owers, M. J., Atom. Energy Res. Est., *HP/R*.2790 (1959).

[4] Peters, B., *J. Atmos. and Terr. Phys.*, 13, 351 (1959).

[5] Gale, H. J., and Peaple, L. H. J., Atom. Energy Res. Est., *HP/R*.2381 (1958).

[6] Israel, H., "Compendium of Meteorology", 155 (American Met. Soc., 1951).

[7] Blifford, I. H., *et al.*, *J. Geophys. Res.*, 57, 499 (1952).

[8] Chamberlain, A. C., and Dyson, E. D., *Brit. J. Radiol.*, 29, 317 (1956).

[9] Wilkening, M. H., *Rev. Sci. Instr.*, 23, 13 (1952).

[10] Wiffen, R. D., Atom. Energy Res. Est. (private communication).

[11] Burton, W. M., and Stewart, N. G., Atom. Energy Res. Est., *HP/R*.2084 (1960).

[12] Dobson, G. M. B., *Proc. Roy. Soc.*, A, 236, 187 (1956).

[13] Brewer, A. W., *Quart. J. Roy. Met. Soc. Lond.*, 75, 351 (1949).

[14] Möller, F., *Petermanns Geographische Mitteilungen*, 95, 1 (1951).

[15] Machta, L. (private communication).

FUEL CELLS: WILL THEY SOON BECOME A MAJOR SOURCE OF ELECTRICAL ENERGY?*

By F. T. BACON

Marshalls Flying School, Cambridge

THE efficiency of all heat engines, that is to say, engines in which heat is converted into mechanical work, is governed by Carnot's cycle; this means that the efficiency is limited in practice by the difference in the temperature at which the heat is taken in by the working fluid and the temperature at which it is rejected. It is the possibility of avoiding the Carnot limitation which constitutes the main, but not the only, reason for interest in fuel cells.

Present-day Fuel Cells

A fuel cell can be defined as an electrochemical cell in which the free energy of combustion of a fuel is converted directly into electrical energy. Gaseous fuels are very convenient for use in electrochemical cells, and either oxygen or air is used as the oxidant. There are various ways of classifying the different types of fuel cell that are now being tried, but it is convenient to divide them up into those working at atmospheric temperature up to, say, 100° C.; those working at a medium temperature, around 200° C.; and those working at a high temperature, say 550° C., and upwards, with electrolytes of fused salts.

Those which work at a low temperature must, as a general rule, have electrodes with a very large internal surface if reasonably large current densities are to be attained; this is usually achieved by using highly porous materials, either porous carbon or porous metals. Porous carbon is peculiarily suitable for the purpose, and surfaces as large as 200 sq. m. per gm. are commonly used. The activity of the electrodes is often further increased by impregnation with catalytically active materials. The electrolyte in low-temperature cells usually consists of a strong aqueous solution of an alkali such as potassium hydroxide, which has a good conductivity. Work is proceeding in the United States on a rather different type of cell which has an ion-exchange membrane as electrolyte; the internal resistance of this type of cell is liable to be rather high, and the figures for performance which have been published so far are rather low; but, on the other hand, if the electrolyte is of the acidic type, ordinary untreated air containing carbon dioxide can be employed without any danger of carbonating the electrolyte. It can be safely said that the best results in low-temperature cells have so far been obtained with pure hydrogen and oxygen, as might be expected.

Cells which work at a high temperature use a mixture of fused salts, usually carbonates, as electro-

---

* Substance of a Royal Institution Discourse delivered on February 12.

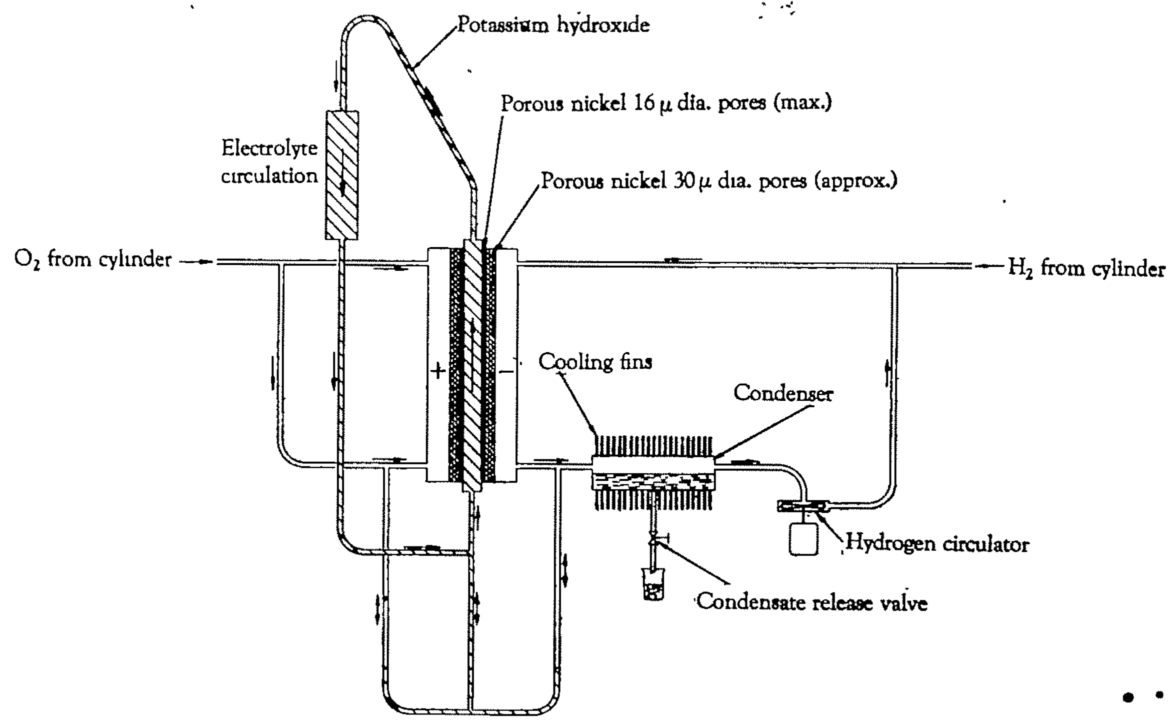


Fig. 1. Hydrogen – oxygen cell

lyte, and this is often contained in a porous diaphragm of sintered magnesium oxide. The electrodes may be of some metal or metal oxide, which must, of course, be kept in close contact with the porous diaphragm. This kind of cell may operate from about 550° up to, say, 800° C., but difficulties with corrosion become greater as the temperature is raised; the pressure is atmospheric. The great advantage of high-temperature cells is that they will consume impure industrial gases, or vaporized hydrocarbons such as kerosene, and air; this is, of course, a fundamental advantage in a genuine fuel cell—it uses cheap and readily available fuels.

The reacting gases in medium-temperature cells are usually hydrogen and oxygen; the theoretical efficiency at atmospheric temperature and pressure is about 83 per cent (based on the total heat of the reaction), and practical efficiencies of about 55 per cent have been obtained at 200° C. and a pressure of 400 lb./sq. in. Work on the high-pressure hydrogen/oxygen cell is now being financed by the National Research Development Corporation.

The electrodes of porous sintered nickel are about one-sixteenth of an inch thick, or less, and the electrolyte is strong potassium hydroxide solution. Fig. 1 shows the arrangement adopted in 1949 and which is still virtually unchanged.

The electrodes are made with a pore size of about 30 microns on the gas side and with a thin layer of much smaller pores on the liquid side; a small pressure difference is set up in the apparatus across each electrode, so that the liquid is expelled from the large pores on the gas side, but the gas cannot bubble through the small pores on the liquid side owing to the surface tension of the liquid. The interior of the 30-micron pores presents a large surface for absorption of gas.

Thus, in a porous metal electrode of this kind, the current density is kept low by the large internal surface of the large pores, and the gas side of the electrode is kept substantially dry, an essential condition for good performance.

The oxygen electrodes are first impregnated with mixed nitrates of nickel and lithium; they are then dried and roasted in air at about 700° C.; in this way they are coated with a conducting oxide layer which is very resistant to corrosion in the cell. Oxygen electrodes treated in this way have lasted for 1,500 hr. in the cell at 200° C. with a drop in output of less than 4 per cent.

The present 10-in. diameter electrodes are not strong enough to be self-supporting against the pressure difference, so they are sintered directly on to solid plates of nickel or nickel-plated steel, which have a large number of holes drilled or punched through them so that gas can readily get through from the other side. Fig. 2 shows the best cell characteristic so far obtained with this size of electrode, and

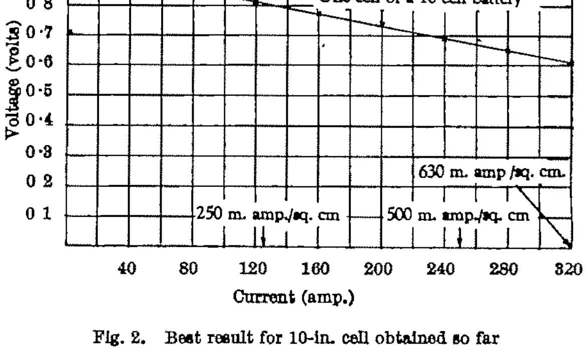


Fig. 2. Best result for 10-in. cell obtained so far

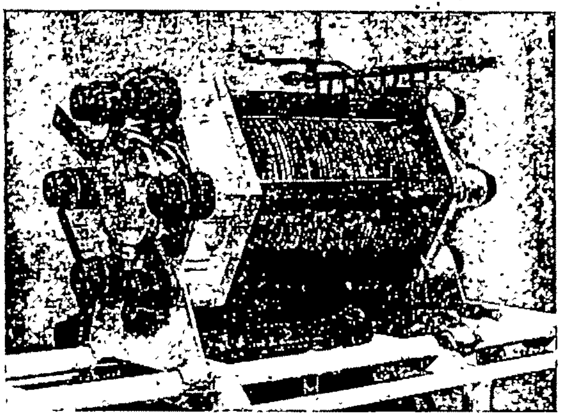


Fig. 3

it will be seen that currents as large as 320 amp. have been achieved.

Longitudinal ports are provided for feeding the two gases and the electrolyte to each individual cell. If bipolar electrodes can be made, a great saving in space and weight will be obtained.

Fig. 3 shows the largest battery built up so far; it has 40 cells, giving an open-circuit voltage of about 40; this gave a performance of 100 amp. at 32 V., or 3·2 kW., and 240 amp. at 24 V., 5¾ kW.

Advantages and Disadvantages of Fuel Cells

It is quite plain that if a fuel cell can be produced which will accept ordinary fuels such as coal, oil or gas, and atmospheric air, a vast field of application is open to it, on both a large and a small scale. Unfortunately, coal must be ruled out, as there is no sign of any cell which can make direct use of it; so we are left with oil in its various forms which can easily be vaporized if necessary, and gas which may be made from coal. Both oil and gas could be considered for large- and medium-scale generation, especially where natural gas is available; and the piping of natural gas over really long distances is now being considered. For large-scale generation, oxygen would probably be too expensive, so air would have to be used. A pressure cell would seem out of the question, owing to the cost of compression, so it seems fairly certain that a high-temperature cell with a fused salt as electrolyte is the answer in this case. Direct current is, of course, generated, so large-scale inversion would have to be considered, unless the device is used for, say, a locomotive, where direct current is desirable.

But the cell on which there is a great deal of controversy at present is the hydrogen/oxygen cell. If it can be brought to the stage of practical application, is it going to be any use in practice? The objections raised are mainly that pure hydrogen is an expensive fuel and is difficult to store; and the oxygen must be carried, too, and this is more expensive than air, which is free. Further, there is no highly developed distribution system, equivalent to that for petrol or diesel fuel. These are important arguments and must be faced.

It is usually agreed that the hydrogen/oxygen cell is essentially a storage device, rather than a genuine fuel cell using a primary fuel, and furthermore, it will be used mainly for road and rail traction. This means that the two gases will be produced by the electrolysis of water, probably in a separate apparatus. Thus the existing electricity grid would provide the distribution system for the fuel, electricity; and the gases would be generated locally. The battery would, of course, produce direct current, which is convenient for driving a vehicle. Considerable developments have taken place in recent years in the field of high-pressure electrolysers, and this should have the effect of reducing the cost of production of compressed hydrogen and oxygen in course of time.

Then there is the further interesting possibility that this particular cell could be made reversible, although it is not fully reversible yet; this should be a great advantage on any vehicle which has to start and stop repeatedly.

It must be admitted that gases are intrinsically difficult to store because they require heavy and bulky gas cylinders; it is tempting to consider storing them as liquids at a low temperature, and in this respect oxygen does not present much difficulty. But hydrogen is much more difficult, and although liquid hydrogen is made in quantities as great as 7 tons per day in the United States for use in rockets, it is still rather expensive. So, in the meantime, we are driven back to gas cylinders.

But the advantages of silence, freedom from fumes and vibration, and very few moving parts, should not be overlooked, and in certain special applications could be important. Further, it is well known that the torque characteristics of a direct-current motor are far better than those of an internal combustion engine which has to rely on a clutch and gearbox for starting. It seems that the hydrogen/oxygen cell is essentially a high-performance device, and therefore inherently suitable for traction.

One further point is that, as more nuclear power stations are built, it will become even more important to look for some method of storing electricity; it is well known that the main proportion of the cost of electricity produced in this way is due to the capital cost of the plant rather than the amount of nuclear fuel used, so that little is saved by shutting them down during time of light load. The present suggestion is that the electrolysers should be kept running at all times, except during the peak-load period, and that the gas produced should be used for driving some of our road and rail vehicles as and when required.

Practical Demonstrations

It is scarcely necessary to discuss applications for fuel cells, as these are fairly obvious if all the technical difficulties can be overcome, and the cost is not too great. The applications for a cell consuming either natural gas or liquid hydrocarbons and air would be enormous, both for static and mobile plant, and the great oil companies have started research work on the problem.

Practical demonstrations have already been given of fuel cells in use. A battery of hydrogen/oxygen cells developing 1 kW. was demonstrated in the United States about two years ago, as a power unit for a mobile radar set used by the U.S. army; it is known as the *Silent Sentry*, and in this case silence was its great virtue.

A demonstration took place at Cambridge in August 1959 of the high-pressure hydrogen/oxygen cell, in which a 40-cell battery was shown operating a small circular saw, providing power for arc-welding, and operating a fork-lift truck. The maximum power was about 6 kW.

A demonstration was given in the United States in October 1959 of a farm tractor driven by a battery of fuel cells supplied with propane and other gases (probably hydrogen) and oxygen. It has 1,008 cells in series and works at quite a low temperature; no details were given of the construction of the cells, but the electrodes must be very active catalytically to be able to make use of propane at a low temperature. 15 kW. is developed. This is the first time that a vehicle has been demonstrated propelled by a fuel cell-battery mounted on the vehicle. This is a great achievement, though the makers are careful to add that it is still a research vehicle.

Conclusion

Why is it that there is so much interest in the United States, and more recently in Germany, in fuel cells, and there is still so little in Britain, though this was where most of the original work was done? Part of the great effort in the United States is no doubt sponsored by the Federal Government, as there are certain military applications where fuel cells would be very valuable; and there is the vast satellite and space vehicle programme, where batteries are used extensively for providing auxiliary power. This is not the whole story, however, as some large companies are putting their own money too into research on fuel cells. It seems that the explanation is that the idea has 'caught on' in the United States, whereas in Britain it has not, as yet; and in any event, American firms are prepared to set aside enormous sums of money for research and development, even on comparatively speculative devices such as fuel cells.

It is, of course, known that the world reserves of coal, oil and natural gas are very great, but we are using them up faster now than ever before; the fuel reserves in Great Britain are not great, in comparison, and practically all oil has to be imported. Surely attention should be given to any device which might show an economy in the use of fuel. Part of the purpose of the vast atomic energy scheme in Britain was to help to conserve dwindling coal supplies; if a small part of the effort devoted to atomic energy could be given to a study of fuel cells in all their possible forms, an answer would probably be obtained within a very few years.

PRELIMINARY FLIGHT TESTS OF AN ATOMIC CLOCK IN PREPARATION OF LONG-RANGE CLOCK SYNCHRONIZATION EXPERIMENTS

By FRIEDRICH H. REDER and GERNOT M. R. WINKLER
U.S. Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey

THE performance of atomic and molecular frequency standards has been the subject of intense studies for several years[1-3]. In particular, tests have been made with a commercial cæsium beam frequency standard[4] ('Atomichron') under various environmental conditions. The 'Atomichron' employs a crystal oscillator which is continuously servo-controlled with respect to a microwave resonance of cæsium atoms. Usually the 'Atomichron' is employed to calibrate and check, at regular intervals, the rate of precision crystal clocks. It can, however, also be operated to drive a clock directly (within the life-time of the cæsium beam tube, which may be better than 6,000 hr.). Irregularities in time as small as one µsec. after 100 hr. have been achieved[5] during laboratory operation of the clocks in a controlled-temperature environment and with a stabilized power source. As an extension of these tests, flight experiments have been carried out with an operating atomic clock of the type mentioned above in preparation for a large-scale clock-synchronization project[6] aiming at an error of less than 1 µsec. between clocks separated by more than 1,000 miles. It is the purpose of this article to describe briefly the preliminary flight experiment and its results.

One atomic clock was operated from a voltage regulator in an air-conditioned laboratory room. The other clock was mounted in a *DC*-3 aircraft. All measurements were done in the laboratory by utilizing a microwave link between laboratory and airport, which are separated by a distance of 10 km. Both one-sec. pulses and the 100-kc /s. output signal were used to measure rate and time difference between the two clocks (Fig. 1). To ensure the least effect of Coriolis forces upon the atoms in the

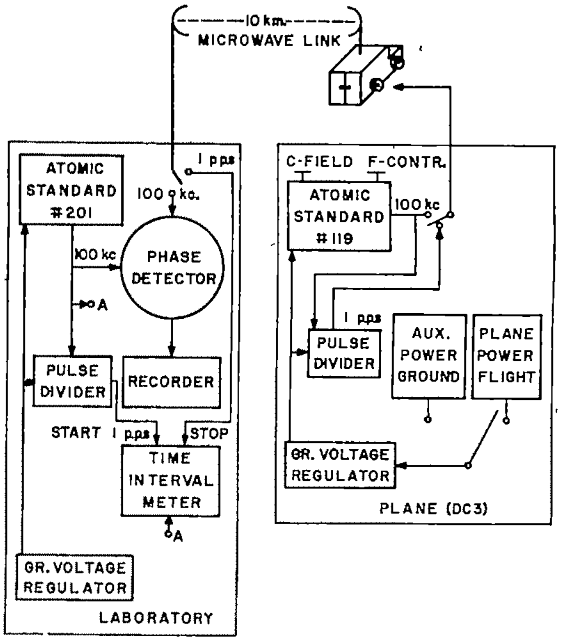


Fig. 1. Block diagram of measurement equipment for the flight test

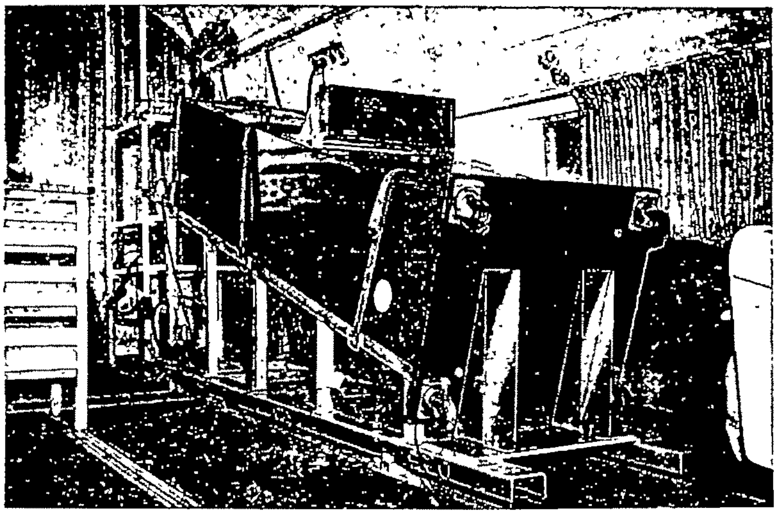


Fig 2. Position of atomic frequency standard in the aeroplane. Off-standing chassis contains the crystal oscillator on shock mounts

beam tube during flight, the plane clock was operated in an almost horizontal position (Fig. 2). While the aeroplane was on the ground, power for the equipment was furnished by a petrol generator mounted in the tail of the plane. Shortly before take-off, power was switched to the main board supply, with the line voltage input to the atomic clock being held constant by a buffer battery and a voltage regulator.

The aeroplane was unpressurized and without temperature control. However, the temperature was kept manually between 15° and 22° C. The flight altitude was about 330 m. above sea-level due to a very low ceiling.

One ½-hr. flight was made on November 16, 1959, and a 1-hr. flight on November 17. The pilots were instructed to turn not faster than about one complete turn per minute to avoid Coriolis effects. Despite considerable vibrations in the plane and rather unfavourable weather conditions on the second day, performance of the transported clock was quite astonishing (Figs. 3 and 4).

The uncertainty of time determination (after correction for the small rate of the clock) was less than 60 nanosec. after the shorter and smoother flight, and less than 150 nanosec. after the longer and rougher flight, which was plagued by a very short power failure caused by a faulty switching operation before take-off. It can be seen from Fig. 4 that this power failure resulted in a short-time perturbation of the relative rate of the two clocks. The results lead us to believe that synchronization of remote clocks by means of a shuttle plane is entirely feasible, and that, even with existing equipment, such synchronization will be about a thousand times more accurate than that at present possible through use of radio time signals.

Further extensive tests on synchronization of widely separated atomic clocks are in progress and will be reported soon.

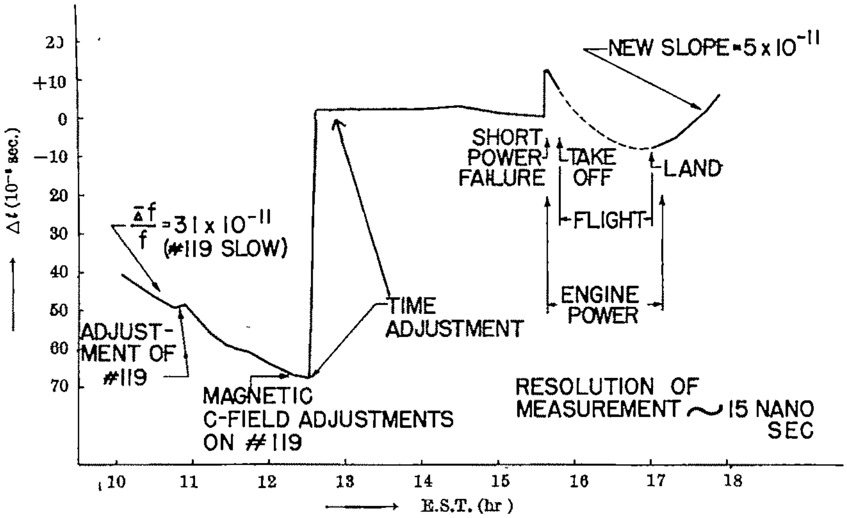


Fig. 4. Results of the second (1 hr.) flight test

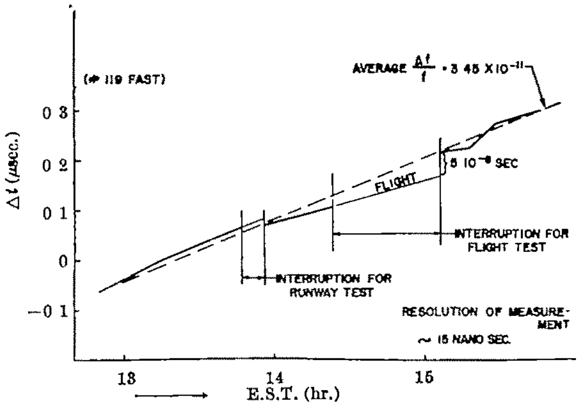


Fig. 3. Results of the first (½ hr.) flight test

[1] Essen, L., and Parry, J. V. L., *Phil. Trans. Roy. Soc.*, A, 250, 45 (1957).

[2] Essen, L., Parry, J. V. L., Holloway, J. H., Mainberger, W. A., Reder, F. H., and Winkler, G. M. R., *Nature*, 182, 41 (1958).

[3] Holloway, J., Mainberger, W., Reder, F. H., Winkler, G. M. R., Essen, L., and Parry, J. V. L., *Proc. Inst. Rad. Eng.*, 47, No. 10 (1959).

[4] National Co., Malden, Mass., Model *NC*-1001.

[5] Bridgham, R., Winkler, G. M. R., and Reder, F. H., "Synchronized Clock Experiment", Proc. Thirteenth Ann. Symp. Frequency Control, Asbury Park, New Jersey (May 1959).

[6] Reder, F. H., and Winkler, G. M. R. (submitted to *Inst. Rad. Eng. Trans. for Military Electronics* (June 1960)).

OBITUARIES

Dr. Roy Chapman Andrews

DR. ROY CHAPMAN ANDREWS, famous for his Gobi Desert discoveries in the early 1920's, died in New York early in March. He was seventy-six. He was born at Beloit, Wisconsin, on January 26, 1884, and was educated at the comparatively small College there, graduating A.B. in 1906. He then proceeded to Columbia, where he took his A.M. degree in 1913. He also had some experience in the Museum of Comparative Zoology at Harvard. His later education was interrupted by his absences on expeditions, those forays and excursions, often with important scientific and geographical results, that were to be the main interest of his life and the foundations of his undoubted eminence.

His association with the American Museum of Natural History began in 1908 when he joined an expedition to Alaska; he did exploration work on the St. Lawrence in 1909, shortly afterwards becoming naturalist in the U.S.S. *Albatross*, which visited the Dutch East Indies and Borneo in 1909–10. During 1911 and 1912 he was in Korea and in 1913 he was back in Alaska. These were, however, but preludes to his main task, which came when, in 1916, he was appointed leader of the American Museum expeditions to Central Asia. From 1917 until 1931 he was intermittently in Mongolia and in China in pursuit of vertebrate fossils and the remains of man.

His chief, the distinguished director of the Museum, Prof. Henry Fairfield Osborn, held the theory that the likely area of the dispersal of mammals and of man was to be found in the Orient, and the expedition's results, if not exactly convincing for this theory, were encouraging in the considerable materials that they produced. Dinosaurs and dinosaurs' eggs earned the expedition fame, though the dinosaurs were not so important as many that had already been found, and dinosaurs' eggs had been discovered earlier in England and in France. Andrews also found small Cretaceous mammals and giant Tertiary mammals and mastodons, but not a scrap of the fossil man he was working for, though *Sinanthropus* was later to turn up not so very far from the house where he kept palæontological court in Pekin.

Judged by any standards, Andrews's Asiatic expeditions were a success, and resulted in considerable additions to many museums other than his own, for the American Museum was generous, and excellent representatives of the dinosaurs from the expeditions are in the British Museum (Natural History).

Scientific and other honours rightly came to him. He was made Sc.D. of both his native Beloit and of Brown University, Rhode Island. He also received many medals, mainly for the geographical aspect of his work, from the National Geographic Society and the Explorers' Club in his own country, and from the national geographical societies of Sweden and Hungary.

During 1931–35 Andrews was vice-director in charge of exploration and research at the American Museum of Natural History, and from 1935 until 1942 he was director. He retired in 1942 with the title of honorary director.

He was the author of ten books and many scientific papers. Most of these were written in his beautiful homes in Connecticut or in California, where successively he lived after his retirement. But they were far from being his only interests. The Boy Scout movement and many sports, mostly connected with horses, engaged his attention, and he was always a hospitable man.

His name will be remembered in the annals of vertebrate palæontology and in the history of the distinguished Museum he served so well for so long.

W. E. SWINTON

Mr. C. A. Shain

CHARLES ALEXANDER SHAIN, an outstanding member of the radio astronomy group at the Commonwealth Scientific and Industrial Research Organization (Australia) Radiophysics Laboratory in Sydney, died on February 11 at the early age of thirty-eight. His contribution to radio astronomy lay in the frequency-range around 20 Mc./s. where he pioneered the study of the two features peculiar to this range of radio astronomy: absorption in ionized interstellar hydrogen (H II regions), and absorption and refraction in the ionosphere. Observations in this frequency-range are particularly difficult owing to interference from radio stations and the complicating effects of the ionosphere; but they give unique information of great importance to radio astronomy. Shain's work is basic in this field.

Shain studied physics in the University of Melbourne and graduated in 1942. He immediately entered the second Australian Imperial Force, but was discharged on medical grounds late in 1943. He then joined the staff of the Radiophysics Laboratory, where he stayed until his death. During the remaining stages of the War, he worked on radar counter-measures, and from 1945 on various aspects of decametre-wave radio astronomy.

His work in radio astronomy began with a study of Moon echoes at a frequency of 20 Mc./s. This work, which was an immediate follow-up of the pioneering American and Hungarian experiments, led to the recognition of the dual causes of the fading of Moon echoes: libration of the Moon and propagation effects in the ionosphere. Using parts of the same equipment, he then began the observations of the distribution over the sky of relatively low-frequency (20-Mc./s.) cosmic radio waves which he continued until his death. He first used broadside arrays, the largest of which consisted of 30 half-wave dipoles and had a beam-width of 17°, and then a 'Mills cross' with arms 3,500 ft. long and a resolution of 1·4°.

In the first phase of these investigations he was able to show conclusively that the brightness distribution over the Milky Way at this frequency was markedly influenced by absorption in H II regions; but he had insufficient angular resolution to delineate even the largest of these regions, and his 'Mills cross' was designed to overcome this limitation. At the time of his death he had nearly completed a 19-Mc./s. map of the greater part of the Milky Way, which shows numerous examples of the obscuring regions which he sought. His colleagues plan to complete and publish this unique and important work as soon as practicable.

In this frequency-range, the absorption of cosmic radio-waves in passing through the ionosphere is often appreciable and the interpretation of cosmic observations requires a knowledge of absorption in the various ionospheric layers. Shain's pioneering work on such absorption, particularly interesting at the time of solar flares, sufficed for his own purposes and has since given rise to a vigorous branch of ionospheric research which follows the inverse approach and uses observations of the absorption of cosmic radio waves to obtain information about phenomena in the ionosphere.

A by-product of the cosmic radio wave studies concerns radio emission from Jupiter. Following the discovery in the United States in 1956 of emission from this planet in the 20-Mc./s. range, Shain examined his old records. He found a large number of extended bursts of emission, which had previously been attributed to terrestrial interference, but which could now be identified with reasonable certainty as due to emission from Jupiter. Examination of the times of occurrence of these bursts showed a remarkable correlation with the rotation period of Jupiter, indicating that the emission originated in a very few active areas on the planet which remained in fixed positions for long periods.

Alex. Shain was a wonderful colleague in the laboratory—imaginative, well balanced, exceedingly unselfish, and a real friend to all. In his home community he was a leader in Church affairs. In murra where he lived he was, among other things, the Anglican Church in the Sydney suburb of Turra-Sunday school superintendent, lay reader and the leader of a Bible Study Group. He was a man who exemplified the principles of Christianity in all his dealings with men.

J. L. PAWSEY

Mr. K. J. F. Park

THE death of Kenneth John Frederick Park in a drowning accident on March 2 at the age of thirty-two has robbed the Nature Conservancy of a most valued officer, science of a first-rate ecologist and the world of a man of rare quality.

Park was educated at the Royal Grammar School, Newcastle upon Tyne, and at King's College, Newcastle. Between school and college he served three years in the Royal Air Force, and this took him to the Middle East and gave width of experience to an alert mind. He left the University with a first-class degree in botany and a good knowledge of the arctic-alpine vegetation of northern England, the Scottish Highlands and the Hebrides. His interest in field botany led him to postgraduate work on the ecology of Upper Teesdale, particularly the sugar-limestone outcrops. This work was interrupted in 1954 by his appointment as officer-in-charge of the Nature Conservancy's Moor House Field Station more than 1,800 ft. above sea-level in the northern Pennines.

His basic scientific interest was the conservation of upland Britain, using the word conservation in a wide and humanitarian sense. His own research was focused on the potential productivity of the grasslands on mineral soils. He aimed to get quantitative data on long-term trends in fertility-levels, as determined by grazing, leaching, soil weathering and other factors causing gain or loss of nutrients. During the past year or two he had been attacking these problems directly, for example by observations on rates of leaching, but before this he had put in much intensive work on recording the existing state of the various grassland types on the Nature Reserve. He did this by setting up a series of sheep exclosures and using various methods of mapping, point-quadrat recording, and detailed photography of vegetation. The methods were not of course original, but the standard of accuracy and the finish of the work are altogether outstanding and are witnessed in the volumes of the Nature Reserve Record Book. The plots have been laid out and recorded as the firm starting-point for observations visualized as going on over a century or more.

Over and above his own research line, he built up an impressive collection of information about the Reserve and the surrounding countryside, and himself contributed many superb photographs.

When he went to the Field Station he had nothing to work on but rather sketchy possibilities; but in his six years of imaginative and efficient management, he created a live centre of scientific work in remote and difficult conditions, where visiting workers could come and use their time productively. His achievement was due not only to his very hard work and exceptionally high standards but even more to his personal qualities, which enlisted the co-operation of anyone who came into contact with him, and the devoted loyalty of all his colleagues, both senior and junior.

Dr. Paul Haas

PAUL HAAS, who died on April 6 at Cheam, was born in 1877, the son of distinguished parents. His father was professor of Sanscrit at University College, London, and his mother was a gifted pianist who, before her marriage, had a European reputation as a soloist. Even in her old age, Madam Haas played the music of Bach in a manner few could equal, and her son inherited musical appreciation.

Paul Haas was educated at University College School when it was in Gower Street, then at University College, and he studied also both at Freiburg and Geneva. As an investigator, he was very deliberate and conscientious. With the late Prof. T. G. Hill, he collaborated in the investigation of the biochemistry of seaweeds and the chromogens of *Mercurialis perennis*, and they produced, in 1913, "An Introduction to the Chemistry of Plant Products", which was afterwards extended into a two-volume work.

It was in teaching, however, that Haas found his chief interests, and his lectures and demonstrations were always carefully prepared. He lectured on organic chemistry both at St. Mary's and St. Thomas's Hospital Medical Schools, and also at the Royal Botanic Gardens, Kew, until he became reader in plant chemistry at University College, of which he was a Fellow.

Paul Haas had a retiring kindly personality with a quiet sense of humour. He looked after his mother devotedly, at their home in Westbourne Park, until her death, and his colleagues had regarded him as a confirmed bachelor. But romance came to him when inspecting schools for the University of London, and at the age of sixty-one he married Beryl Grace Wood who, with a son of the marriage, survives him.

E. J. SALISBURY

Prof. J. A. Hanley

The death of Prof. J. A. Hanley on April 10 occurred after several years of physical handicap, gallantly borne with the help of his devoted wife, following a breakdown in health he suffered in the post-war years. He has been living during this period of retirement from his academic career in Applethwaite, near Keswick. His last appointment was that of professor of agriculture and rural economy in King's College, University of Durham, Newcastle upon Tyne, where he directed the work of the School of Agriculture and Cockle Park (then Northumberland County Experimental Station, now owned by the College) from 1931 until 1947.

Hanley, who received his school education at Wakefield Grammar School, served later in the county of his birth and forbears as lecturer in agricultural chemistry and advisory chemist in the University of Leeds. Prior to this appointment he had obtained the degree of Ph.D., University of Munich, as well as becoming an associate of the Royal College of Science, for which he studied in London. Before going to Leeds he had been engaged in research at Rothamsted, and was Board of Agriculture Research Scholar during 1912–14. From Leeds he went as professor of agriculture and chief advisory officer in the University of Bristol, where he served from 1924 until 1927, whence he became principal of the Royal Agricultural College at Cirencester, where he continued during 1927–31. His appointment to the chair of agriculture at Newcastle—in succession to the famed Somerville, Middleton and Gilchrist—was made in 1931.

There is no doubt that he experienced much satisfaction from the opportunities afforded him in the scientific directorship of Cockle Park—an office which devolves on the professor of agriculture in King's College—for Hanley's major interest in agriculture was the subject of grassland management. As early as 1927 he was the joint author with Prof. R. G. Stapledon of the book "Grass Land : its Management and Improvement", published by the Oxford University Press, and in subsequent years he was responsible for the Ministry of Agriculture's well-known bulletin on "Grassland", as well as for several of the Ministry's leaflets on various aspects of the same subject. He was a leading spirit in the national campaign for grassland improvement, taking a prominent part as judge and adviser in the grassland competitions organized in the four northern counties of England during the early 'thirties.

While giving much attention to grassland, especially to the then recent developments in its utilization as dried grass and silage, in which subject he carried out early investigations at Cockle Park, Hanley had a wide knowledge of agriculture and agricultural education. In a volume of essays presented to Sir Daniel Hall on "Agriculture of the 20th Century", published in 1939, Hanley's fine contribution was a comprehensive study entitled "Agricultural Education in College and County".

Among his original contributions when at King's College was a survey of agriculture in the Northern Province (Counties Durham, Northumberland, Cumberland and Westmorland), made possible by a financial grant given by the Right Hon. David Lloyd George. Although this was a comparatively quick survey, the report published in 1936 gives an informative account of the agriculture of the area which for the purpose of the survey was divided into twenty districts ; Hanley being assisted in this extensive project by two of his students, Messrs. Boyd and Williamson.

As in the case of his predecessors mentioned in the chair of agriculture, King's College, he formed many mutually helpful friendships with northern farmers—as, for example, D. J. Brown of West Learmouth, and J. B. Barr of Pressen—the study of whose farms, and discussion of changes in management, resulted in his contribution to the *Journal* of the Royal Agricultural Society of England, entitled "Tweedside Farming Enterprises", which itself is a typical example of the wide range of subjects on which he wrote for various journals. In his latter years he was editor of a series of four volumes published by Caxton in November 1949, under the title of "Progressive Farming".

During the Second World War, from 1940 onwards, he became the Ministry of Agriculture's liaison officer for the northern counties in connexion with the food production campaign.

From my personal knowledge as a colleague for the period of his professorship at King's College, I knew him to be a very good teacher, whose courses of lectures on soils and geology are remembered. He showed a greatly appreciated interest in the social and athletic activities of his students, being *inter alia* a keen supporter of their Rugby achievements, to which a photograph (still hanging in the Dean's private room in the School of Agriculture) bears testimony showing him surrounded by members of the team. No one who knew him intimately could fail to be aware of his emphasis on efficiency and his keen interest in his work as a teacher and adviser on agriculture, and of his continuous desire to make his contribution to the progress of that distinctive movement in the present century towards the improvement in management of the grassland of Great Britain.

H. CECIL PAWSON

Dr. F. Jones

DR. FRANCIS JONES, T.D., died suddenly at Crowborough on February 28.

Francis Jones was born at Belper, Derbyshire, in 1887. He was educated at Wirksworth Grammar School, graduated at the University of London, and later took his Ph.D. in geology. He was commissioned as a lieutenant in the Royal Engineers during the First World War and served in France, Gallipoli and Egypt. He taught as a science master, first in Leicester and then from 1929 until 1947 at St. Dunstan's College, London, where he served as commanding officer of the Officers Training Corps for eight years. During this period he also acted as head of the Department of Geology at the Northern Polytechnic. Between 1926 and 1936 he published a number of papers on his researches on the petrology of the Pre-Cambrian rocks of Charnwood Forest.

His love of geology and young people coupled with his tremendous energy would not allow him to retire, and in 1947, at the age of sixty, he joined the staff of the Geology Department of the Imperial College of Science and Technology, where he remained until 1958 ; at the same time he continued until his death his teaching at the Northern Polytechnic. In the lecture theatre and the laboratory he was insistent on fundamentals. Influenced by his great friend, the late Dr. Alfred Brammall, he brought his knowledge of chemistry to bear on theoretical aspects of mineralogy and petrology, and his lectures and discussions on these topics were a stimulus to all those who were privileged to hear them.

Anxious to use every minute of his day, he turned the accumulated knowledge of his academic career to the problems of engineering geology, and from the age of sixty-one until his death worked during vacations as a consultant geologist on civil engineering projects in Syria, the Lebanon, Iraq, Iran, Ghana, the Sudan and on the Kariba Dam in Central Africa. His kind but rugged features were a true expression of his character. He possessed a physical toughness and endurance which were remarkable for a man of his age. Twenty miles a day on foot in the deserts of the Middle East or the bush of Africa left him undaunted; he invariably led the way. His only admission of physical discomfort was at the age of seventy, when he said that he felt somewhat sore after riding on horseback for two days through the Elburz Mountains of Iran.

Loyalty was the keynote of his personal life, and despite the failing health of his last two months he travelled to various parts of the country to fulfil lecture engagements regardless of the advice of his doctor and friends. It was his sense of loyalty supported by his great physical courage which carried him from his home at Crowborough to London to give his last lecture to his students at Northern Polytechnic ten days before he died.

D. J. SHEARMAN

Dr. August Gansser-Burckhardt

DR. AUGUST GANSSER-BURCKHARDT, who died on January 27 at his home in Basle, will be remembered by many for his achievements in fields on the borderlines of technology, and by his friends for his radiant personality. He was born in Milan in 1876. After passing the examination in chemistry at the Federal Technical College in Zurich, he obtained a doctorate at the University of Zurich in 1900. After one year's further study in London, Dr. Gansser began his life-long association with the family enterprise, the present S.A. Ledoga in Milan, manufacturers of vegetable tannins and natural dyes. It was at an opportune time, since Dr. Lepetit had just worked out his revolutionary process of making cold-water soluble quebracho extract by sulphitation. Gansser contributed substantially to the success of this venture. Since 1917, he had resided at the old home of his family, Basle, serving as the international co-ordinator for the family concern.

Along with his business activity, two major inquiries became gradually the all-absorbing interests in his life. His name will always be connected with the battle against the warble fly and with his contributions to the ancient history of leather. His fight for the eradication of the warble fly, which not only inflicts sufferings on cattle but also does a great deal of damage, resulting in much decreased value of the hides and impaired yields of milk and meat, made him well known throughout the world. His untiring efforts in this vital crusade were recognized by his Alma Mater by the award of the honorary degree of D.V.M. His second interest was archæology, particularly the study and analysis of finds from excavations of Roman settlements on the Continent and particularly of sites in Italy. His broad humanistic knowledge and his scientific training became a most effective combination in this pioneering research. He handled the archæological issues as well as the chemical analysis of the finds most competently.

Dr. Gansser was the founder of the Swiss Society of Leather Chemists, and he was instrumental in re-establishing international contacts after the two World Wars. At the time of the first one, he served as the president of the International Society of Leather Chemists.

Dr. Gansser was a man of wide culture, embodying the best traditions of his beloved Switzerland and Italy, and of kind and unassuming disposition. His sterling personality and his talents as a linguist and speaker—with five languages ready to his service—made him a well-known, and lately legendary, figure at international gatherings in his field of work for more than half a century.

K. H. GUSTAVSON

Mr. F. H. Edmunds

WITH the death of Francis Hereward Edmunds on April 19 at Westhumble, Surrey, British practical geology lost an exponent whose work had long been an encouragement to civil engineers and many other professional men seeking advice on geological problems. His friendly guidance will no less be missed by innumerable students, research workers, amateur geologists, naturalists and interested laymen in the south of England. Many will recall with pleasure the field excursions led by Edmunds and the lectures he was always pleased to give to promote popular understanding of the influence and application of geology. Most of all, however, he will be missed by his colleagues on the Geological Survey of Great Britain, where he served from 1922 until 1957 and was always happy to encourage the younger geologist.

Edmunds was proud to own himself a native of Wiltshire. He was born at Mere in 1893 and was educated at Gillingham Grammar School, in the neighbouring county of Dorset. After serving in France as a captain in the Tank Corps during the First World War, he went up to Emmanuel College, Cambridge, where he made many friends in the University. He obtained first-class honours in geology in Part II of the Natural Sciences Tripos in 1922.

Throughout his career on the Geological Survey, Edmunds maintained his strong interest in geological mapping. Large areas on a number of published 1 in. to the mile maps, notably in Surrey, are the result of this work, and Edmunds was part-author of the explanatory memoirs on the Reigate, Guildford and Romford districts. Among other official publications, he was author of "British Regional Geology: The Wealden District" and part-author of "The Central England District" in the same series. Edmunds compiled a memoir on "The Wells and Springs of Sussex", and published papers in the *Journal of the Institution of Water Engineers* and elsewhere. During his period in charge of a small unit formed at the Geological Survey in 1936 on the request of the Inland Water Survey Committee, Edmunds organized the systematic collection and collation of well-records and undertook many advisory duties for Government departments and the Services, particularly during the Second World War. During 1945–57 Edmunds was district geologist for South-Eastern England.

Perhaps the strongest appeal of his book, "Geology and Ourselves", lies in its treatment of aspects of civil engineering and geology in everyday life. Edmunds also wrote and lectured with authority on the geology of scenery, of soils and of building materials. He was president of the South-Eastern Union of Scientific Societies in 1949 and took an active part in the Geology Section at the British Association meetings of 1954 and 1955.

Among his activities after retiring from the public service, Edmunds continued to put his geological knowledge at the disposal of the community on questions of planning in the County of Surrey.

It is sad that the fatal recurrence of an illness he had suffered three years previously prevented Edmunds from enjoying longer a happy retirement in the beloved Mole valley where he had made his home since 1939. His wife and daughter will know that his memory will long be cherished in the Dorking and Mickleham district for his activities both as townsman and countryman, and the delight he took in music and musical affairs.

S. C. A. HOLMES

NEWS and VIEWS

Earth Satellite 1960ε

THE heaviest satellite yet to be placed in orbit about the Earth was launched from the U.S.S.R. at about 00 hr. U.T. on May 15. Its total weight, excluding the final stage of the rocket which took it into orbit, is 4,540 kgm. (10,010 lb.), more than three times as heavy as *Sputnik* 3, which was launched two years earlier. The satellite, which has been called *Korabl'-Sputnik* or space-ship satellite, consists of a pressurized cabin weighing about 2,500 kgm., which contains a dummy astronaut and all apparatus necessary to keep a man alive in space, together with extensive instrumentation, weighing about 1,500 kgm. The satellite carries various radio transmitters, with the main one operating on a frequency of 19·995 Mc./s. The chief purpose of the satellite is to test the design of the cabin, and the first measurements made by the instruments suggested that the environment in the cabin was suitable for human survival. It is stated that the cabin is to be detached from the remainder of the satellite ; it will then probably burn up in the atmosphere, since it is not designed to withstand re-entry.

The orbit of the satellite, like that of *Sputniks* 1, 2 and 3, is inclined to the equator at an angle near 65°. The initial period of revolution was 91·2 min., corresponding to a semi-major axis of 6,713 km., and the orbit was nearly circular, having an eccentricity of about 0 0048. The satellite was at perigee when going north at a latitude near 54° N., the perigee height being about 320 km. (200 miles) and the apogee height about 380 km. (235 miles). The lifetime of the satellite is uncertain, being dependent on conditions after the separation of the cabin, but does not seem likely to be more than a few months. At latitudes between 40° N. and 60° N. the satellite will be favourably placed for observation in the night sky during May and June. The final stage of the launching rocket separated from the satellite on entering orbit.

Cryptogamic Botany at Manchester : Prof. J. Colhoun

DR. JOHN COLHOUN, reader in mycology and plant pathology in the Queen's University, Belfast, has been appointed to the chair of cryptogamic botany in succession to Prof. C. W. Wardlaw, who now occupies the George Harrison chair of botany in the University. Though his published work lies in the fields of mycology and plant pathology, of which he is a distinguished exponent, Dr. Colhoun is also a botanist of wide experience. He entered the Queen's University of Belfast in 1930, graduated in science in 1933 and in agriculture in the following year. The next four years were spent in research at the Department of Agricultural Botany in Belfast and at the Imperial College of Science and Technology, London. He returned to Belfast in 1938 to the Department of Plant Pathology and from 1940 up to the present has held posts in the Departments of Agricultural Botany and of Mycology and Plant Pathology. Since 1939, he has held, concurrently with his University appointments, corresponding posts in the Plant Pathology Division of the Ministry of Agriculture of Northern Ireland. During 1942–49, Dr. Colhoun was warden of the Queen's Elms hall of residence for men in Belfast and has also held other University posts. During the past twenty-five years Dr. Colhoun's researches have been directly related to fundamental problems in plant pathology, particularly in relation to plant environment, the control of the diseases of economic plants, and the investigation of the physiology of various fungi. He has also co-operated with geneticists in a programme of breeding disease-resistant plants. He is the joint author of a book on "The Diseases of the Flax Plant", the author of an important monograph on "Club Root Disease of Crucifers" and of many contributions to scientific journals.

Physiology at the London Hospital Medical College: Prof. K. W. Cross

KENNETH WILLIAM CROSS, who has been appointed to the chair of physiology in the London Hospital Medical College, in succession to Prof. J. L. D'Silva (see *Nature*, 184, 405 ; 1959), entered St. Mary's Hospital as a Scholar soon after the outbreak of the Second World War. After qualifying, he held a research studentship in the Wright–Fleming Institute, and having obtained the M.R.C.P. spent the remainder of the War as casualty physician at St. Mary's and as resident physician to the E.M.S. Hospital at Amersham. After the War, he worked for a year with the Friends' Ambulance Unit in China and taught at Cheeloo University. On his return in 1947 he was appointed lecturer in physiology in St. Mary's Hospital Medical School and soon afterwards also clinical assistant on the Pædiatrics Unit of the Hospital. He then settled down to study respiration and metabolism in the new-born infant, and this has remained his principal interest. He devised an accurate method for determining the infant's respiratory movements and oxygen consumption, and made a special study of the effects of lack of oxygen. The value of his investigations was soon recognized by the Sir Halley Stewart Trust and by the Medical Research Council. In 1951 he became joint organizing secretary of the symposium on anoxia of the new-born infant, arranged in London under the auspices of the International Organization of Medical Sciences. He remained at St. Mary's, being appointed reader in human physiology in 1953 and reader in physiology in 1956, and obtaining the degrees of Ph.D. and D.Sc.

His work led to more basic studies of the mechanisms of respiration in new-born animals, pursued with Dr. June Hill at St. Mary's and with Dr. G. S. Dawes and his colleagues at the Nuffield Institute for Medical Research at Oxford. Cross spent last year in Dr. Julius Comroe's laboratory at the University of California Medical Center and developed a method for inflating the infant's lungs which led to the discovery of surprising reflex mechanisms and may have opened an entirely new field. His many physiological and pædiatrical friends look forward to further important contributions from the London Hospital Medical College.

Statistics at University College, London : Prof. E. S. Pearson, C.B.E.

At the end of the current session Prof. Egon Sharpe Pearson retires from University College, London, and for the first time in seventy-six years there will no longer be a Pearson in charge of the statistics at the Department there which has become world famous. Egon Pearson was educated at Winchester and Trinity College, Cambridge, and continued his studies in statistics at University College, London, where he became a lecturer in 1921. Not long afterwards Jerzy Neyman joined the Department, and before long he and Egon Pearson began a remarkable series of papers which effectively laid the foundations of the Neyman-Pearson theory of statistical inference, undoubtedly one of the profoundest influences on modern statistical thought. Pearson has continued to work in this field and the related area of confidence-interval theory and has notably advanced knowledge of the sample range. His work on the Ordnance Board of the Ministry of Supply during the Second World War was recognized by his appointment as C.B.E. in 1946. He has also taken particular interest in the teaching of statistics ; his work both at University College and as chairman of various committees of the Royal Statistical Society has laid both students and colleagues under a heavy burden of indebtedness to him for his constant endeavours to raise the standards of statistical instruction. He was president of the Royal Statistical Society during 1955–57 and received the Society's Gold Medal in 1955.

For about 25 years Pearson has been editor of *Biometrika*, and the high standing of that journal is largely due to his painstaking work and constant care. Another of his many contributions has been his work on statistical tables, embodied in the Pearson–Hartley "Tables for Statisticians, Part 1", and the *Biometrika* series of reprints. His many friends will be glad to know that he intends to devote a good deal of his time to continuing this work.

Prof. M. S. Bartlett

Prof. Maurice Stevenson Bartlett, professor of mathematical statistics in the University of Manchester, is to succeed Prof. Pearson. Prof. Bartlett read mathematics at Queens' College, Cambridge, and was awarded the Rayleigh Prize in 1934. After a short period as assistant lecturer at University College, London, and four years as statistician with Imperial Chemical Industries, Ltd., he returned to Cambridge as a lecturer in statistics in 1938. With the late John Wishart he helped to introduce modern statistical methods there and contributed some noteworthy research papers in a wide range of subjects : experimental design, factor analysis, regression theory and statistical inference. He was appointed to the chair of mathematical statistics at Manchester in 1947, and has worked there since that time. His principal contributions in more recent years have lain in two main fields, multivariate analysis and stochastic processes including time-series, both of them complicated and difficult subjects in which his work has given him a world-wide reputation.

Communication Research at Keele : Prof. Donald M. MacKay

The University College of North Staffordshire, Keele, has appointed Dr. Donald M. MacKay to the new Granada research chair of communication, founded by a gift of Granada Television Network, as from June 1, 1960. Dr. MacKay, who is at present reader in physics at King's College, London, graduated from the University of St. Andrews in 1943. After war-time work on radar with the Admiralty, he joined the staff of King's College, where he was concerned with the early development of information theory and the theory of 'brain-like' self-organizing information systems. On the experimental side, a period of research on the informational limits of high-speed analogue computing led to his present interest in the mechanism by which information is processed in the central nervous system.

The work at the University College of North Staffordshire is expected to develop along three main lines : (1) the study of perceptual mechanisms, and the development of methods for the analysis of electrical brain-activity in perception ; (2) the development of artificial mechanisms capable of identifying patterns in space or in time, as an experimental 'testing ground', for theories of perception ; (3) the study of disorders of function, as clues to the organization of the brain. Research on these interdisciplinary lines will require the collaboration of physiologists and experimental psychologists as well as of physicists and electronic engineers ; and the setting up of an independent University department at Keele for the purpose marks a significant step in the academic development of this new subject. Dr. MacKay's gifts as a research worker and a teacher will be sorely missed at King's College ; but we may surely look forward to a period of great activity and development in his new environment. In spite of his new responsibilities, we may also be sure that his interest in undergraduates and their problems will continue undiminished.

Principalship of Fourah Bay College : Dr. D. Nicol

Dr. Davidson Nicol has been appointed principal of Fourah Bay College, the University College of Sierra Leone, in succession to Mr. J. J. Grant. Dr. Nicol was educated at primary schools in Nigeria, the Government Model School, Freetown, and the Prince of Wales School, Freetown. In 1943 he entered Christ's College, Cambridge, having won an open Colonial scholarship for medicine. He was elected Foundation Scholar at Christ's College in 1946 and also in that year was the Open Universities Entrance scholar to the London Hospital. In 1947 he obtained first-class honours in the Natural Sciences Tripos and he graduated in medicine at the London Hospital in 1950. Dr. Nicol was awarded a Beit Memorial Fellowship for Medical Research in 1954, and when he became a Fellow of Christ's College, Cambridge, in 1957, he was the first African to be elected to a fellowship at either Oxford or Cambridge. During 1952–54 he was lecturer in physiology and biochemistry in University College, Ibadan, Nigeria, and has been guest lecturer in the University of Toronto and at a number of American universities. He is at present senior pathologist and head of the Laboratory Services of Sierra Leone.

Recruitment of Teachers in Britain

IN replying for the Government in an adjournment debate in the House of Commons on the supply of teachers of mathematics, which was opened by Mr. A. Skeffington and Mrs. E. White on May 9, the Parliamentary Secretary to the Ministry of Education, Mr. K. Thompson, said that a survey carried out in the schools in March 1959 showed that there are 5,100 people with honours degrees teaching mathematics in maintained schools, and 4,500 of these were in 2,600 maintained secondary schools with General Certificate of Education courses in mathematics or science, in which at that time there were 250 vacancies for honours graduates to teach mathematics. In these 2,600 schools there are also 3,250 non-graduate specialists teaching to General Certificate of Education standards. Mr. Thompson pointed out that of honours mathematics graduates from British universities, two-thirds already go into the educational system at some point and the universities are increasing their output. If the proportion recruited for teaching could be increased, this would be done. He also stated that during the period when teaching qualified a man for deferment from National Service, there was a net gain of about 500 honours graduates into the teaching profession, and that this modest gain had continued since 1957 when honours graduates had been completely free to choose between industry and the teaching profession. Mr. Thompson thought that the debate had not been completely fair to those coming from training colleges in Britain: he is confident that many of them are quite capable of teaching mathematical subjects and some of the sciences to Ordinary level General Certificate of Education standard with success, and some of them would be able to take these subjects at a higher level. Apart from his reference to attempts to attract more university graduates into the schools, Mr. Thompson stressed the need to attract more married women to come back into teaching either full-time or part-time, and he referred to the refresher and short courses in mathematics promoted by the Ministry, and to the 106,000 Ordinary level and 21,000 Advanced level passes from maintained secondary schools, compared with 71,000 and 13,000, respectively, in 1954.

British Books for Export

IN a written answer in the House of Commons on May 9, the Chancellor of the Duchy of Lancaster, Dr. Charles Hill, stated that the Advisory Committee on the Selection of Low-Priced Books for Export has made good progress, and he understood that the Committee will shortly recommend its first list from the 2,000 titles put forward by publishers and others to the Ministers concerned. The Advisory Committee is also studying a first list of some twenty-five scientific and technical text-books for issue in low-priced editions for university and college libraries, instructors and students. The Government has decided to give a measure of priority to university text-books in view of the importance attached by the Commonwealth Educational Conference to the supply of books of educational, scientific and technical value. Initially, the arrangement will be applied in India, and subject to negotiations with publishers, it is hoped that low-priced editions of text-books will be made available for distribution through normal trade channels in India by December next. The size of editions will depend upon demand, among other factors, but the Government has in mind editions of up to 5,000 copies of the more specialized and advanced university text-books.

Dental Research in Britain

IN answer to a question about dental research in the House of Commons on May 9, Mr. D. Walker-Smith, Minister of Health, as representing the Minister for Science, said that current annual expenditure on dental research by the Medical Research Council exceeds £35,000, and that at least one quarter of the annual expenditure of £750,000 of the university dentistry departments is spent on research. The Minister is not satisfied with the scale of dental research in Britain, and he attributes the position to lack of interest and enthusiasm on the part of dentists and graduates in science.

European Co-operation for Science

A MAJOR project in international co-operation in science education is to be launched as the result of an agreement signed between the Minister of Education and the Organization for European Economic Co-operation. The project will consist of a series of films aimed at stimulating the interest of young people in scientific subjects and made by a number of national organizations. The organizations are: the Educational Foundation for Visual Aids (United Kingdom); Institut Pedagogique National (France); Institut für Film und Bild (Germany); Statens Filmcentral (Denmark); Statens Filmsentral (Norway); Nederlandse Onderwijs Film (Holland). The contribution of the United Kingdom will be a film on 'Faraday' and the others are: "The Atomic Age" (Denmark); "Fight against Bacteria" (France); "Discovery of the Rare Gases" (Holland); "The Story of X-Rays" (Germany); and "The Story of Electrochemistry" (Norway). The scheme, initiated by the United Kingdom, received the full support of the national organizations represented on the International Council for Educational Films. It has been made possible by financial help from the Organization for European Economic Co-operation which is contributing half the cost, the remainder being provided by the national organizations already mentioned. The project will be organized by the Educational Foundation for Visual Aids. When complete, the films will be available to all schools in the member countries of the Organization for European Economic Co-operation.

The Association of Universities of the British Commonwealth

THE report of the Executive Council of the Association of Universities of the British Commonwealth for the year ended July 31, 1959, includes the usual particulars of appointments in which the Association was asked to act in one way or another (pp. 28. London: Association of Universities of the British Commonwealth, 1959). These totalled 720, compared with 651 in 1957–58, and the office dealt with 4,896 inquiries, of which 4,260 related to advertised appointments. Eighty advisory committees were convened and reports sent to the universities concerned on 139 candidates. Of the 115 candidates making application through the Association whose appointment was announced by member universities, eighty were in Australia. Membership of the Association now comprises 102 universities, 15 university colleges and 4 other institutions, and some notes on the meetings of the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom are appended to the report.

Fuel Abstracts and Current Titles

THE annual report of the Council for the Institute of Fuel for the year 1959 makes reference to a new publication that will be called *Fuel Abstracts and Current Titles* (The Institute of Fuel. Report of the Council and Statement of Accounts for the year 1959. Pp. 16. London: Institute of Fuel, 1960). The first number is expected to be issued in mid-May. With the changes that took place in the reorganization of fuel research following the cessation of the activities at Greenwich of the Fuel Research Board, the Department of Scientific and Industrial Research had ceased to publish the most successful series of abstracts known as *Fuel Abstracts*. It was recognized by many fuel interests that the entire disappearance of the undertaking should not be allowed to occur, and therefore efforts have been made by the Institute to keep the venture alive. The problem has been to find the necessary financial support, and the Council of the Institute now announces that such further support has been promised for a period of development to a self-supporting stage to an extent to justify the Institute in undertaking the responsibility of publication. One of the major problems of modern technological development is that of keeping in touch with the really important scientific advances. Accordingly, the function of such an undertaking is invaluable. This is particularly the case since one of the weaknesses of our modern scientific activity is the amount of repetitive work that is done, mainly because the records of past achievements have not been adequately reported, or that the investigators themselves have not been able to consult the volumes in which the work was originally reported. In other words, in the battle for progress our lines of communication have been weak. In the present context the moral is obvious, and it is hoped that the new venture will supply the necessary strength.

Journals and the Science of Glass Making

DURING the forty-three years of its existence, the *Journal of the Society of Glass Technology* achieved world-wide recognition as the leading publication in its field; this pre-eminence was due, in no small measure, to Emeritus Prof. W. E. S. Turner, who was editor for thirty-five years and a leading contributor to its pages. It is fitting that Prof. Turner should have been invited to write a foreword to the twin offspring of 'his' journal. Of recent years, glass-making—and for that matter the related industry of ceramics—has become firmly based on fundamental science applied through a complex technology. New work for the glass industry has become increasingly varied and the Society of Glass Technology has decided to distinguish between that which is technological and that which is more a matter of pure chemistry and physics; papers of the former type will in future appear in *Glass Technology*, papers of the latter type in *Physics and Chemistry of Glasses*. In the first issue of *Glass Technology* there are articles on glass-furnace refractories and on glass-making machinery (1, No. 1; February 1960 Pp. xl+68. Published bi-monthly. 25*s*. per issue or 135*s*. per volume). *Physics and Chemistry of Glass* contains papers on the strength of glass-fibres, the viscosity of sodium germanate glasses, the structure of boric oxide and borate glasses, and the change in the hardness of some simple glasses with increasing temperature (1, No. 1; February 1960. Pp. 54. Published bi-monthly. 25*s*. per issue or 135*s*. per volume). Each journal carries its own collection of appropriate abstracts. Both are edited by Prof. R. W. Douglas, who is to be congratulated on their excellent lay-out and presentation. A joint annual subscription can be obtained at 200*s*.

Cytology

A NEW Russian journal is to be devoted to cytology (*Cytology*, 1, No. 1. Editor in chief, A. S. Troshin. (In Russian.) Pp. 140. Moscow: Akademii Nauk SSSR, 1959). 'Cytology' is regarded for this purpose as encompassing a rather wide field, including nerve and muscle physiology and radiation biology, for example, as well as more narrowly cytological topics. It seems clear that there is at the present time in the Soviet Union a considerable expansion of effort and widening of interests, so far as studies at the cellular and sub-cellular levels are concerned. The recognition in the editorial preface of *Cytology* of the fact that contributions from the U.S.S.R. have lagged behind foreign work in some fields of cytology (especially in sub-microscopic structure, cytogenetics and cytochemistry) is unfortunately underlined to some extent by the contents of several of the papers in the first issue. The future development of cell biology in the U.S.S.R. will be watched with a great and friendly interest. It is therefore very much to be hoped that, until such time as a complete translation service is available for this journal, there will be included, in addition to the present contents list in English, an English summary of each paper in future issues.

Russian Journal of Physical Chemistry

THE Chemical Society, in co-operation with the Department of Scientific and Industrial Research, is issuing a translation of the *Russian Journal of Physical Chemistry*, beginning with the Russian July 1959 issue. The English version appears about three months after the Russian, and each part contains about twenty illustrated papers and shorter notes. The English editor is R. P. Bell. Each number is of about 112 pages, 8½ × 11 in., in covers. Most of the papers are quite short and a wide field of interest is covered. Much very good work in physical chemistry has been appearing in the U.S.S.R. (the tradition goes back over a long period of time) and chemists generally will be glad to have this translation available. The print is clear. The symbols in the mathematical equations are rather small, although they are clear. It is noticed that Russian translations of English and American works are referred to instead of the originals. The price of the first eighteen monthly issues (corresponding with the Russian issues for July 1959–December 1960) is £45 or 135 dollars, with a reduction of 25 per cent for colleges and universities. Thereafter, the annual subscription, beginning with the Russian January issue, will be £30 or 90 dollars, with the same reduction. The world distributors are Cleaver-Hume Press, Ltd., 31 Wright's Lane, London, W.8, from whom further information can be obtained.

Document Micro-reproduction

"MICROTEXTS as Media for Publication" (Hertfordshire County Council Technical Information Service, Hatfield. 9*s*.) records the papers and discussion of a symposium held at Hatfield Technical College in November 1959. The organizers are to be congratulated on getting as main speakers three of the best known names in the microtext field—Mr. Eugene Power, of University Microfilms, Inc., who spoke about successes achieved with microfilm, particularly in the academic field; Dr. L. J. van der Wolk, director of the library of the Delft Technical University, on the increasing use of microfiche (that is to say, flat film, 75 × 125 mm. or 90 × 120 mm., containing 8–100 pages); and Mr. C. D. Gelatt, on the 'Microcard'. The experts in three forms of document micro-reproduction have not previously been heard together in Great Britain, and it is noticeable that there is no feeling of competition between them; each believes that there is a place for his particular form of microtext. The booklet also reproduces a delightful talk given in London early in 1959 by Fremont Rider, whose book, "The Scholar and the Future of the Research Library", originally published in 1944, suggested 'Microcards' to the library world. The idea was taken up by Mr. Gelatt, who was and is an industrialist in Wisconsin. He endowed the Microcard Foundation with 100,000 dollars, and the success of the idea is apparent when we remember the millions of 'Microcards' being made for the International Geophysical Year and the Atomic Energy Commission. (This booklet's 88 pages are reproduced on two 'Microcards' placed in a pocket on the inside of the back cover.) The pamphlet will be of great interest to librarians and others concerned with the newer ways of publishing and photocopying.

Radiochemistry of the Elements

THE Subcommittee on Radiochemistry of the Committee on Nuclear Science of the United States National Academy of Sciences (National Research Council) is sponsoring a series of monographs on the radiochemistry of the elements, three volumes of which, on cadmium, arsenic and francium, have now been issued (National Academy of Sciences—National Research Council. Subcommittee on Radiochemistry. NAS-NS-3001: The Radiochemistry of Cadmium. By James R. DeVoe. Pp. vi+57. 75 cents. NAS-NS-3002: The Radiochemistry of Arsenic. By Harold C. Beard. Pp. vi+27. 50 cents. NAS-NS-3003: The Radiochemistry of Francium. By Earl K. Hyde. Pp. vi+34. 50 cents. Washington, D.C.: Office of Technical Services, Department of Commerce, 1960). It is expected that about fifty volumes will be issued within the next six months.

Preventive Aspects in the Teaching of Pathology

IN the past the practice of medicine was almost wholly, if not altogether, confined to the treatment of patients. Nowadays, the doctor is often called upon to apply his knowledge for the prevention of disease. This change in medical practice is being increasingly recognized by the medical schools with the introduction of preventive medicine and social medicine into the curriculum, not as an isolated subject, but as one integrated with the other disciplines. In 1957 a Study Group was convened by the World Health Organization to consider how the preventive aspects of medicine could be introduced into the teaching of physiology. A similar task has now been undertaken for pathology by the Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel (World Health Organization. Technical Report Series No. 175: Preventive Aspects in the Teaching of Pathology—Seventh Report of the Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel. Pp. 30. (Geneva: World Health Organization; London: H.M. Stationery Office, 1959.) 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollar). In its report, the Committee points out that the essential task of the teacher of pathology in promoting the concept of prevention is to trace the complete evolution of lesions, paying special attention to their causation, their progressive development, and the disturbances in function that they bring about. He is in a particularly advantageous position to show the stages in the progress of the disease at which the changes are still reversible, and so the limits beyond which efforts at prevention and cure become increasingly less effective.

Semiconductor Components

THE front cover of the 1959 annual report of Texas Instruments, Inc., consists of a full colour photomicrograph showing the crystal structure of a high-purity bismuth telluride bar made during thermoelectric experiments in the Texas Instruments Central Research Laboratories (Texas Instruments, Inc. Annual Report, 1959. Pp. 20. Dallas: Texas Instruments, Inc., 1960). The report states that during 1959 the company continued its pattern of rapid growth and improvement of operations, with an increase of 110 per cent in sales and 136 per cent in net income over the previous record. The total personnel increased from 7,500 to 15,000. Three new buildings were completed on the 300-acre estate in North-east Dallas, and an addition to the semiconductor-components plant and a building for the manufacture of basic semiconductor and other materials are under construction. During September the construction of a new 120,000-sq. ft. plant was begun at Bedford, England, for Texas Instruments, Ltd., a subsidiary company, which manufactures semiconductor devices for the markets of the United Kingdom and Western Europe The plant will be completed late this year and will augment the 35,000-sq. ft. factory now in use. The work of the Metals and Controls Division and of the Geosciences and Instrumentation Division is briefly described and illustrated in the report. In addition, the revolutionary new solid circuit semiconductor introduced in March 1959 is discussed. This product represents a new approach to electronic circuitry and component miniaturization, providing an entire circuit in a single-crystal semiconductor slab no larger than a match head. Nearly a dozen different types of circuits have already been produced and many more can be constructed using the existing techniques. The first applications are to computers, missiles, rockets and space vehicles.

Acoustic Tiles for Noise Control

IT is sometimes possible to make considerable improvements by controlling noises at their sources. In the many cases where this cannot be done, sound-absorbing materials can be used to reduce noise to an acceptable level. Investigations in the Architectural Physics Section of the Division of Building Research of the Commonwealth Scientific and Industrial Research Organization, Highett, Victoria, have made it possible to determine the characteristics of sound-absorbing materials. The information obtained has enabled the Section to assist Australian firms in the design and manufacture of acoustic tiles and other sound-absorbing materials (*Industrial Research News*, 19 ; January 1960). In offices, halls and houses extensive use is made of acoustic tiles. These are relatively costly, but have substantial advantages over most other sound absorbers in both appearance and performance. A typical tile consists essentially of a perforated facing of metal or plaster and behind this a blanket of fibrous material, such as mineral wool. In Australia, tiles of this kind, with plaster facings, have become well known and are used to a greater extent than in most countries. With the growing demand, the number of firms producing acoustic tiles has increased considerably in the past few years and the Division has received many inquiries concerning their design. Dr. W. K. Lippert and Mr. W. Davern have been concerned both with research on the basic characteristics of sound-absorbing materials and with tests on products submitted by manufacturers.

Snow Loads and Roof Designs

In Canada, the heaviest load for which the roof of a building must normally be designed is the load imposed by snow. The magnitude of the design snow-load is thus of considerable importance. It must be high enough to reduce the probability of failure to an acceptable level, but not so high as to result in unreasonable construction costs. Snow loads to be expected in different locations across Canada are given in the National Building Code. These loads are based directly on measurements of maximum ground snow depths over a number of years and are generally considered to meet the requirements of safety. Appreciating the influence of design snow-loads on the cost of construction, the National Research Council Division of Building Research decided to undertake a study of the actual accumulations of snow, ice and rain on roofs as well as on adjacent ground. It was realized that this study must be carried out for a number of years and take into account the whole of Canada. Before embarking on this project, a pilot survey was conducted during the 1956–57 winter. Its results showed that a country-wide survey of actual snow loads on roofs would yield useful information, and that the proposed method and apparatus used would, with a few changes, be suitable for the full survey. More detailed investigations have since been carried out in successive winters, each time increasing the number of locations. A more detailed report of these investigations is to be found in the February issue of *Discovery*.

Organic Acid Synthesis in Tomato Roots

In studies of metabolism in tomato roots, J. van Die has ascertained that carboxylic- and amino-acids are synthesized in the roots and translocated to aerial regions of the plant (*Koninkl. Nederl. Akad. Wetens., Proc.* C, 62, No. 5, 504 ; 1959). In experiments in which potassium bicarbonate-^{14}C was supplied to the roots of plants in sand culture, he found that a few minutes after supplying the tracer to the roots, labelled organic compounds could be detected in the bleeding sap. After about 15 min. the secretion of active compounds reached its maximal rate, which was maintained for several hours. Analyses of the bleeding sap showed that most of the activity was present in the organic acid fraction, with malic acid as main constituent, followed by citric acid and a number of still unidentified acids. About 15 per cent of the activity was localized in amino-acids, and a small amount in α-ketoglutaric acid. In the roots the largest part of the activity was found in the organic acids and α-ketoglutaric acid, while only small amounts of active amino-acids were present. About 10 per cent of the activity of the roots was localized in proteins.

Geological Society of London

At the annual general meeting of the Society, held at Burlington House on April 27, the officers and Council for the ensuing year were elected, as follows : *President*, Prof. S. E. Hollingworth ; *Vice-Presidents*, Mr. A. J. Butler, Mr. T. C. Nicholas, Sir William Pugh, Dr. C. J. Stubblefield ; *Secretaries*, Mr. J. M. Edmonds, Dr. P. A. Sabine ; *Foreign Secretary*, Prof. O. T. Jones ; and *Treasurer*, Mr. P. Evans. *Council Members*, Prof. J. G. C. Anderson, Dr. H. W. Ball, Prof. O. M. B. Bulman, Mr. A. J. Butler, Prof. K. C. Dunham, Mr. J. M. Edmonds, Mr. P. Evans, Prof. T. N. George, Prof. W. D. Gill, Dr. D. R. Grantham, Prof. S. E. Hollingworth, Dr. R. G. S. Hudson, Prof. O. T. Jones, Prof. B. C. King, Dr. W. S. McKerrow, Mr. T. C. Nicholas, Sir William Pugh, Dr. Dorothy Rayner, Dr. P. A. Sabine, Prof. R. M. Shackleton, Dr. C. J. Stubblefield, Prof. J. Sutton, and Prof. P. C. Sylvester-Bradley.

Seventh Commonwealth Entomological Conference

The seventh Commonwealth Entomological Conference will be held in London during July 7–16, delegates to it being nominated by the Governments of the various countries of the Commonwealth, including many of the Colonial Territories. The proceedings of the Conference will include a number of open meetings, to be held in the Memorial Hall of the Royal Geographical Society (Exhibition Road entrance), South Kensington, London, S.W.7, on July 7, 8, 11, 12 and 14, and these will be open to all entomologists and others who may be interested, whose participation in the discussions will be welcomed. At each session a subject of wide interest to economic entomologists will be introduced by one or more invited speakers. The subjects are as follows : recent developments in insecticides for crop protection ; problems of applying insecticides ; hazards and precautions associated with the use of pesticides ; research on stored-products pests and their control ; biological control of insects and weeds ; insect attack in relation to the physical characters and physiological state of the plant ; investigations on timber-boring beetles ; termite control in afforestation projects and constructional timbers ; pathogenic organisms for the control of insect pests ; current trends in the study and control of tsetse flies and of locusts ; studies of dispersal of insects in relation to their control ; developments in the study of plant viruses and their vectors ; the link between research and its application in the field of plant protection. Programmes giving full details will be available about four weeks before the Conference from the Director, Commonwealth Institute of Entomology, 56 Queen's Gate, London, S.W.7.

University News : Cambridge

Matriculation requirements are to be modified. Each candidate will be required to hold the General

Certificate of Education (Ordinary Level) in the use of English, two languages other than English, mathematics or a science subject, and one other subject; in addition, two passes at Advanced Level in approved subjects will be necessary. Thus, the classical languages, and in particular Latin, are no longer compulsory subjects.

The Night Sky in June

FULL moon occurs on June 9d. 13h. 02m. U.T., and new moon on June 24d. 03h. 27m. The following conjunctions with the Moon take place: June 10d. 07h., Jupiter 5° S.; June 11d. 10h., Saturn 4° S.; June 18d. 19h., Mars. 2° N.; June 22d. 04h., Aldebaran 0·5° S. In addition to these conjunctions with the Moon, Mercury is in conjunction with Pollux on June 20d. 05h., Mercury being 6° S. Mercury is an evening star, visible low in the west after sunset; it sets between one and two hours after the Sun. Venus is too close to the Sun for observation. Mars rises at 1h. 50m., 1h. 15m. and 0h. 35m. at the beginning, middle and end of the month, respectively; it is in Pisces on June 1 and moves into Aries on June 20. Its stellar magnitude is + 1·0 and its distance from the Earth on June 15 is 151 million miles. Jupiter rises at 21h. 30m., 20h. 30m. and 19h. 30m. on June 1, 15 and 30, respectively, and sets at 3h. 10m. on June 30; it is thus above the horizon throughout the hours of darkness. It is in Sagittarius, its stellar magnitude is − 2·2, its distance from the Earth in the middle of the month is 400 million miles, and it is in opposition on June 20. Saturn is also in Sagittarius, rising at 22h. 35m., 21h. 35m. and 20h. 35m. on June 1, 15 and 30, respectively. Its stellar magnitude is + 0·4 and its distance from the Earth on June 15 is 845 million miles. There are no occultations of stars brighter than magnitude 6 visible at Greenwich. The summer solstice occurs on June 21d. 10h.

Announcements

PROF. D. G. CHRISTOPHERSON, professor of applied science in the Imperial College of Science and Technology, London, has been appointed warden of the Durham Colleges in succession to Sir James Duff, who is retiring.

DR. MILO P. HNILICKA has been appointed to the new post of scientific assistant to the vice-president and director of research for the National Research Corporation of the United States. Dr. Hnilicka will act as scientific advisor to the director of research and as a consultant on a number of projects now under way. His assignments will include technical liaison on new projects between the National Research Corporation and other laboratories in the United States.

A DINNER in honour of Mr. F. Howarth, on the occasion of his retirement from the Botany Department, Imperial College of Science and Technology, will be held on July 15 at the College. Old students who wish to attend this dinner, and who have not already been invited, should write as soon as possible to Dr. A. J. Rutter or Dr. R. K. S. Wood, Imperial College, London, S.W.7.

THE University of Maryland is to receive a grant of 216,000 dollars from the U.S. National Aeronautics and Space Administration to accelerate its programme of basic research dealing with the growth and metabolism of unicellular algae. Since 1949 personnel in the University's Department of Botany under the direction of Dr. Robert W. Krauss, professor of plant physiology, have been engaged in fundamental studies on the physiology of algae.

THE sixteenth International Congress of Zoology will be held in Washington, D.C., during August 21–27, 1963, under the presidency of Dr. Alfred S. Romer, Alexander Agassiz professor of zoology and director of the Museum of Comparative Zoology, Harvard University.

AN international conference on "Science in the Advancement of New States" is to be held in Israel during August 15–30 under the auspices of the Weizmann Institute of Science Further information can be obtained from the Scientific Attaché, Embassy of Israel, 2 Palace Green, London, W.8.

A CONFERENCE on "The Chemical Organization of Cells: Normal and Abnormal" will be held at the University of Wisconsin, Madison, during August 25–27. Further information can be obtained from Dr. J. F. A. McManus, Department of Pathology, University of Alabama Medical Center, Birmingham, Alabama.

THE seventh international conference of the Society for Biological Rhythm will be held at Siena, Italy, during September 5–7 in conjunction with the International Basimetric Society. Further information can be obtained from Dr. A. Sollberger, Department of Anatomy, Caroline Institute, Stockholm 60.

THE tenth Pacific Science Congress of the Pacific Science Association will be held in the University of Hawaii, Honolulu, during August 21–September 6, 1961. It will be sponsorod by the U.S. National Academy of Sciences and Bernice P. Bishop Museum, Honolulu, with the co-operation of the University of Hawaii. Scientific sessions will be held during August 21–September 2, with a post-sessional field-trip until September 6.

THE fifteenth Calorimetry Conference will be held at Gatlinburg, Tennessee, during September 7–10. Among the topics to be considered are: precision reaction and bomb calorimetry, solution calorimetry, microcalorimetry, heat-capacity measurements at low and high temperatures (0·1–1,400° K.); temperature scales and standard calorimetric samples, etc. Those wishing to attend or to present a paper should write to Dr. J. P. McCullough, Bureau of Mines, Box 1321, Bartlesville, Oklahoma.

THE Royal Meteorological Society is organizing a two-day meeting to be held at Queen's College, Dundee, during June 29–July 1. The meeting will take the form of two symposia, namely: "Convection" (June 30); and "Agricultural Meteorology" (July 1). Contributors to the symposium on convection include F. H. Ludlam (Imperial College of Science and Technology), C. Dixon (Queen's College, Dundee), F. W. G. Warren (University of Sheffield) and R. P. Peace (Queen's College, Dundee). Contributors to the symposium on agricultural meteorology include H. L. Penman and J. L. Montieth (Rothamsted Experimental Station) and G. J. Day and R. W. Gloyne (Meteorological Office).

ERRATUM. In the article entitled "A Synoptic Study of Infra-Red Radiation over the United States" by Dr. J. L. Gergen and Dr. W. F. Huch (*Nature*, May 7, p. 426), the units are printed incorrectly as "MW."; they should be "mW.".

THE SERENGETI NATIONAL PARK

By Dr. A. S. THOMAS

THE magnificent film "Serengeti shall not die" is not only pictorially beautiful but also scientifically fascinating. The film shows that the game animals amount to only about 367,000 instead of the million previously estimated; it shows that the migration routes lie outside the southern boundaries of the National Park, and that none of the herds goes near the area to the north, proposed as an extension of the Park; and it shows how the grasses were being investigated to discover the preferences of the antelopes.

The film itself goes far to answer the grass question; much of that on which the antelopes were grazing appeared to be *Themeda triandra*, but, whatever the species, the grass was always short, less than 2 ft. high and often reduced by fire or grazing to a few inches. Not only do antelopes like short grass for grazing but also they need it for observation of their predators, the lions and hyenas.

Prof. W. H. Pearsall recommended in his report[1] "That arrangements be made for the early exclusion of pastoral occupation from the National Parks" and that recommendation was adopted by the Board of Trustees of the Park in its 1957–58 report. Have trials been made to discover what will happen to the Serengeti grassland if it is protected from fire and from grazing? Much of it would probably grow to 6 ft. or more, much too tall to suit the smaller antelopes.

Some indication of what will happen may be seen in other places; I will mention two of them. The first place is the Gulu elephant sanctuary in Uganda, where the grass of the uninhabited area is up to 9 ft. high and is almost deserted by antelopes, which swarm on the shorter grazing lands at the edge of the sanctuary. The other place is the National Park in the Belgian Congo, east of Lake Edward, from which the sparse pastoral population was moved, with the result that the grassland grew so tall and coarse that the population of antelopes was much reduced. "Man certainly is an important member of the biome in Africa; human settlement is not, as might be imagined, solely antipathic to the increase of wild animals; the pastoral tribes, by controlled burning, produce flushes of grass which benefit not only their stock, but also the wild animals as well"[2].

As I have visited the Serengeti only once, I do not know it well, but I can think of no difference in the soil to account for the migration of antelopes outside the southern boundary of the National Park; it must be that the grass there is shorter, as they prefer it. Similarly, the area north of the Park, and suggested for inclusion in it, may well be avoided by game animals because it has little human population, little grazing by cattle, and the grass is therefore too long for the antelopes.

Prof. Pearsall noted the over-grazing and erosion from the flocks and herds of the Masai: "Even where the Masai cattle alone are using the grasslands there is evidence of grassland deterioration and it seems clear that it would not be possible for both cattle and game to occupy the same areas permanently". But, if there were more sources of water, more frequent movement of the stock, might there not be less erosion, less competition for grazing near the water holes?

The area of the Serengeti National Park is about 5,000 square miles, or 3,200,000 acres. The Masai cattle number about 120,000, sheep and goats about 220,000, donkeys about 6,000 (ref. 1). It is usually accepted that about eight grazing sheep or goats may be reckoned as equal to one ox; therefore, the total livestock of the Masai may be considered as about 150,000 units; there are about 3,000,000 acres of grazing, so there are about twenty acres of grazing for each head of cattle.

The soil analyses in Prof. Pearsall's report show good supplies of bases; there seem to be no marked deficiencies as in the acid grasslands to the west of Lake Victoria. The average rainfall of the National Park is about 30 in. a year; there is a dry zone near the eastern volcanic hills, but the hills themselves have more precipitation. As the Serengeti is near the equator, the rainfall is fairly well distributed, with two dry seasons and two wet seasons each year.

Under such conditions, is it not reasonable to expect that, with correct management, the Serengeti plains could support both the Masai stock and the game animals (a large proportion of which are small antelopes) without undue damage to the grass and the soil? It has long been evident that the management of the large open plains, and not the management of fenced pastures on European farms, is the main problem of grassland research in East Africa; that point was emphasized at the first East African Grassland Conference, held nearly twenty years ago. In spite of deficient knowledge about the management of the plains, of possible difficulties in arranging supplies of good water by dams and boreholes, yet it should be possible to preserve the grass and the game without displacing the Masai who are living in the area.

Scientists should be grateful to the Fauna Preservation Society, which arranged that Prof. Pearsall should visit Serengeti and made a comprehensive report on problems which had been given little definite scientific study; they should be grateful to Dr. Grzimek for all he did at his own expense; but above all they should be grateful to gallant young Michael Grzimek, who gave not only his money, but also his life, to this work.

With the rising tide of African nationalism, is there not a danger that we may be thought to devote too much attention to the animals of Africa and not enough to the people? David Howarth[3] has directed attention to the disparity of publicity about "Operation Noah", in which four or five thousand animals were taken to safety, and the plight of fifty thousand Batonga people who had to leave their homes before the flood of the Kariba Dam. Must we not make it clear that we are more concerned with the welfare of African peoples than of African animals?

May not the future of the animals be more secure if the Masai continue to live in the National Park of a self-governing Tanganyika? Is there no risk that an African Government will not look favourably on a large tract from which the Africans have been displaced and which to them seems reserved for animals and for American and European tourists?

If the National Park is preserved from fire and from grazing, the grass may soon be too long for the antelopes, which will go to the grazed land outside the reserve and fall a ready prey to poachers. Despite the lack of present knowledge, there must be an attempt to secure a balance of grazing which will suit both domestic stock and wild animals. The Masai are a proud and a conservative people; but they love their cattle and, if it were shown that measures were designed to maintain their herds in their present numbers, in their present homelands, I think they would co-operate.

---

[1] Pearsall, W. H., *Oryx*, 4, 73 (1957).

[2] Thomas, A. S., *J. Ecol.*, 31, 149 (1943).

[3] Howarth, D., *Sunday Times* (Feb. 28, 1960).

THE WATHEROO MAGNETIC OBSERVATORY, MELBOURNE

WATHEROO Magnetic Observatory was established in 1919 by the Carnegie Institution of Washington, at a site about 110 miles north of Perth, Western Australia, and about 50 miles from the coast. Since that date the Observatory has carried out a programme of observations in terrestrial magnetism and electricity and ionospheric research. In 1947, the Observatory was transferred by gift to the Australian Commonwealth Government, and the Commonwealth Bureau of Mineral Resources, Geology and Geophysics has operated and maintained the Observatory since then.

In recent years there has been great difficulty in maintaining Watheroo Observatory as a residential establishment; so much so that consideration had to be given to moving the Observatory to suitable sites near Perth, where it would be possible to continue observations, and at the same time avoid the expense and staffing difficulties associated with the maintenance of a residential establishment in a remote locality. It was also believed that work of the Observatory would benefit from bringing the staff in closer contact with scientific workers at the University and other establishments in Perth.

In 1955, a site was selected in the Gnangara Pine Plantation, north of Perth, for magnetic observations, and another in the vicinity of Mundaring Weir, 20 miles east of Perth, in the Darling Ranges, for ionospheric and seismological observations. A site for an office and laboratory was selected in Mundaring township. When selecting observatory sites, the Bureau sought and was guided by the advice of many local and overseas scientific authorities.

The magnetic station was completed at Gnangara late in 1956, and observations and recordings began at that station in parallel with those at the Watheroo Observatory in July 1957. Both stations were operating throughout the International Geophysical Year.

The buildings at Mundaring necessary for the transfer of ionospheric observations from Watheroo have now been completed. A new ionospheric recorder has been purchased and will be installed soon. Magnetic observations and recordings ceased at Watheroo on January 31, 1959, and on March 18, 1959, the other observatory activities were transferred to Mundaring. Seismological recording began at Mundaring in August 1959, using a three-component Benioff seismograph, with both long- and short-period galvanometers.

The new organization is known as Mundaring Geophysical Observatory, with headquarters in Mundaring township. The magnetic and ionospheric data are distributed on the same basis as for Watheroo, and seismological bulletins are issued on the same basis as for other stations operated by the Bureau.

For the particular scientific observations undertaken, the transfer from Watheroo to Mundaring will have no significant influence on the results. The move of about 100 miles is not important on the global scale. It is believed that, although Perth Observatory has operated seismographs for many years, the new Observatory will fill a real need for a high-sensitivity seismograph in this area.

Further information concerning the new establishment should be addressed to the Observer-in-Charge, Mundaring Geophysical Observatory, Mundaring, Western Australia.

THE LE PLAY SOCIETY

FOUNDED in 1930 to encourage international studies along the lines advocated in the middle of last century by the French sociologist Frederic Le Play, the Le Play Society, under the direction of Miss Margaret Tatton, has for thirty years organized an annual 3-day conference and study visits to the less-familiar regions of Europe and North Africa. The formula for the overseas work was for a group with varied backgrounds to spend a few days getting the general 'flavour' of a country and then to settle down in a village to make an intensive study of the community and its environment. In the evenings geologist, botanist, agriculturist, geographer, sociologist, doctor, teacher would meet to pool their findings and, under expert visiting and local guidance, compare notes to build up a remarkably complete picture. About a dozen such studies reached a wider audience through publication as monographs.

On April 9–12, 1960, the Society met for the last time at Wadham College, Oxford, and Sir John Russell delivered his twenty-third annual address as president. Rather than face a slow decline, the Society decided to terminate its work in a blaze of glory—the final conference dealt with "Present Problems in World Affairs", with contributions from many angles by Prof. L. F. Rushbrook-Williams (India and Pakistan), Prof. A. L. Goodhart (International Law), Sir Reader Bullard (Middle East), Prof. L. Dudley Stamp (Food and Population), Dr. F. M. Brewer—now mayor of Oxford (Science and the Ordinary Man), Mr. William E. Abraham of All Souls (African Independence), Prof. E. M. Hugh-Jones (America:

The Influence of Affluence), Mr. E. Paget (West Indies), and Mr. N. H. Leyland (Economic Problems). Old friends who assisted in this final conference included Prof. H. J. Fleure, who presented to the president a handsomely bound volume including typescripts of his series of annual addresses, Sir Richard Livingstone, who took the chair at the presidential address, Prof. Kenneth Mason and more than a hundred members, who paid tribute in the form of a presentation to mark the devoted work of Miss Tatton.

The main reason for the decision to wind up the Society is a tragic commentary on the post-war world. While international tourism is being encouraged, study groups which moved so freely and were accorded unstinted help everywhere in the inter-war years are now faced with official frustration and danger of arrest as spies if they attempt to see anything not on the accepted tourist routes. In addition, increasing costs have placed such journeys beyond the resources of younger people who, if they can get grants, are required to attend meetings in their own specialisms. Few seem to have leisure for the quiet exchange of views with workers in other fields. Le Play methods in social and regional survey have, however, become basic requirements in physical and social planning all over the world.

L. Dudley Stamp

THE LACK OF THINKING IN EXAMINATIONS

In marking examination scripts, Dr. Margaret Sutherland, lecturer in education at the Queen's University, Belfast, has noticed that many students do not deal with the topic set (*The Universities Review*, 32, No. 7; February 1960). This occurs mainly in subjects which require a basic knowledge (of facts, or of a book, theory, or other works) and some more or less intelligent discussion of some aspect of this basic knowledge. The examiner has attempted to set a question which will differ from those set in previous papers and yet allow the students to display knowledge, select relevant data and comment reasonably thereon. To this, many students pour forth a statement of basic knowledge which is mostly without relevance to the question set.

Some examiners would classify this behaviour as 'examination technique' or conscious bluffing on the part of the students who, knowing that they are unlikely to pass, have memorized answers on strictly limited topics and are going to use them no matter what the question. But not all erring students can be credited with this conscious cunning, for some irrelevant answers display conscientious and thorough preparation.

Occasionally the explanation lies in the examiner's technique; the question may have been badly worded, the interpretation which seemed obvious to the examiner was not obvious to other readers; thus seemingly irrelevant answers may prove relevant, if the question is re-interpreted.

In other cases the weakness seems to be in the student's reading ability. The student must be technically able to read the question; but the sense of the sentence is not grasped. One word only, or part of the sentence only, dominates the rest and evokes the associations to this one element. This is an example of the so-called global thinking supposedly characteristic of early childhood, where a general concept is present or brought to mind, but finer discriminations cannot be made, and analysis, perception of detail and component parts do not occur. This leads to regression to an earlier stage of behaviour, possibly caused, like other regressions, by a stressful situation. Yet surely the concepts in question have been analysed during preparation for the examination? Surely, too, the student has been trained to attend to the different parts of meaning conveyed by whole sentences?

Does the error occur in grasping the meaning of the question or in attempting to respond to it? If it is the latter, the behaviour may be explained as regression to another primitive type of mental activity, to rote-memory in which the information sought can be reproduced only imbedded in the impressions originally accompanying it. It is difficult to believe that, having reproduced all the data, the student still cannot select from this reproduction all that is relevant.

Yet this the student seems unable to do. It is precisely selection and discussion that are avoided. It seems increasingly probable that this avoidance may be due not to ignorance of what is wanted, not to bluff or sophisticated examination technique, not to failure in reading ability, but to emotional factors of anxiety and fear. The student approaches the examination with the feeling of not knowing enough, or of not knowing the material sufficiently well to remember it all. Acute anxiety is aroused by what seems a request to be judged on only a part of what has been learned.

Yet if the relevant material were selected and discussed, the student's answer should develop fully satisfactory dimensions. The student is invited to display a lesser amount of factual knowledge, provided evidence of thought is added.

It is possible that this avoidance by the student of thinking out a new aspect is not irrational, but the result of learning from experience. Even good examination candidates considering a new aspect of a familiar subject discover that their knowledge is inadequate; items of related knowledge do not always present themselves. The candidate has either been content to accept words without close inquiry into meaning, or has learned the accepted formulæ without considering all their implications.

Even where there is no discovery of ignorance, thought does not always operate smoothly; although we have relevant points to make, they may not all occur to us, or arrange themselves in the appropriate pattern immediately. It could be argued that students should have thought so much about the subject beforehand that their thinking has become flexible and well integrated. It remains possible that the examiner calls for discussion of an unforeseen aspect. Thus the student's resistance, conscious or not, to following a new line of thought in examination circumstances (or elsewhere) might be well founded on past experience of unsuccessful effort. It is so much easier to let thinking follow the usual path indicated by a signal word, or let memory take over from it.

This avoidance is to be deplored. It can be overcome at least partly by good teaching. Students who have had sufficient practice both in thinking about new aspects of their subject and in criticizing irrelevant responses may come to recognize more clearly what is relevant and to feel some confidence in their own ability to think independently. More independent study could also help, since thinking flexibly in a subject and perceiving most of its implications are made more easy by increasing knowledge and work in it.

RESISTANCE OF GONOCOCCUS STRAINS TO PENICILLIN

GONOCOCCUS strains isolated in 1944 were found to be highly sensitive to penicillin. From 1946 onwards, the existence of less sensitive strains were observed. Up to the end of 1955, doses of penicillin, twice to four times as great as those which were effective against the strains isolated in 1944, were enough to stop the development of the less sensitive strains isolated at the Statens Seruminstitut, Copenhagen. Then, from a case of gonorrhoea without complications, four strains were isolated which were found to be only one-twentieth as sensitive as the 1944 strains. This discovery and the fact that the incidence of gonorrhoea remained about the same in spite of penicillin therapy indicated the need for further research. This was carried out during 1957 and 1958 by Alice Reyn and M. W. Bentzon, who made a comparison of several hundred recently isolated gonococcus strains with a hundred strains isolated in 1944 (*World Health Organization Chronicle*, 14; No. 3. March 1960). This showed that, for inhibition, about 25 per cent of the strains sent to the laboratory for diagnosis in 1957 required doses of penicillin twenty times greater than had been needed for most strains originally.

Twenty strains showing reduced sensitivity to penicillin were subcultured for 30–90 days on a medium with no penicillin, without any increase in sensitivity being produced.

Both in 1957 and 1958, some 200 strains were tested for penicillin sensitivity by the tablet method, that is to say, by placing penicillin tablets in the culture medium and measuring the zone of inhibition around them. The zone diameters varied between 20 and 50 mm. In both years, about 39 per cent of the strains showed reduced sensitivity, that is to say, zone diameters of 34 mm. or less. In 1958, however, the number of strains with zone diameters of 44 mm. or more was significantly lower than in 1957, which seems to indicate that the selection (and induction) of the strains with a comparatively reduced penicillin sensitivity continues.

None of the 1957 strains was completely resistant to streptomycin, but two of the 1958 strains (from the same patient) were.

In both the 1957 and 1958 strains a significant positive correlation was observed between sensitivity to penicillin and sensitivity to streptomycin.

From June 1957 onwards, atypical gonococcus strains—most of them sensitive to penicillin—appeared in the cultures. The growth of these strains on the routine media is poor; they require special conditions for culture and are able to ferment glucose only weakly or not at all. Serological examination showed them to be distinguished from normal strains by the frequent presence of anti-complementary antigens. The proportion of atypical strains rose to 40 per cent in January 1958 when the culture and fermentation media were changed. The change of culture medium had yet another effect: the inhibition zones of the atypical strains—and of these alone—were greater on ox-heart broth than on ox-meat broth. This phenomenon has not yet been explained. It is possible that the emergence of atypical strains is related to the mode of action of the penicillin.

GLOBULAR CLUSTERS

ASTRONOMY has always suffered because of the uneven distribution of its personnel and equipment between the northern and southern hemispheres. Especially welcome, therefore, are the growing number of contributions from the Radcliffe Observatory at Pretoria. A series of three contributions by Dr. T. D. Kinman (*Mon. Not. Roy. Astro. Soc*, 119, 157, 538, 559; 1959) represents an important addition to our knowledge of globular clusters. A study of their motions in the Galaxy is of interest because these clusters are prototypes of Baade's Population II and are believed to contain the oldest stars in the Galaxy. Kinman has obtained the radial velocities of thirty southern globular clusters, for sixteen of which no previous determinations of velocities existed; velocities are now available for seventy clusters in all, more than two-thirds of the known clusters in our Galaxy. The effect of the metal/hydrogen ratio on the strengths of the spectral lines of metallic elements in the clusters was studied by Kinman. He found that this ratio varies from 0·1 to less than 0·01 for different clusters. He also found that clusters of the earliest spectral type, the stars of which have a very low abundance of metal, form an extended spherical distribution with little concentration in the galactic plane, while those of latest type, the stars of which have the highest abundance of metal, show a strong concentration in the galactic plane. Clusters of intermediate type show an intermediate distribution.

The motion of the Sun relative to the globular clusters was determined; the apex of the solar motion does not deviate from the direction of the Sun's galactic rotation. The new analysis confirms the older conclusion that the orbits of the individual clusters in the Galaxy are highly eccentric. The mean angular momentum per unit mass of the cluster system is the same as the mean for the rest of the Galaxy. This is in accord with the hypothesis that the clusters were formed in a spherical gas cloud which was in the process of contracting to form the galactic disk.

SOME BOTTOM CORES FROM THE SWEDISH DEEP-SEA EXPEDITION, 1947–48

THE final publication of the analyses and conclusions to be drawn from the world-wide collection of cores made by the Swedish Deep-Sea Expedition during 1947–48 is still to come. However, with the enormous amount of material collected and the wide scope of the examinations, it is inevitable that the results of particular studies made by many different workers should be published separately and as soon as completed. Thus during the past two years, five fascicules, comprising ten separate papers on sedimentation problems, have been published in the series of the Expedition reports*. Some of these papers represent exhaustive studies of particular cores, whereas others merely present briefly the results of the application of one particular technique to some core material. The cores from the different oceans of the world crossed by the *Albatross* during the Expedition are dealt with in separate volumes in the reports, all papers relevant to these cores being published in one volume, consisting of several fascicules published as the results become available.

Fasc. 4 of the volume on West Pacific cores contains four papers describing a core of 4 m. taken from a depth of 7,710 m. in the Mindanao Trough. This consists of a thin layer of sand overlying a thick bed of fine-grained terrestrial mud which in turn overlies a bed deposited by series of turbidity currents, containing graded sand layers. The principal work is described by Fredriksson, who has undertaken mechanical, chemical and petrological analyses of both the fine and coarse fractions of the core. These show that the sedimentary material has been derived mainly from the andesitic to basaltic rocks of the nearby Snellius Ridge. The breaking up process is attributed to tectonic movement and volcanic explosion, the fine material being transported by sea currents and the coarser silts and sands by mud slides followed by turbidity currents.

This conclusion is confirmed by the discovery of shallow water benthonic Foraminifera in the coarse layers in the core (Reyment) and of fragments of calcareous algae known to exist in reef-building corals characteristic of shallow water (Horn af Rantzien).

Two papers by Locher describe five cores taken in the West Equatorial Atlantic basin between the Amazon Estuary and the Mid-Atlantic Ridge. All these cores show sand and silt layers with associated beds of blue mud. Mineralogical and petrographical analyses of the heavy minerals of the cores are described and show that there are significant differences between their mineral assemblages and those of samples taken from the Amazon Estuary. The sand layers, which are rich in Foraminifera, have all the properties of turbidity current deposits and are assumed to be derived from the South American continent.

The work of Norin on a core of 18 m. from the central Tyrrhenian Sea is the most complete description of any of the cores discussed here. The core consists chiefly of a calcareous pelagic clay sparsely intermixed with aerial dust and silt. The clay minerals are shown to have been largely derived from the land mass to the east, although it is suggested that the montmorillonite is authigenic. Intercalated in the column of normal pelagic sediment are many layers of coarser and darker materials. Each of these has been studied in detail and is described with regard to its mechanical and mineralogical composition. The layers can be ascribed to three different modes of deposition, each with its own characteristic composition and formation. Eruptions of nearby volcanoes contribute volcanic glass and pumice, although it has been difficult to correlate the layers with known periods of volcanic activity. Some layers with sharp boundaries both below and above are characteristic of exceptionally severe dust storms. Very small quantities of such eolian deposits are found throughout the core. Thirdly, there are the turbidity current deposits which apparently originate on a ridge nearby. The material of these deposits is highly mixed, containing volcanic ash, Foraminifera and quartz. It is thought that the quartz is first deposited on the ridge by eolian transport and later moved by the turbidity currents. A thorough study of the surrounding land geology and of the petrography of the volcanoes in the region enables a very precise study of the origin of the sediments to be made. It is unfortunate, however, that more is not known of the topography of the sea-floor surrounding the core and that more cores are not available to correlate simultaneous deposits.

In the volume on "Special Investigations", the mineral composition of the clay fraction of two cores from the Atlantic and Pacific is compared (Dekeyser and Lippman). From the rather limited data it is concluded that there are marked differences between cores but surprising constancy throughout each core. Brotzen and Dinesen have attempted to correlate the stratigraphic sections of two Pacific cores using a statistical treatment of the foraminiferal assemblages. These appear to be controlled by climatic conditions, and warm and cold periods can be distinguished.

---

* Göteborgs Kungl. Vetenskaps-och Vitterhets-Samhalle. Reports of the Swedish Deep-Sea Expedition, 1947–1948.

Vol. 6. Sediment cores from the West Pacific. No. 4. A sediment core from the Mindanao Trough. By K. Fredriksson, p. 97–134. No. 5. Mineralogical composition of some <2 micron fractions in a sediment core from the Mindanao Trough. By J Ch. L. Favejee, p. 135–138. No. 6. A Note on the Foraminifera in a sediment core from the Mindanao Trough. By R. A. Reyment, p. 139–156. No. 7. Fragments of calcareous algæ in a sediment core from the Mindanao Trough. By H. Horn af Rantzien, p. 157–160. 25 Sw. kr.

Vol. 7. Sediment cores from the North Atlantic Ocean. No. 4. Sedimentpetrografische Untersuchung der Lotkerne 255 und 257. By F. W. Locher, p. 185–208. No. 5. Ein Beitrag zum Problem der Tiefseesande im westlichen Teil des Äquatorialen Atlantiks. By F. W. Locher, p. 209–225. 10 Sw. kr.

Vol. 8. Sediment cores from the Mediterranean Sea and the Red Sea. No. 1. The sediments of the Central Tyrrhenian Sea. By E. Norin, p. 1–136. 35 Sw. kr.

Vol. 10. Special Investigations. No. 2. Examinations of core 72 and 723. By W. Dekeyser, p. 33–38. No. 3. X-ray determination of phillipsite in a sediment core from the Central Equatorial Pacific. By F. Lippman, p. 39–42. 5 Sw. kr. No. 4. On the stratigraphy of some bottom sections from the Central Pacific. By F. Brotzen and A. Dinesen, p. 43–55. 5 Sw. kr.

(Goteborg: Elanders Boktryckeri Aktiebolag. 1958 and 1959.)

The correlations, however, are not striking, and there is no evidence that the cores do in fact represent continuous and undisturbed sedimentation.

Perhaps the most interesting general conclusion to be drawn from this series of papers on deep sea sediments is that it is extremely rare to find a core that does represent continuous and undisturbed sedimentation. In every core described, there is evidence of a great deal of horizontal displacement of sediments after their initial deposition, by slumps, mud slides and turbidity currents. As these are processes controlled by gravity, and taking place on the bottom, the local topography is of the utmost importance. Different physiographical regions, as defined by Heezen, will have different types of sediment deposited. Any attempt at correlation between cores must take this into account.

The work that has been carried out on analysis of the cores obtained by the *Albatross* represents, perhaps, one of the most exhaustive studies ever made on deep-sea sediments. Certainly the collection of papers provides a solid mass of accurate data to which other sediment studies can be referred and which will inevitably lead to a better understanding of the processes involved in deep-sea sedimentation.

A. S. LAUGHTON

A RELATION BETWEEN SOLAR RADIO EMISSION AND POLAR CAP ABSORPTION OF COSMIC NOISE[*]

By DR. M. R. KUNDU and PROF. F. T. HADDOCK
The Observatory, University of Michigan, Ann Arbor

IONOSPHERIC absorption of cosmic noise in polar regions (called polar cap absorption) is believed to be caused by ionization of the upper atmosphere by fast protons (in the energy-range of 10–50 MeV.) emitted from the Sun after a big flare[1,2]. Direct balloon observations of protons have confirmed this hypothesis[3,4]. It is further known that, following the associated solar phenomena, the absorption event begins after a highly variable delay of 1–50 hr. The association of some proton events with metre-wave outbursts of continuum radiation has led to the belief that cosmic-ray particles, or fast protons, are accelerated by the same mechanism as the fast electrons responsible for continuum radiation, that is, synchrotron radiation from high-energy electrons accelerated in magnetic fields in the solar atmosphere. The use of polar cap absorption as a detector of low-energy cosmic rays suggests the importance of identifying the nature of solar radio emission which might be associated with these absorption events. In this article, we intend to make a statistical study of the nature of centimetre-wave as well as metre-wave radio outbursts associated with polar cap absorption events and, if possible, to draw general conclusions regarding the prediction of the proton events.

During February 1956–July 1959, 31 events of polar cap absorption have been reported[1,2]. For the radio burst data we have used the single frequency observations of the University of Nagoya on 9,400, 3,750, 2,000 and 1,000 Mc./s., of Ottawa on 2,800 Mc./s., and the dynamic spectrum records of the University of Michigan and the Harvard station at Fort Davis in 100–600 Mc./s. band and of Sydney in 40–240 Mc./s.

Metre-wave outbursts of continuum radiation characterized by its broad-band spectrum, long duration and strong polarization is called type IV radio emission, and it is believed that broad-band centimetre-wave outbursts are also of the same nature. A centimetre-wave outburst is defined as a burst of emission having a peak intensity greater than 100 units (1 unit = 10^{-22} W.m.$^{-2}$(c./s.)$^{-1}$), and we shall define the centimetre-wave outbursts having peak intensities greater than 500 units over the entire wave-length range of 3–30 cm. as intense broad-band centimetre-wave outbursts and those having peak intensities greater than 100 but less than 500 units over the same wave-length range as moderate broad-band centimetre-wave outbursts.

Of the 31 polar cap absorption events so far reported, 28 events occurred during periods of centimetre-wave observations, and in only 18 events were there simultaneous metre-wave spectral observations. All 28 absorption events have been identified as being associated with centimetre-wave outbursts. The solar radio events associated with polar cap absorption events are intense centimetre-wave burst radiations which have a very wide spectrum, extending down to metre-waves. The burst radiation on centimetre/waves is always partially polarized and it usually lasts more than 10 min.; in some cases several hours. Simultaneous dynamic-spectrum observations made in 18 cases on metre-waves show that in the majority of the cases they are associated with type IV radio emission. The details of the association of the polar cap absorption events with the solar radio outbursts are summarized in Table 1.

Table 1. TWENTY-EIGHT POLAR CAP ABSORPTION EVENTS (August 1956–July 1959)

Associated centimetre-wave outbursts	Associated metre-wave outbursts		
	Type IV	Type II (No Type IV)	No spectral observations
28	15	3	10

Table 1 shows that all 28 polar cap absorption events are associated with centimetre-wave outbursts. Their peak intensities are comparable over the whole wave-length range of 3–30 cm.; the spectrum is rather flat in this wave-length range.

---

[*] Since the preparation of this article, a note on the same subject (*Nature*, 185, 89; 1960) by Drs. A. R. Thompson and A. Maxwell came to our notice. These authors discuss the relation of low-energy cosmic rays with type IV metre-wave outbursts of continuum radiation, but do not consider the centimetre-wave outburst radiation which, as discussed in this article, plays a very important part in the occurrence of low-energy cosmic ray events.

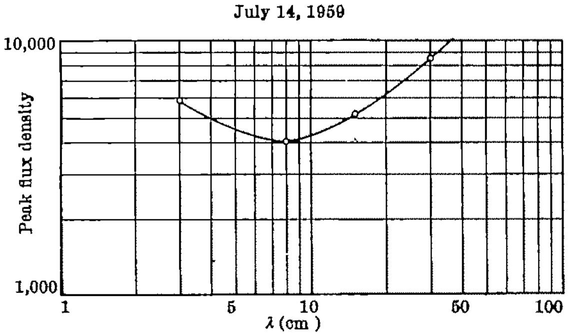


Fig. 1. Peak intensity ($\times 10^{-22}$ W.m.$^{-2}$ (c./s.)$^{-1}$) as a function of wave-length (cm.) during a broad-band centimetre-wave outburst associated with a polar cap absorption event

The spectrum of a typical outburst associated with an absorption event is shown in Fig. 1.

As shown in Table 1, nearly all the centimetre outbursts have type IV metre-wave emission associated with them. There are three cases in which the metre-wave event consists only of a group of type III bursts and a type II outburst without the appearance of a type IV event. Since there are reasons[5] for believing that centimetre-wave outbursts are emissions of type IV and that the type IV emission spectrum can sometimes have an abrupt low-frequency cut-off, one can assume that these three events are also type IV emission with peak intensity in the centimetre range.

As we have mentioned above, the polar cap absorption event follows the associated solar radio event with a delay varying from 1 to 50 hr. If we divide the centimetre outbursts according to their intensity into two classes, intense and moderate, we find that the average delay does not exceed 5 hr. for events associated with intense centimetre outbursts. For the moderate outbursts, the delay is greater. This result is summarized in Table 2.

Table 2 shows that the polar cap absorption event has a strong tendency to occur within 5 hr. of an intense centimetre-wave outburst. Statistically, the greater the intensity of the centimetre-wave outburst, the shorter the delay of the onset of the absorption event.

Table 2. CENTIMETRE-WAVE EVENTS ASSOCIATED WITH POLAR CAP ABSORPTION EVENTS

Centimetre-wave intensity class	Number of centimetre-wave outbursts	Number of associated metre-wave outbursts			Delay of polar cap absorption events	
		Type IV	Type II (No Type IV)	No spectral observations	< 5h	> 5h
Intense	16	10	2	4	13	3
Moderate	12	5	1	6	3	9

Thus, one can conclude that the polar cap absorption events are very closely associated with metre-wave continuum outbursts of type IV as well as broad-band centimetre-wave outbursts which are believed to be of the same nature as type IV emission on metre-waves. However, it is rather difficult to determine if all centimetre-wave outbursts will be associated with polar cap absorption events, since observations of polar cap absorption were not continuous until May 1958. Moreover, centimetre-wave dynamic-spectral observations will probably be necessary to determine if a particular centimetre outburst is the type associated with a polar cap absorption event and such observations have only just begun[5]. However, continuous observations of polar cap absorption since May 1958 are available, and some knowledge of the spectra of centimetre-wave outbursts can be obtained from single frequency measurements in the wave-length range of 3–30 cm.

We have analysed the centimetre-wave outbursts observed during the period May 1958–July 1959 in an attempt to determine the characteristics of centimetre-wave outbursts which are most likely to be associated with the polar cap absorption events. From our knowledge of the polar cap absorption events and the characteristics of the centimetre-wave outbursts associated with them, we have made a pre-selection of the outbursts used in our analysis. Thus, we have selected only the outbursts having a rather flat spectrum in the wave-length range of 3–30 cm. with peak intensities greater than 100 units over the entire range, and the duration of which is greater than 10 min. We have selected 34 such centimetre-wave outbursts. The association of these outbursts with the polar cap absorption events is shown in Table 3. Also shown in the same Table is the association between type IV metre-wave outbursts and the polar cap absorption events. It should be noted that metre-wave dynamic spectral observations were not available in all cases, and therefore we have used the single frequency observations on 200 Mc./s. to identify type IV emission in five cases.

Table 3 shows: (1) Only about one-third (35 per cent) of all centimetre-wave outbursts having peak intensities greater than 100 units over the wave-length range of 3–30 cm. are associated with polar cap absorption events. (2) About 83 per cent of intense broad-band centimetre-wave outbursts are associated with polar cap absorption events. (3) About 53 per cent of all type IV metre-wave outbursts are associated with polar cap absorption events.

Table 3. ASSOCIATION OF RADIO OUTBURSTS WITH POLAR CAP ABSORPTION EVENTS (May 1958–July 1959)

Radio outbursts	Centimetre-wave intensity	No. of radio events	Polar cap absorption events		Percentage of polar cap absorption association
			Yes	No	
Broad-band centimetre-wave outbursts independent of metre-wave outbursts occurrence	intense and moderate	34	12	22	35
	intense only	12	10	2	83
Type IV metre-wave outbursts independent of centimetre-wave outbursts occurrence		19	10	9	53
Type IV metre-wave outbursts associated with broad-band centimetre-wave outbursts	moderate	7	0	7	0
	intense	12	10	2	83

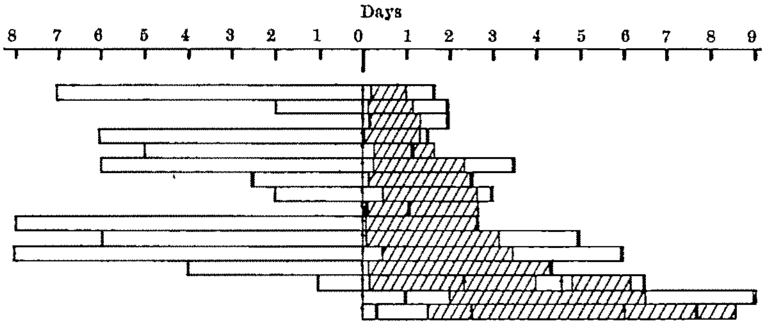


Fig. 2. Vertical arrow indicates the onset of broad-band centimetre-wave outburst or type IV event, double vertical lines indicate the appearance (left) and disappearance (right) of an active region of noise storms and hatched portions correspond, from top to bottom, to polar cap absorption events starting on Sept. 12, 1957; July 24, 1957, Sept. 26, 1957; July 29, 1958; Feb. 10, 1958; Sept. 21, 1957; July 14, 1959; Jan. 20, 1957; Sept. 22, 1958; Aug. 16, 1958; July 3, 1957; June 22, 1957; May 11, 1959; Aug. 29–Sept. 2, 1957; Mar. 25, 1958; Aug. 21–26, 1958

These outbursts are also associated with broad-band centimetre-wave outbursts, and therefore the association of the latter with polar cap absorption events increases from 35 to 53 per cent when type IV emission is associated with them. (4) Type IV metre-wave outbursts associated with moderate centimetre-wave outbursts are not associated with polar cap absorption events. (5) About 83 per cent of the type IV metre-wave outbursts associated with intense centimetre-wave outbursts are also associated with polar cap absorption events.

Thus, it follows that the intense broad-band centimetre-wave outbursts which are frequently associated with type IV metre-wave outbursts are the type of solar radio events most likely to be associated with polar cap absorption events. The occurrence of type IV outbursts on metre-waves alone is not a sufficient indication for the occurrence of polar cap absorption, but it must be simultaneous with intense centimetre-wave outbursts observed over the whole wave-length range of 3–30 cm. This result can be used in the prediction of the solar proton events. It should be noted, however, that the foregoing result is based upon limited results covering only 15 months, during which continuous observations of polar cap absorption were available.

It is known that broad-band centimetre-wave outbursts and type IV metre-wave outbursts of continuum radiation following solar flares do not last more than several hours, but the associated polar cap absorption can last several days. Also, balloon observations have detected the presence of protons up to several days after the associated solar event. The time-scale of the proton-induced polar cap absorption event is comparable to the duration of radio noise storms originating in active regions on the solar disk. We know that such noise storms occur only on metre waves and longer. A convenient source of daily records of radio-noise storms is given by the Nançay 169-Mc./s. interferometer observations which are displayed as 'active regions' on a diagram showing one-dimensional evolution of these regions[6]. On analysis, it is found that of the 27 polar cap absorption events, during which there were simultaneous interferometric observations, only seven (about 25 per cent) occurred during periods free of noise storms on 169 Mc./s. The remaining 20 events occurred during periods of enhanced 169-Mc./s. radiation. A graphical representation of the sequence of events—the 'active regions' of noise storms, the polar cap absorption events and the onset of broad-band centimetre-wave outbursts or type IV event—is shown in Fig. 2.

It is seen that the duration of the polar cap absorption event appears to be related to the presence of noise storm regions. The absorption starts after broad-band centimetre-wave outbursts or type IV event and continues approximately so long as the 'active region' is present. Further, there exists a close correlation between the presence on the Sun of the sources (determined by optically associated flares) where broad-band centimetre-wave outbursts or type IV events occur and the 'active regions' of noise storms[7].

The relation of the duration of the polar cap absorption events with the presence on the Sun of the 'active regions' of noise storms on 169 Mc./s. is more clearly seen from the two correlation diagrams shown in Fig. 3. In these diagrams, the duration of the polar

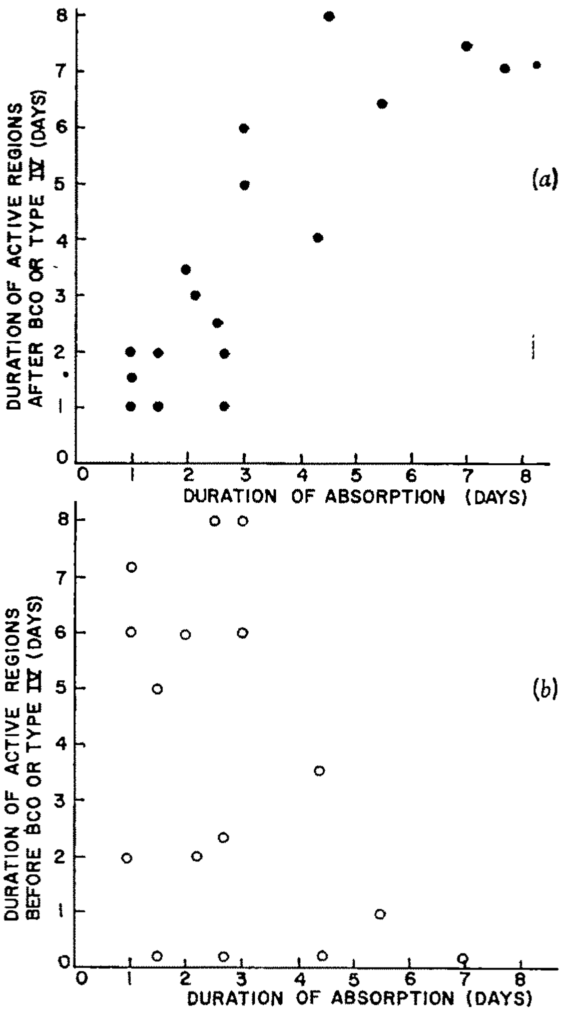


Fig. 3. Duration of active regions of noise storms (a) after and (b) before the onset of broad-band centimetre-wave outburst or type IV event, plotted against the duration of polar cap absorption

cap absorption event is plotted against the duration of the 'active regions' of noise storms (*a*) after the occurrence of the broad-band centimetre-wave outbursts or type IV event (Fig. 3*a*), and (*b*) before the occurrence of the broad-band centimetre-wave outbursts or type IV event (Fig. 3*b*). Where more than one type IV event occurs during the presence on the Sun of the 'active regions', the total duration of all the polar cap absorption events is considered. It is evident from these two diagrams that the occurrence of a broad-band centimetre-wave outburst or type IV event is an important indication for the occurrence of a polar cap absorption event the duration of which appears to be related to the duration of the 'active regions' of noise storms after the broad-band centimetre-wave outburst or type IV event, but seems to have no relation at all to the presence of the 'active regions' before the onset of the broad-band centimetre-wave outburst or type IV event.

From the foregoing considerations it appears that the polar cap absorption events are very closely associated with the occurrence of broad-band centimetre-wave outbursts or type IV events and their duration is related to the presence on the Sun of 'active regions' of noise storms.

Thus, our results are consistent with the hypothesis that the cosmic ray particles, or fast protons, are accelerated by the same process as the fast electrons responsible for the emission of broad-band centimetre-wave outbursts or type IV continuum radiation. The presence of magnetic fields over the source of type IV emission, as evidenced by the strong polarization of the radio bursts, suggests the possibility of trapping of high-energy charged particles. The exact mechanism by which the protons accelerated during broad-band centimetre-wave outbursts or type IV emission are retained or generated in the solar atmosphere and gradually diffuse out of the Sun, with the gradual dissipation of magnetic fields, is not known. However, the fact that there is a close correlation between the presence on the Sun of the sources of broad-band centimetre-wave outbursts or type IV events, and of the 'active regions' of noise storms, on one hand, and between the duration of the polar cap absorption event and the duration of 'active regions' following the broad-band centimetre-wave outbursts or type IV events, on the other, suggest that these 'active regions' might play some part in the storage (or trapping) of the protons responsible for absorption events in the polar regions.

Thanks are due to Mr. H. Leinbach of the Geophysical Institute of University of Alaska and Dr. D. K. Bailey of the National Bureau of Standards, Boulder, for supplying us with polar cap absorption data before publication. The work described here was financially supported by the Office of Naval Research Contract Nonr. 1224(16).

[1] Reid, G. C., and Leinbach, H., *J. Geophys. Res.*, **64**, 1801 (1959).
[2] Bailey, D. K., *Proc. Inst. Rad. Eng.*, **47**, 255 (1959).
[3] Anderson, K. A., Arnoldy, R., Hoffman, R., Peterson, L., and Winckler, J. R., *J. Geophys. Res.*, **64**, 1133 (1959).
[4] Freier, P. S., Ney, E. P., and Winckler, J. R., *J. Geophys Res.*, **64**, 685 (1959).
[5] Haddock, F. T., and Kuiper, J. W. (in preparation).
[6] Avignon, Y., Blum, E. J., Boischot, A., Charvin, R., Ginat, M., and Simon, P., *C.R. Acad. Sci., Paris*, **244**, 1460 (1957).
[7] Avignon, Y., and Pick, M., *C.R. Acad Sci. Paris*, **248**, 368 (1959).

SCINTILLATION COUNTING OF CARBON-14

By DAVID S. JENKINSON

Rothamsted Experimental Station, Harpenden

A PRECISE method for the radioassay of carbon-14 in aqueous solution was developed for use in work on the decomposition in soil of plant material labelled with carbon-14. This method is suitable for handling large numbers of samples with specific activities of 0·1–10 μc., and does not depend on the chemical form of the carbon or on the colour of the solution. The new method is a development of published methods[1-3] for the radioassay of weak β-emitters by counting the pulses of light emitted by a plastic phosphor in contact with a solution of the isotope.

A cell was made by cementing a disk of plastic phosphor (*N.E.* 102, 0·127 mm. thick, 4·12 cm. diameter, obtained from Nuclear Enterprises, Ltd.), on a disk of 'Perspex' (1·4 mm. thick, 4·12 cm. in diameter) using amyl acetate as solvent. A 'Perspex' ring (internal diameter 3·80 cm., height 2·50 cm., external diameter 4·12 cm.) was then cemented to the phosphor side of the combined disk. The cell fitted the counting chamber of a Panax model *S.C.–L.P.* scintillation counter, being held directly above the photomultiplier tube and in optical contact with it through a film of silicone oil. The radioactive solution was poured into the cell, placed in the counting chamber, and counted using a gain of 14,400, a discriminator voltage of 7·5, and with a voltage of 1,560 on the photomultiplier tube. The cell was then removed, rinsed with distilled water, dried with absorbent paper, and the next sample poured in. When the cell was exposed to strong light the background (32 c.p.m. at 25° C.) increased and returned to normal only after a number of hours. This effect was less marked the thinner the sheet of plastic phosphor; the cell described above could be handled in indirect light without significant rise in background count. An additional advantage in using a thin sheet of plastic phosphor is to decrease the normal background of the cell: a cell constructed with plastic phosphor 1·0 mm. in thickness had a background of 40 c.p.m. at 25° C. The volume of liquid required to cover the floor of the cell completely (4 ml.) covers the plastic phosphor to a depth of 3·5 mm., a depth much greater than the maximum range (0·3 mm.) of carbon-14 β-particles in water. For a given solution of carbon-14 the count rate should therefore be independent of the volume of liquid in the cell, once the floor of the cell had been completely covered. Fig. 1 shows that this was not so. This is because the amount of light reaching the photomultiplier by total internal reflexion at the liquid – air surface varies with depth. This effect was eliminated by adding an opaque dye to absorb all light transmitted through the solution, when the count rate becomes independent of the volume of active solution for volumes greater than 6 ml. (Fig. 1). The count rate is reduced 10–12 per cent by loss of reflected light. Naphthalene leather carbon *G.S.* was a suitable dye for all the neutral and alkaline solutions tested; indian ink was suitable for solutions in which it did not coagulate. The amount of dye is not critical; a concentration of 0·1 per cent was normally used, but varying it from 0·05 to 0·15 per cent did not affect the result. Adding dye to solutions being counted makes it unnecessary to add an exact volume of an active solution to the cell, any volume between 6 and 18 ml. being suitable, and also makes it possible to count coloured solutions, because none of the light reaching the photomultiplier is transmitted through the liquid.

Fig. 2 shows that the count rate is directly proportional to the concentration of carbon-14 in aqueous sodium carbonate solutions, a result also obtained with aqueous solutions of sodium formate labelled with carbon-14. The counting efficiency of the cell depends on the volume of active solution in the cell; for a volume of 6 ml. the efficiency is 0·15 per cent, for a volume of 12 ml., 0·075 per cent. An estimate of the accuracy of the method was made by making two counts (approximately 75,000 each) on a solution of radioactive carbonate, emptying and cleaning the cell, doing another pair of counts on the same solution and repeating the emptying and filling of the cell ten times in all. The standard deviation between cell fillings was 0·5 per cent, within the pairs (statistical counting error) 0·4 per cent.

For accurate results all solutions counted must be homogeneous; when the active material precipitates or settles out high results are obtained, and the count rate rises with time. If the count rate increases the cell should be washed out, replaced in the counter and the background measured. If the background is then normal, sedimentation has occurred; if it has risen then another phenomenon, probably caused by incomplete quenching in the solution, is involved. This occurred with a few of the neutral solutions and all the acid solutions examined. For example, a 10 per cent sucrose solution containing 0·07 µc. labelled sodium formate/ml. gave a count of 2,101 c.p.m. rising to 2,825 c.p.m. in 10 min. When the sucrose solution was removed and the cell washed and dried the background was 1,138 c.p.m., falling in 40 min. to 340 c.p.m. The effect is completely eliminated by adding alkali; a 10 per cent sucrose solution 0·1 molar with respect to sodium hydroxide containing 0·07 µc. formate/ml. gives a count of 1,478 c.p.m., the cell background being the same before and after counting. In counting solutions the behaviour of which has not been investigated it is best to make the solution 0·1 molar with sodium hydroxide as a routine procedure, because once the background count of the cell rises it takes 48 hr. to return to normal.

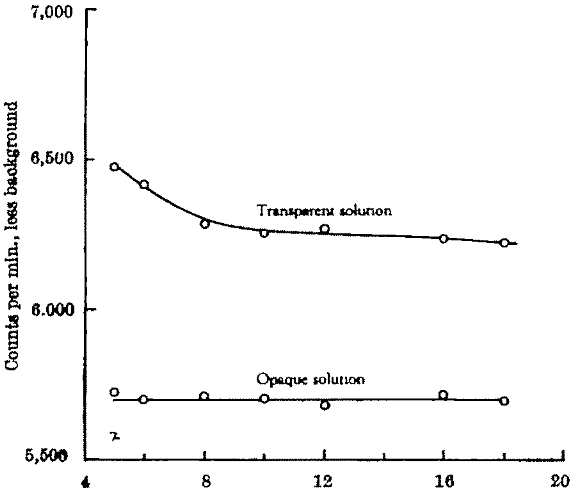


Fig. 1. Relationship between volume of active solution (0·29 µc./ml.) in cell and pulses counted

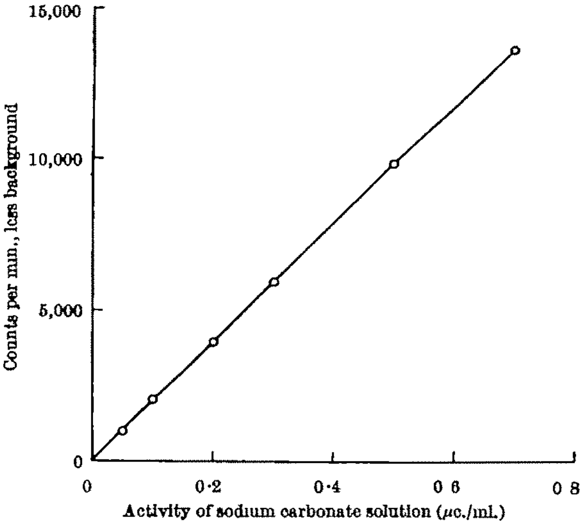


Fig. 2. Relationship between concentration of carbon-14 and pulses counted

The range of β-particles in a liquid is affected by the presence of dissolved organic or inorganic material, particularly at high concentrations, and with materials containing heavy elements. The effect is small with materials containing light atoms; 10 per cent solutions of sucrose, sodium acetate, glycine and sodium hydroxide containing labelled formate or carbonate gave count rates differing by less than 5 per cent from those of aqueous solutions containing labelled sodium formate or carbonate alone. A 0·5 *N* sodium pyrophosphate extract of a compost and a 0·5 *N* sodium sulphite extract of the organic matter of a soil both containing labelled formate gave a count rate 4 per cent lower than the formate alone. Larger effects were obtained with solutions containing heavy metals; a 10 per cent solution of phosphotungstic acid made alkaline with sodium hydroxide depressed the count rate of a formate solution by 14 per cent. In accurate work this effect must be taken into account, either by the use of internal standards or by comparing activities in solutions as nearly identical in concentration and type of solute as possible.

The counting efficiency of this method is very low, but provided sufficient activity is available to give a convenient count rate it provides a very rapid and precise method for the radioassay of carbon-14.

I wish to thank Mr. J. H. A. Dunwoody for the statistical examination of some of the data, Dr. O. Talibudeen for helpful advice, and the Dyestuffs Division of Imperial Chemical Industries, Ltd., for the naphthalene leather carbon *G.S.*

[1] Schram, E., and Lombaert, R., *Anal. Chim. Acta*, **17**, 417 (1957).
[2] Greenfield, S., *Analyst*, **83**, 114 (1958).
[3] Steinberg, D., *Nature*, **182**, 740 (1958).

DEVELOPMENT OF RESISTANCE IN MICE TO TUMOUR INDUCTION BY S E POLYOMA VIRUS

By SARAH E. STEWART, BERNICE E. EDDY, MARJEAN IRWIN and STEPHANIE LEE

National Cancer Institute and Division of Biologics Standards,
National Institutes of Health, Bethesda, Maryland

HYBRID $(C3Hf/Hen \times AKR)F_1$ mice were highly susceptible to the induction of multiple types of neoplasms when inoculated, as newly born, with polyoma virus carried in tissue culture[1,2]. In more recent work, they were found to be resistant to the oncogenic effects of the virus after sublines had been carried for 3–13 serial passages in tissue cultures of Swiss mouse embryos, whereas Swiss mice retained full susceptibility to the virus. It thus appeared that while the virus had become adapted to the Swiss mouse by passage in Swiss mouse embryo cultures, it had lost its ability to infect the hybrids. This article reports the results of experiments performed to explore this possibility.

Tissue culture. Mouse embryo tissue cultures of Swiss or $C3H$ mice were prepared by the method previously described[2,3]. Polyoma virus was carried in serial passage in Swiss mouse cultures in all experiments with the exception of one series where three sublines of the virus were carried simultaneously in both Swiss and $C3H/Hen$ embryo cultures.

Virus. Nine sublines of virus were used. The origin of five (Nos. 3469, 60, 3919, 3607 and 3791) has been described[1,2]. The others (Nos. 5729, 5881 and 5884) were isolated from Swiss mice with parotid tumours induced by virus, while No. 695 was recovered from a hamster with sarcomas induced by virus. Sublines 5729, 5881, and 5884 were those carried simultaneously in both Swiss and $C3H/Hen$ embryo cultures.

Mice. Some of the $(C3Hf/Hen \times AKR)F_1$ litters were from mice bred in our laboratory. Others were obtained from the Animal Production Center of the National Institutes of Health, Bethesda, Md. The litters of Swiss mice were also from the Animal Production Center. The importance of these different sources of the experimental animals will be shown in this article. All mice were inoculated subcutaneously within 24 hr. of birth with 0·1 ml. of fluids from tissue cultures. The mice were observed for development of gross tumours, and those not developing neoplasms were killed 24 months after inoculation.

Immunological procedures. Mouse sera obtained by cardiac puncture were tested for the presence of neutralizing antibodies by a procedure described earlier[4,5], and by inhibition of virus hæmagglutinin[6]. Milk obtained from nursing mothers was also tested for antibody content by the inhibition of hæmagglutination of washed guinea pig erythrocytes.

To test for the inhibition of hæmagglutinin, twofold dilutions were made from the serum of individual mice ranging from 1/10 to 1/81,920. Each dilution was tested against two hæmagglutinating doses of the virus. Controls for the hæmagglutinating titres of the virus were made with each test. Milk was tested for antibodies by the same method.

Results. Polyoma virus sublines Nos. 3469 and 60 which were passed serially in Swiss mouse embryo cultures had produced tumours in $(C3Hf \times AKR)F_1$ mice inoculated with passage virus through the ninth and eighth passages, respectively[2]. The hybrid mice receiving subline 60 showed a marked drop in susceptibility after the third passage[2]. The decline in response to subline 3469 was not so pronounced, but became obvious by the thirteenth passage under similar conditions. Three other sublines of virus also did not show oncogenic activity for the $(C3Hf \times AKR)F_1$ mice but produced tumours in Swiss mice. These findings are shown in Table 1.

A possible explanation for the loss of oncogenic activity of polyoma virus for the hybrid mice was that the virus had become adapted to the Swiss mice because it was carried in tissue cultures of Swiss mouse embryos. To determine if this had occurred, virus sublines Nos. 5729, 5881 and 5884 were procured and grown simultaneously in both Swiss and $C3H/Hen$ mouse embryo cultures from their first isolation and then tested for oncogenic activity in newly born Swiss and $(C3Hf \times AKR)F_1$ hybrid mice. Table 2 shows that the hybrid mice were relatively resistant to the virus, although it had grown for 3–5 passages in cultures of strain $C3H$ embryos. Such results

Table 1. COMPARISON OF SUSCEPTIBILITY OF $(C3Hf \times AKR)F_1$ MICE AND SWISS MICE TO *S E* POLYOMA VIRUS
(Virus carried in Swiss mouse embryo cultures)

Virus subline	Passage	$(C3Hf \times AKR)F_1$ mice		Swiss mice	
		Mice inoculated / Mice surviving	Per cent with tumours*	Mice inoculated / Mice surviving	Per cent with tumours
3469	13*A*	35/34	0·3	30/29	100
	15	6/6	0	—	—
	17	5/4	0	—	—
	18	11/8	0	—	—
	20	—	—	15/14	93
	21	4/4	0	9/9	100
60	10	8/6	0	80/74	93
3607	6*B*	4/4	50	7/7	100
	10*B*	17/13	0	—	—
	11*B*	8/7	0	8/6	100
3791	6	7/6	0	18/15	100
	8	16/16	0	32/22	95
	10	17/10	0	15/15	100
3919	2	4/4	0	—	—
	3	—	—	27/27	92
	6	6/5	0	22/19	100
	7	18/13	0	9/9	100
	8	10/10	0	—	—
	12	—	—	63/59	100
	24*b*	—	—	56/50	96
Pooled virus 3919 3791 3469	6 8 17	21/20	26	30/29	100

* Exclusive of leukæmia, which occurs spontaneously in these hybrids.

Table 2. COMPARISON OF ONCOGENIC ACTIVITY ON *S E* POLYOMA VIRUS CARRIED IN EMBRYO CULTURES OF *C3H* MICE AND OF SWISS MICE

Virus subline	Virus passage	Mice	*C3H* mouse embryo		Swiss mouse embryo	
			No. inoculated / No. surviving	Per cent with tumours	No inoculated / No. surviving	Per cent with tumours
5729	5	*C3Hf* × *AKR*	7/7	0	8/6	16
,,	5	Swiss	7/7	70	8/7	85
5881	3	*C3Hf* × *AKR*	6/6	16	6/6	32
,,	3	Swiss	8/6	100	7/7	100
5884	3	*C3Hf* × *AKR*	7/7	0	7/7	0
,,	3	Swiss	6/5	100	7/6	83

Table 3. INHIBITION OF *S E* POLYOMA VIRUS HÆMAGGLUTINATION BY SPECIFIC ANTIBODIES PRESENT IN STRAIN *C3H* MOUSE MILK*

Source of milk	Age of mice (months)	Milk dilutions							
		1/10	1/20	1/40	1/80	1/160	1/20,480	1/40,960	1/81,920
Two female mice inoculated with virus when newly born	5	—	—	—	—	—	—	±	3+
Two female mice from virus-free environment	6	—	—	—	3+	4+	4+	4+	4+
Cow's milk†	—	—	—	—	—	4+	4+	4+	4+

* Minus signs indicate complete inhibition of hæmagglutination. Plus signs preceded by numeral indicate degree of hæmagglutination.
† Calf serum has been shown to contain an inhibitor which prevents tumour induction in mice (ref. 7).

Table 4. INHIBITION OF *S E* POLYOMA VIRUS HÆMAGGLUTINATION BY MOUSE SERUM ANTIBODIES*

Mice	Age when bled (months)	Serum dilutions							
		1/80	1/320	1/1,280	1/2,560	1/5,120	1/20,480	1/40,960	1/81,920
Had virus inoculated when 4 weeks old	14	—	—	—	—	—	—	—	±
,, ,, ,,	14	—	—	—	—	—	—	±	3+
,, ,, ,,	14	—	—	—	—	—	4+	4+	4+
Not inoculated but kept in virus-contaminated environment	21	—	—	—	—	—	4+	4+	4+
,, ,, ,,	9	—	—	—	4+	4+	4+	4+	4+
,, ,, ,,	19	—	—	—	—	4+	4+	4+	4+
,, ,, ,,	19	—	—	4+	4+	4+	4+	4+	4+
,, ,, ,,	14	—	—	—	4+	4+	4+	4+	4+
With adrenal tumour graft 114*G*†	2	—	—	—	—	—	—	—	1+

* Sera of 12-month-old breeders from environment free of polyoma failed to inhibit hæmagglutination above 1/80 dilution.
† Transplanted tumour induced by virus carried through 114 serial transfers for period of 7 years.

show that growth of the virus in cultures of Swiss embryos was not responsible for its inability to infect the hybrids.

Resistance of the hybrid mice to polyoma virus was finally traced to maternal antibodies. Strain *C3H/Hen* female mice which were used as breeders and housed in the same room with mice that had received polyoma virus were found to have antibodies specific for the virus[5]. Their sera administered to newly born Swiss mice 1 hr. before receiving virus produced passive immunity. Tumour induction could also be prevented by mixing serum with virus prior to inoculation. Pooled sera from 12 breeders tested completely inhibited tumour induction in 100 per cent of 24 Swiss mice given sufficient virus to cause tumours in all of 16 mice that did not receive serum.

It was also found that the antibody could be transferred to the offspring by way of mother's milk. Milk taken from nursing strain *C3H* and Swiss mothers that had been exposed to the virus and from those not exposed when tested for antibody content by the method of inhibition of hæmagglutination showed pronounced differences in effectiveness. The results of a test are shown in Table 3. The range of antibody titres of pooled milk from exposed mice was similar to that observed in the sera of mice which had been exposed to virus (Table 4). The milk and sera from mice free of the virus showed a non-specific inhibition of hæmagglutination in titres of 1/40–1/80, while those with specific polyoma virus antibodies had titres of 1/1280–1/81,920. Since calf serum has been found to have a substance inhibitory for polyoma virus[7], cow's milk was also tested for hæmagglutination inhibition, but was found free of antibodies (Table 3).

Hybrid $(C3Hf \times AKR)F_1$ mice from animals bred in an environment free of polyoma virus were susceptible to the virus. Newly born litters of these hybrids injected with virus subline 695, 16th–18th passage in Swiss mouse embryo, developed the same spectrum of neoplasms (with the exception of mesotheliomas; it was previously reported that mesotheliomas were not observed in the hybrid mice) as did control Swiss mice. 83 per cent of 30 hybrid mice and 100 per cent of 27 Swiss mice developed neoplasms.

Polyoma virus has been shown to be highly antigenic. Serum antibodies specific for the virus have been found in the following animals: rabbits inoculated with virus for the purpose of developing immune sera[4]; mice inoculated when newly born which eventually developed neoplasms[5]; mice not injected with the virus but housed in an environment with inoculated animals[5]; suckling hamsters actively immunized with virus-antiserum vaccine[8].

Specific antibodies against polyoma virus have also been stimulated in adult female hamsters with virus treated with formalin. The offspring of such animals when inoculated at less than 1–3 days of age developed fewer neoplasms, and the neoplasms appeared after a longer latent period than in the offspring of non-immunized females[8].

In a colony of mice with latent polyoma virus infection, transfer of maternal antibodies to the offspring by way of milk, as observed in our experiments, could account for any irregularity of results following inoculation of this virus. Maternal antibodies may also explain the lack of spontaneous parotid gland tumours in an infected colony. Antibodies transferred to the offspring could also explain the absence of these neoplasms in the offspring of tumour-bearing females (Stewart, S. E., unpublished work).

It is also conceivable that latent polyoma virus infections may become activated under certain conditions. Radiation has been reported as activating a latent leukæmia virus[10]. It is also possible that other carcinogens, viral or chemical, may produce tumours by the activation of this or other latent oncogenic viruses.

[1] Stewart, S. E., Eddy, B. E., Gochenour, A. M., Borgese, N. G., and Grubbs, G. E., *Virol.*, **3**, 380 (1957).

[2] Stewart, S. E., Eddy, B. E., and Borgese, N. G., *J. Nat. Cancer Inst.*, **20**, 1223 (1958).

[3] Eddy, B. E., Stewart, S. E., Young, R., and Mider, G. B., *J. Nat. Cancer Inst.*, **20**, 747 (1958).

[4] Stewart, S. E., and Eddy, B. E., "Perspectives in Virology", 245 (John Wiley and Sons, New York, N.Y., 1959).

[5] Stewart, S. E., Eddy, B. E., and Stanton, M. F., in Proc. Third Canadian Cancer Conf., 287 (Academic Press, New York, 1959).

[6] Eddy, B. E., Rowe, W. R., Hartley, J. W., Stewart, S. E., and Heubner, R. J., *Virol.*, **6**, 290 (1958).

[7] Stewart, S. E., and Eddy, B. E., Proc. Seventh Hematology Conference (in the press).

[8] Stewart, S. E., and Eddy, B. E., *Amer. J. Pub. Health*, **49**, 1493 (1959).

[9] Eddy, B. E., Stewart, S. E., and Touchette, R. H. (Abstract), *Fed. Proc.*, **18**, 565 (1959).

[10] Lieberman, M., and Kaplan, H. S. (Abstract), *Proc. Amer. Assoc. Cancer Research*, **3**, 38 (1959).

AMINO-ACID COMPOSITION OF PROTEINS FROM SURFACE TISSUE OF THE TONGUE

By DR. C. J. BARNES and DR. L. N. FERGUSON
Chemistry Department, Howard University, Washington, D.C.

THIS investigation is part of a programme[1] to find a set of molecular properties which may serve as a parameter for predicting the tastes of compounds, and to learn the mechanism by which sapid substances stimulate the chemoreceptor taste organ. The fact that the tongue is practically the only taste-sensitive area indicates that there is something unique about its surface tissue. Since enzymes are involved in all biological processes and in view of the fact that optical isomers may have different tastes, thus revealing the stereospecificity of taste chemoreception, it is logical to examine first the protein material of the surface tissue of the tongue. It was thought that a knowledge of the amino-acid composition of the surface proteins might reveal the presence of unique amino-acids, or, if certain amino-acids are present in unusually large amounts, one could possibly get a clue to the type of molecular interaction occurring between the chemoreceptor and the sapid compound. In this study, the amino-acid composition was determined for the total proteins precipitated from the surface tissue of the tip of a human tongue.

Rectangular strips were removed from the outer surface of the tip, edges, and centre area of a human tongue. The underlying muscle and fatty tissue were scraped away, and the tough outer surface consisting of mucous membrane and papillæ was cut into very small pieces, and homogenized with 5 per cent trichloracetic acid in a Potter–Elvehjem-type tissue grinder. It was necessary to grind some of the very resistant tissue in a mortar. After centrifugation, the supernatant liquid was removed by suction. The precipitated protein was washed several times with 95 per cent ethyl alcohol, twice with acetone, centrifuged, and dried in a vacuum desiccator over concentrated sulphuric acid.

A 50-mgm. sample of this proteinic material was weighed and washed into a 50-ml. glass ampoule with constant boiling-point hydrochloric acid. The ampoule was evacuated, sealed, and heated for 24 hr. at 110 ± 2° C. to affect hydrolysis. 0·5 Ml. portions of the hydrolysate were placed in smaller ampoules and each sample dried in an evacuated desiccator over solid sodium hydroxide for 20 hr. The residue in each ampoule was dissolved in 0·5 ml. distilled water, then 0·5 ml. of 0·2 *M* sodium phosphate buffer *p*H 6·5 was added, and the solution was allowed to stand unstoppered for 4 hr. to oxidize any cysteine present to cystine. Then were added 0·06 ml. of freshly prepared 1 *N* hydrochloric acid and 2 ml. of 0·2 *N* sodium citrate buffer *p*H 2·2, containing *BRIJ*-35 and thiodiglycol. The ampoules were sealed and stored in a freezer for subsequent analysis.

'Amberlite *IR*-120' (*CG*-120) type II from the Rohm and Hass Co. was prepared by the Moore and Stein tap water modification[2] of Hamilton's[3] method of fractionating resins. Two fractions were taken for use, a 280-ml./min. fraction and a 580-ml./min. fraction. Columns of 150-cm. and 49-cm. lengths were prepared using 0·9-cm. inner-diameter tubes.

The 50° C. and the 30–50° C. systems of Moore and Stein were used with the long column. The short column was started at 30° and raised to 50° C. after the carnosine peak.

A synthetic mixture of amino-acids was prepared by adding 125 μmoles of the desired amino-acids to a 50-ml. volumetric flask half-filled with water plus 0·5 ml. of concentrated hydrochloric acid. The volume was brought up to 50 ml. and 2- or 3-ml. portions added to small ampoules. The air in each ampoule was replaced by nitrogen before sealing. The vessels were stored in a freezer until analysed. For analysis, 1 ml. of this solution of mixed amino-acids was diluted with 4 ml. of 0·2 *N* sodium citrate buffer *p*H 2·2 containing thioglycol and detergent solution. 2 Ml. of this solution, equivalent to 1 μmole of each amino-acid, was taken for analysis.

The volume at which each amino-acid was eluted, using a fraction collector, was determined from the contour of the resulting chromatograms and by comparison with the chromatograms of Moore and Stein. Then, the fraction number for the various amino-acids was used for determining the amino-acids present in the hydrolysates, and the sums of the absorbances at each peak were used for determining the quantities of each amino-acid present. Because of the small variations in the volumes used for releasing a given amino-acid from the column, the analysis of hydrolysates were checked by applying the chromatographic procedure to a 50-50 mixture of a synthetic sample and a sample from the protein hydrolysate.

Since tryptophan is destroyed during acid hydrolysis, it was determined by the spectrophotometric method of Goodwin and Morton[4].

Several runs were made on the protein material taken from the tip of the tongue. Typical chromatograms are shown in Figs. 1 and 2.

Lysine from the protein hydrolysate sometimes provided an asymmetrical peak. This raised the question as to whether or not ammonia accompanied the release of lysine from the column. Since the lysine peak from a synthetic mixture was also slightly asymmetric, it was concluded that this 'lysine' peak from the hydrolysate does represent lysine with no more than a trace of ammonia or some other contaminant.

In some runs, a rise in the base-line occurred where histidine would have been eluted. Because of the variable nature of the peak, it was not labelled as such. Even if this elusive peak, is histidine it corresponds to no more than 1·4 mgm. of amino-acid per 100 mgm. of dried protein.

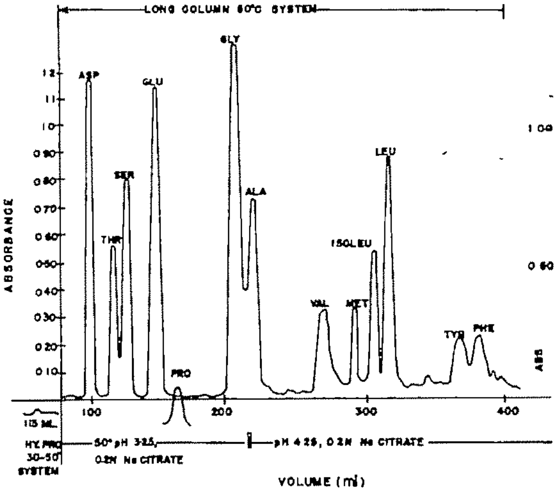


Fig. 1. Chromatogram of a hydrolysate of the precipitated proteins from the surface tissue of the tip of a tongue

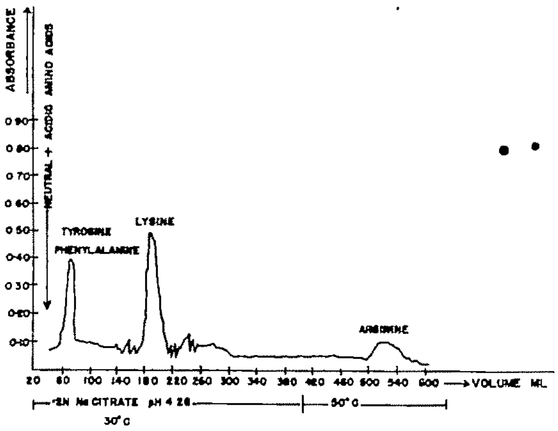


Fig. 2. Chromatogram of a hydrolysate of the precipitated proteins from the surface tissue of the tip of a tongue

Table 1. Amino-acid Composition of Precipitated Proteins from Human Tongue Surface Tissue in mgm. of Amino-acid per 100 mgm. of Protein

Amino-acid	Tip				Average value on tip area	Centre area
	1*a*	1*b*	II	III		
Glutamic acid	12 4	12·1	12 1	13·8	12 6	11 0
Lysine		15·2	7 6	12·2	11·7	14·6
Glycine	8 5	9 8	10·5	10 9	9·9	12 0
Aspartic acid			9 5	9 9	9·7	8·3
Leucine		7 0	7·2	7·9	7·2	6 4
Hydroxyproline	9 6	5 0			7 3	13·9
Alanine			6 2	6·9	6 6	6·7
Tyrosine plus phenylalanine		6·4	5·4	5 9	5 9	1·6
Valine	6 3	5 8	5 3	5 6	5 8	4 2
Arginine				4·3	4·3	5·4
Serine	3 9	3 8		5 4	4·4	
*Iso*leucine			3 6	4·4	4·0	3 5
Proline			3 6	4·2	3 9	5·0
Threonine	3 0	3 2		4·4	3 5	3 9
Tryptophan					(3 5)	
Methionine			3 4	3·2	3 3	1·9
Histidine						
Total					103·7	

Table 2. Amino-acid Compositions of Several Proteins in mgm. per 100 mgm. of Protein

Amino-acid	Horse hæmoglobin	Pepsin	Insulin	Beef tongue	Collagen	Tongue surface tissue (tip)
Alanine	7 4		4·5	6 4	9 4	6 6
Arginine	3·7	1·0	3 1	6 5	8 5	4 3
Aspartic acid	10 6	16 0	6 8	9·9	6 3	9 7
Cystine	1 0	2·1	12 5	1·3		0
Glutamic acid	8 2	11·9	18·6	17·0	11·3	12·6
Glycine	5 6	6 4	4·3	6·7	27·2	9 9
Histidine	8·7	0·9	4 9	2 5	0·8	?
Hydroxylysine					1·1	0
Hydroxyproline	0		0 0		14 0	7·3
*Iso*leucine	0·2	10·8	2·8	4 8		4 0
Leucine	15·2	10 4	13 2	7 8	5 6	7·2
Lysine	8·5	1 6	2·5	8 8	4 5	11·7
Methionine	1 0	1·7	0·3	2·2	0·8	3·3
Phenylalanine and tyrosine	10·7	14 9	21·1	7 3	3·5	5·9
Proline	8 5	5·0	2 5	5 6	15·1	3 9
Serine	5 8	12 2	5 2	4 7	3 5	4 4
Threonine	4 4	9 6	2·1	4·3	2 3	3 5
Tryptophan	1·7	2·4	0 3	1 2	0	3 5
Valine	9 0	7·1	7 8	5·1	3 4	5 8
Total	110	114	113	99 9	117	103 7

Occasionally other rises occurred in the base line absorbance. The base lines generally were not stable enough to attribute these fluctuations to amino-acids.

The computed amino-acid compositions of the protein material from the tip and centre areas of the surface tissue of the tongue are given in Table 1. In general, the ranges of values for a given amino-acid were not large, although there are two exceptions. Samples 1*a* and 1*b* represent two different analyses of the same batch of hydrolysate. One analysis was made on the precipitated proteins from the centre (bitter sensitive) area of the tongue. Little significance can be given to this single run, which was incomplete, because its reliability has not been determined through repeated analyses.

In Table 2 are listed amino-acid compositions of some other proteins for comparison. Since our work dealt with the mixture of proteins precipitated by trichloracetic acid, it is unlikely that a resemblance will be found with a single protein. It is observed, however, that the tongue surface proteins, unlike bulk beef tongue, contain no cystine, and are unique with collagen in having significant amounts of hydroxyproline. Tongue-surface proteins differ from collagen in that the former have tryptophan, a much smaller content of proline and glycine, and a higher percentage of lysine.

The work reported here should be carried further by first making a more refined sectioning of the tongue tissue to include only papillæ. Secondly, the tissue proteins should be fractionated and analyses made on homogeneous fractions.

[1] Lawrence, A. R., and Ferguson, L. N., *Nature*, 183, 1469 (1959).

[2] Moore, S., Stein, W. H., and Sparkman, D. H., *Anal. Chem.*, 30, 1185 (1958); *J. Biol. Chem.*, 211, 893 (1954).

[3] Hamilton, P. B., *Anal. Chem.*, 30, 914 (1958).

[4] Goodwin, T. W., and Morton, R. A., *Biochem. J.*, 40, 629 (1946).

HIGH FREQUENCY OF SPONTANEOUS AND INDUCED SOMATIC SEGREGATION IN *ASPERGILLUS NIDULANS*

By Dr. ETTA KÄFER

Department of Genetics, McGill University, Montreal

THE ascomycete *Aspergillus nidulans* normally carries haploid nuclei in its hyphæ and produces vegetative spores (conidia) each with a single haploid (n) nucleus. Diploid nuclei arise spontaneously with a very low frequency by fusion of nuclei in the hyphæ. Such diploids can easily be selected and seem fairly stable. As a rare event mitotic crossing-over occurs and diploid segregants are produced, which show recombination for markers of a single chromosome arm[1]. This process seems to be analogous to that occurring in *Drosophila*[2]. The relative frequency of the different cross-over types is very constant and their absolute frequency low[3].

Besides mitotic cross-overs a variety of other mitotic segregants have been isolated from diploids. Recent results show that the types and frequencies which are observed depend to a high degree on the methods of selection and isolation. When standard methods of selection are used, two main further types of segregants, stable haploids and 'non-disjunctional' diploids, are isolated with frequencies usually lower than that of mitotic cross-overs. Special less-strongly selective methods, on the other hand, yield a large variety of *unstable* types, some with much higher frequency. These segregants vary in colony appearance, but they all have reduced growth-rate and viability, and are unable to compete with haploid or diploid colonies. Under favourable conditions, for example, when replated at low density, they all produce vigorous, stable sectors with apparently high frequency. The actual frequency of segregation may not be very high; but as soon as a few stable segregants are produced, these grow so much faster that they surround the unstable parental colony and stop its growth. Usually it is possible to harvest conidia from the centre of such colonies, which are still of the original unstable type and on replating show again the same pattern of segregating sectors.

It was found that any one unstable segregant produces either only haploid or only diploid sectors, except in rare cases when among the diploid sectors a fair proportion of haploid ones is found. All diploid sectors which show any recessive markers segregate simultaneously for all the markers on a chromosome, that is they are always of a 'non-disjunctional' type. The same mechanism of irregular segregation of whole chromosomes may therefore be responsible for the production of all unstable presumably aneuploid types as well as their stable haploid or diploid sectors. It would produce all mitotic segregants, except mitotic cross-overs. It is the aim of the present work to test this hypothesis.

Two methods of isolating segregants are used, which yield unstable segregants with high frequency. Preliminary results have been obtained using for analysis a diploid heterozygous for 19 markers on 7 out of 8 chromosome pairs. This diploid is wild type in phenotype with respect to all recessive markers, but if any mutant becomes homozygous or hemizygous the corresponding mutant phenotype is observed.

The first method of isolation is selective: single conidial heads, which show the mutant phenotype for recessive colour markers, are touched with a needle and the conidia sticking to it plated. This method yields many unstable segregants, which all give sectors of haploid type only. The haploid sectors of any one unstable segregant are identical with respect to most markers, but show segregation for the markers of a few chromosome pairs. The unstable segregant appears therefore as an aneuploid of a hyper-haploid type, and it is possible to deduce which chromosomes are monosomic and which disomic. As not all chromosomes were marked, only a minimal estimate of the chromosome number in any one aneuploid was obtained.

Table 1

Ploidy	Diploid	Aneuploid				Haploid
		$n+1$	$n+2$	$n+3$	Total	
Observed numbers	42	40	14	5	59	14
Frequency	37%				51%	12%

Among 115 segregants isolated in this way the frequency of the various ploidy types was as shown in Table 1 (ref. 4).

The second method is unselective and consists simply in plating random samples of conidia from different colonies of the original diploid on to complete medium. The density (conidia per plate) greatly influences the frequency of segregants recovered by this method. In a first set of platings with about 50 conidia per plate, segregant types were obtained with a frequency of 1/150, while in a second set with much lower density as many as 1/40 were observed. Different strains also may vary in the frequency of segregants produced. All colonies showing abnormal phenotype were classified as segregants and analysed by secondary platings. As all of them showed sectoring with high frequency they are assumed to be aneuploids.

The phenotypes of the different aneuploids vary and seem to fall into several types: (*a*) compact colonies; (*b*) colonies with poor conidiation and dark background colour; (*c*) very slow-growing, sometimes spidery thin colonies, which often are completely overgrown by segregating sectors. Among the last type about half of the aneuploids were found to be hyper-haploid often with at least $n + 3$ or $n + 4$ chromosomes. These hyper-haploids, which represent 10–20 per cent of the total number of aneuploids, produce only haploid sectors.

All other aneuploids produced diploid sectors, which in a high proportion were of parental genotype. It seems likely, therefore, that these aneuploids are of a hyper-diploid type. Besides parental diploid sectors, segregant diploid sectors were found in all cases, which were always of a 'non-disjunctional' type. The minimum number of extra chromosomes in these hyper-diploids could be deduced from the number of different 'non-disjunctional' types found among the diploid sectors. Most hyper-diploids seemed to be of the type $2n + 1$ and $2n + 2$. Some of these hyper-diploids also produce large haploid sectors, with much higher frequency than the parental diploid. Each one shows a distinctive pattern of segregation.

These results suggest that frequently in mitosis of diploid *A. nidulans* chromosomes are irregularly distributed, producing two nuclei of the types $2n + x$ and $2n - x$. So far the analysis of hyper-diploids ($2n + x$) suggests that x is usually small (1 or 2). This would explain why segregants 'non-disjunctional' for more than one chromosome have only very rarely been observed. As the $2n - 1$ or $2n - 2$ types which, according to this hypothesis, are produced have not been recovered with certainty, it has to be postulated that these types are often too unbalanced and short-lived to produce conidia, but that they produce by successive accidental loss of individual chromosomes more stable nuclei of smaller chromosome number. Haploids and 'non-disjunctionals' would then all arise as stable end-products of a secondary process of segregation in aneuploids.

If, on the other hand, aneuploids are produced by a chance distribution of chromosomes, x would have all possible values from 1 to 16 (accepting 8 as the haploid chromosome number[5]). As the types $2n + 3$ up to $4n$ have not been isolated, it would have to be assumed that they are either not present in conidia or produce colonies indistinguishable from the parental diploid. As a rare event this process would then produce a triploid and a haploid nucleus as originally postulated by Pontecorvo[1].

A further possible mechanism for production of haploids is genome segregation[6]. The observation of two cases of 'twin spots' makes it necessary to consider this process as an additional possibility. In both cases haploids of two types, complementary for all 16 distinguishable markers, were recovered from a single head. But in one case the number of colonies obtained was very small; in the other, aneuploid types were present in addition to the complementary haploid types. Obviously further information is needed to decide whether genome segregation occurs.

Two new diploids have now been developed with markers on practically all chromosomes of the eight pairs, mostly in repulsion in one diploid, mostly in coupling in the other. It is hoped that they will provide conclusive evidence as to whether one or several types of mitotic segregations are producing haploids in diploid fungus strains.

Some observations on effects of high doses of X-rays on mitotic segregation in another heterozygous diploid have been obtained recently[7]. It was found that at a dose of about 50,000 r. none of the surviving conidia is of the parental type. The few strains with normal growth-rate and phenotype carry recessive lethals and reciprocal translocations which change the pattern of mitotic segregation, but do not increase its frequency. But the majority of survivors grow very slowly and show a high frequency of segregant sectors, often of a haploid type only. Some unstable, fairly well-growing strains, giving diploid sectors comparable to those found in spontaneous hyper-diploid strains, have also been obtained. In all cases the segregation seems to involve whole chromosomes and appears to be the same mechanism as that observed in spontaneous mitotic segregation. But much more detailed analysis using diploids containing many more chromosomes marked on both arms is needed for a conclusive comparison of spontaneous and induced mitotic segregation.

The segregation found in *Aspergillus nidulans* is parallel in most details to that observed in *Penicillium chrysogenum*, where unstable segregants are obtained after treatment with X-rays[8] or nitrogen mustard[9]. Aneuploidy has been rejected as an explanation of the results in *Penicillium*, because only aneuploids of a hyper-haploid type were considered, but it seems that these new results can provide a good explanation of most observed features of the induced 'high-frequency-segregation' described in *Penicillium*. Unfortunately the number of markers used in the *Penicillium* diploids is too small, and the mutagenic treatment too drastic, to permit detailed comparison and really safe conclusions.

This work is supported by a grant from the National Research Council of Canada.

[1] Pontecorvo, G., Tarr-Gloor, E., and Forbes, E. C., *J. Genet.*, **52**, 226 (1954).

[2] Stern, C., *Genetics*, **21**, 625 (1936).

[3] Pontecorvo, G., and Käfer, E., "Adv. in Genet.", **9**, 71 (1958).

[4] Kafer, E., Carnegie Yearbook, **56**, 376 (1956–57).

[5] Kafer, E., "Adv. in Genet.", **9**, 105 (1958).

[6] Stern, C., *J. Cell. Comp. Physiol.*, **52**, 1 (1958).

[7] Tector, A. (unpublished work).

[8] Sermonti, G., and Morpurgo, G., *Genetics*, **44**, 437 (1959).

[9] Morpurgo, G., and Sermonti, G., *Genetics*, **44**, 137 (1959).

LETTERS TO THE EDITORS

ASTRONOMY

Dirac's Cosmology and the Origin of the Solar System

In one of his earlier papers, Dirac[1] concluded that the gravity coefficient, far from being constant, varies inversely with a "universe time parameter". This result was not accepted by the physicists and it was common opinion that a field theory featuring a non-constant gravity coefficient falls outside the limits of the general theory of relativity. However, Dirac's idea was revived recently. Starting from reasonable assumptions, C. Gilbert[2] showed, in 1956, that Dirac's hypothesis is a corollary of the general theory of relativity. He further computed the age of the universe from the present value of the gravity constant and found it to be $4{\cdot}1 \times 10^9$ years, in remarkable coincidence with the age of the Earth of $4{\cdot}2 \times 10^9$ years, as determined by radioactive methods.

I wish to put forward an apparently acceptable hypothesis of the origin of the solar system, based on the results of Dirac and Gilbert.

Let us consider the state when t, the universe time parameter, was quite small, and let us assume that the mass of the solar system was at that time concentrated in the Sun. Because of the relation $f = x/t$, gravity acceleration in the Sun must have been very great, resulting in large-scale pressure-dependent degeneration of matter. Therefore, the radius of the Sun must have been very small and its angular velocity must have been several times as great as at present.

The centrifugal force and gravitational acceleration on the solar equator have, however, steadily decreased. In the case of gravity acceleration, this was due partly to the decrease of $f = x/t$ and partly to the resulting increase of the solar radius. The increase of radius is considered to have been at first a linear function of universe time, so that:

$$g_s = \frac{xM}{t\,(r_0 + \alpha t)^2}$$

M being the mass of the Sun, and g_s the gravitational acceleration on the solar surface.

However, the impulse momentum of a rotating Sun is given by:

$$\omega \Sigma m_i r_i^2 = \lambda = \text{constant}$$

giving for the solar equator a centrifugal force:

$$r\omega^2 = \frac{r\lambda^2}{(\Sigma m_i r_i^2)^2} = \frac{A}{(r_0 + \alpha t)^3}$$

Comparing the gravity acceleration with the centrifugal force, it is apparent that the two terms will vary, when disregarding the coefficient $\frac{1}{(r_0 + \alpha t)^2}$, according to the functions $\frac{A}{r_0 + \alpha t}$ and $\frac{B}{t}$ respectively. The graphs of the two functions are shown in Fig. 1. In case $A - \alpha B > 0$, there will be an instant t_1 when the centrifugal force becomes equal to the attraction of gravity on the solar equator, so that part of the solar mass can escape into the universe. The molecular forces could inhibit escape temporarily. Escape took place when the weightless mass formed a planet in consequence of its own gravitational attraction.

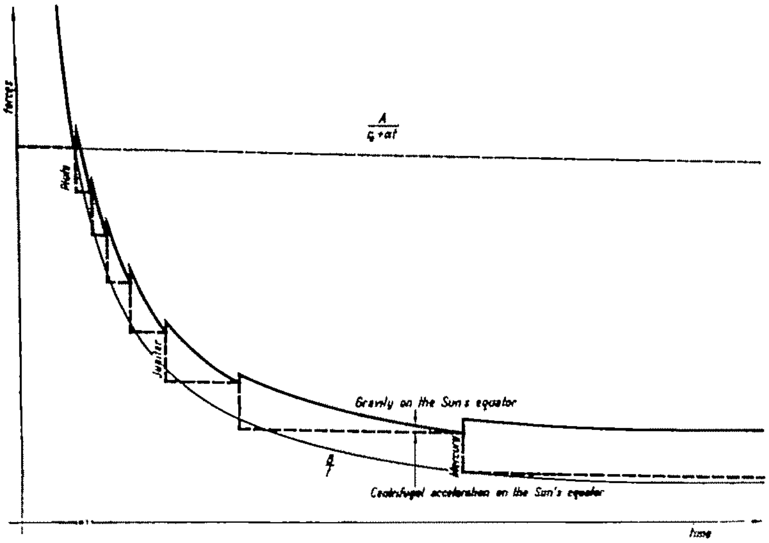


Fig. 1

This escape of mass will result in a decrease of the solar radius and a consequent decrease of centrifugal force on the surface of the remnant Sun. On the other hand, the gravitational acceleration will be greater because of the smaller radius. Therefore the play of forces will be repeated. Fig. 1 shows that after a number of repetitions—at steadily growing time intervals—the centrifugal force will no longer be capable of equalling the force of gravity. (In tracing the diagram the simplifying assumption was made that the discontinuous increase and decrease of the two quantities involved takes place in steps of equal size.)

The escaped masses will, because of the decrease of f, rotate on steadily widening orbits, since fR must be a constant, R being the orbital radius in question.

Therefore, the following equation is valid:

$$\frac{r_n}{t_n} = \frac{R_n}{t}$$

that is:

$$R_n = \frac{r_n t}{t_n} = \frac{r_0 + \alpha t_n}{t_n} . t = \left(\frac{r_0}{t_n} + \alpha\right) t$$

where R_n is the actual orbital radius, r_0 the orbital radius at the moment of formation, that is, at the time t_n.

The graph indicates that the value t_n is—at least within a certain time interval—roughly twice the preceding value, so that:

$$R_n = \left(\frac{r_0}{2^n t_0} + \alpha\right) t = \frac{C}{2^n} + D$$

in agreement with the 'law' of Titius and Bode.

The masses escaping from the Sun will invariably be those of highest specific impulse momentum. Thus it can be understood why the bulk of the impulse momentum of the solar system is borne by the planets.

Gravity differentiation in the Sun must have been most intense at the time when gravitational acceleration was greatest. Therefore, the older, that is, the outer, planets are of smaller bulk density.

The above mechanism can be extended to the satellites of the larger planets, too. The coincidence of the orbital planes is a matter-of-fact corollary and the formation of rings or asteroids is also possible.

This theory is obviously far from being complete. I wish merely to show that the results obtained by Dirac and by Gilbert may in themselves be the nucleus of a theory of the origin of the solar system.

L. EGYED

Geophysical Institute,
Eötvös University, Budapest.

[1] Dirac, P. A. M., *Proc. Roy. Soc.*, A, **165**, 199 (1938).

[2] Gilbert, C., *Mon. Not. Roy. Astro. Soc.*, **116**, 684 (1956).

The Extragalactic Distance Scale

THE establishment of the scale of distances in the extragalactic universe rests primarily on the determinations of the distances of the nearest galaxies. These distances have been obtained primarily from a comparison of apparent magnitudes of variable stars or of Population II giants with the known absolute magnitudes of such objects measured in our Galaxy.

Arp[1] has obtained colour-magnitude diagrams for four clusters in the Small Magellanic Cloud and has found that these diagrams are different from colour-magnitude diagrams of similar objects in the Galaxy. Using a faint sequence of magnitudes lent to me by Arp, I have obtained colour-magnitude diagrams for six clusters of the Large Magellanic Cloud and have found that the diagrams differ not only from those found in the Galaxy but also from those found by Arp in the Small Magellanic Cloud. Three of those studied by me are globular clusters: *NGC* 1846, *NGC* 1978, and Anonymous 4. Their giant branches have slopes much more gentle than any observed in globular clusters of our Galaxy. Even the giant branch of *NGC* 6356, which Sandage and Wallerstein[2] find to have an unusually gentle slope, is steeper than those in the clusters of the Large Cloud.

NGC 1831 and *NGC* 1818, two of the three other clusters, are similar in appearance to globular clusters, but are much younger, with colour-magnitude diagrams somewhat similar to those of *M* 11[3] and *h* and χ Persei[4], respectively. They differ from open clusters of our Galaxy not only in their much larger numbers of stars but also in the unexpected location of the giants in their colour-magnitude diagrams. The sixth cluster, *NGC* 1844, a small open cluster, shares this latter peculiarity. *NGC* 1844 has a main sequence similar to that of *NGC* 4755[5], but its giant stars are bluer and brighter.

Because the distances to the nearby galaxies are determined from the apparent magnitudes of the giant evolved stars such as the Cepheids, the *RR* Lyrae variables, and the brightest stars of Population II, the evidence presented by the Magellanic Clouds indicates that these distances are not necessarily correct. The characteristics of the giant stars, and their evolutionary paths, appear to differ in different galaxies and we may not safely use their apparent magnitudes as an index of distance until we thoroughly understand these differences.

PAUL W. HODGE

Harvard College Observatory.
April 6.

[1] Arp, H. C., *Astronom. J.*, **63**, 273, 487 (1958); **64**, 175, 254 (1959).

[2] Sandage, A. R., and Wallerstein, G., *Astrophys. J.* (in the press).

[3] Johnson, H. L., and Hiltner, W. A., *Astrophys. J.*, **123**, 267 (1956).

[4] Johnson, H. L., Sandage, A. R., and Wahlquist, H. D., *Astrophys. J.*, **124**, 81 (1956).

[5] Arp, H. C., and van Sant, C. T., *Astronom. J.*, **63**, 341 (1958).

RADIOPHYSICS

Faraday Effect in the Transmissions from Fast Spinning Satellites

THE interaction of the satellite spin and the Faraday rotation effect in the ionosphere in producing polarization fading in linearly polarized signals from Earth satellites has been discussed for the case when the satellite rotation period is of the same order as the Faraday fading period[1,2]. In this case, determination of the rate of Faraday fading is difficult unless simultaneous fading records on two frequencies can be taken.

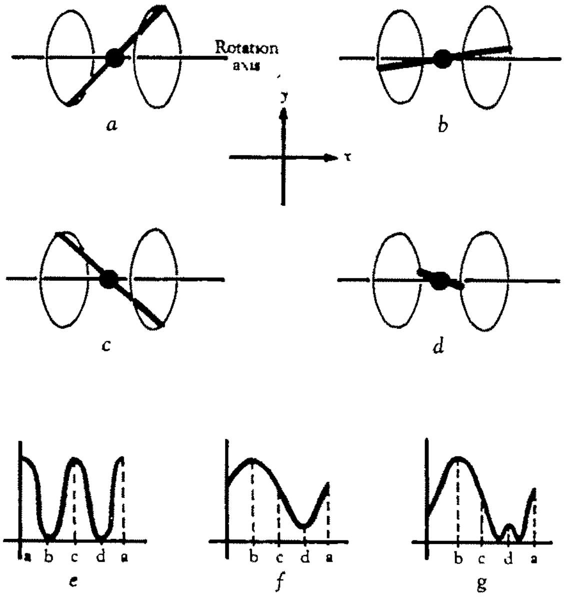


Fig. 1. Four positions of a dipole with its rotation axis and axis of symmetry not coincident. The corresponding signal strength variations for polarizations in the x and y directions are shown at f and e when the line of sight is outside the generated cone, and at g and e when it is inside

The effect of the interaction of satellite spin and Faraday rotation is different for transmissions from a satellite with a rotation period small compared to the Faraday fading period. Consider such a satellite rotating about an axis fixed in space with a transmitting dipole which is not coincident with the rotation axis. As the satellite rotates, the dipole generates a cone, as shown in Fig. 1. Consider the case when the line of propagation is outside this cone. In the absence of Faraday rotation, a receiving aerial with its line of polarization in the x-direction would receive maximum signal strength when the satellite dipole is in the position shown at b and minimum signal strength in the position shown at d. A similar aerial polarized in the y-direction would receive maximum signal strength with the satellite dipole in positions shown at a and c and minimum in positions shown at b and d. These expected signal strength variations over one rotation period are shown in Fig. 1 at e and f. If the line of propagation is inside the generated cone, the variation in the y direction of polarization is somewhat different (Fig. 1g).

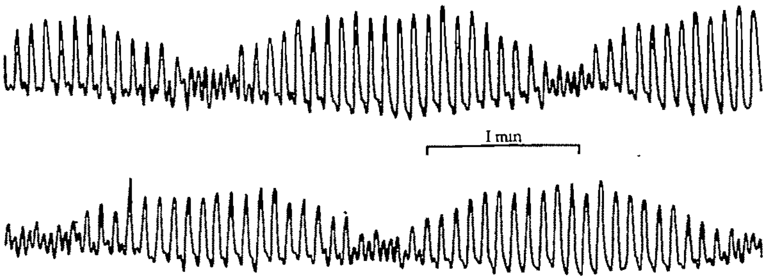


Fig. 2. Variations in the strength of signals from the satellite 1958β2 (*Vanguard I*) received simultaneously on two orthogonally polarized aerials (Feb. 4, 1960)

The effect of 90° of Faraday rotation in the ionosphere would be to interchange the types of variation in the x and y directions of polarization. Changes of a quarter-turn in the amount of Faraday rotation during a satellite passage will thus result in the signal strength variations received on a linearly polarized aerial alternating between types e and f or e and g of Fig. 1.

Records of the 108 Mc./s. signals of 1958β2 (*Vanguard I*) taken on orthogonally polarized aerial arrays show this type of fading (Fig. 2). The rotation period is about 6 sec. and the Faraday fading period is normally greater than 30 sec. The points on the record corresponding to the variation in Fig. 1e are well defined and their times can usually be determined to within ± 3 sec.

Such records taken at the Jodrell Bank Experimental Station over the past nine months are at present being analysed to determine ionospheric electron contents from the observed rates of Faraday fading.

This work is supported by a grant from the Royal Society. One of us (R. S. R.) holds an Athlone Fellowship.

R. S. Roger
J. H. Thomson

Jodrell Bank Experimental Station
(University of Manchester),
Lower Withington,
Macclesfield. April 8.

---

[1] Thomson, J. H., *Phil. Mag.*, **3**, 912 (1958).

[2] Aitchison, G., Thomson, J. H., and Weekes, K., *J. Atmos. Terr. Phys.*, **14**, 236 (1959).

Electron Density Measurements in the Upper Ionosphere using the Faraday Rotation of Radio Signals from Artificial Satellites

Several workers have used the Faraday rotation of radio signals from artificial satellites as a means of investigating the upper ionosphere, and in most cases it has been assumed that the ionosphere is spherically stratified.

Observations made at Cambridge on 1957α2 and 1958δ2 have shown that the variation of the ionosphere with latitude and longitude must be taken into account for satellite passes near or below the peak of the $F2$ layer, if results consistent with vertical incidence soundings are to be obtained. It was found that a sufficiently accurate estimate of this variation could be obtained from hourly ionograms taken at Slough and Inverness.

The effect of the horizontal variation of the ionosphere in a particular case is shown in Fig. 1. On this

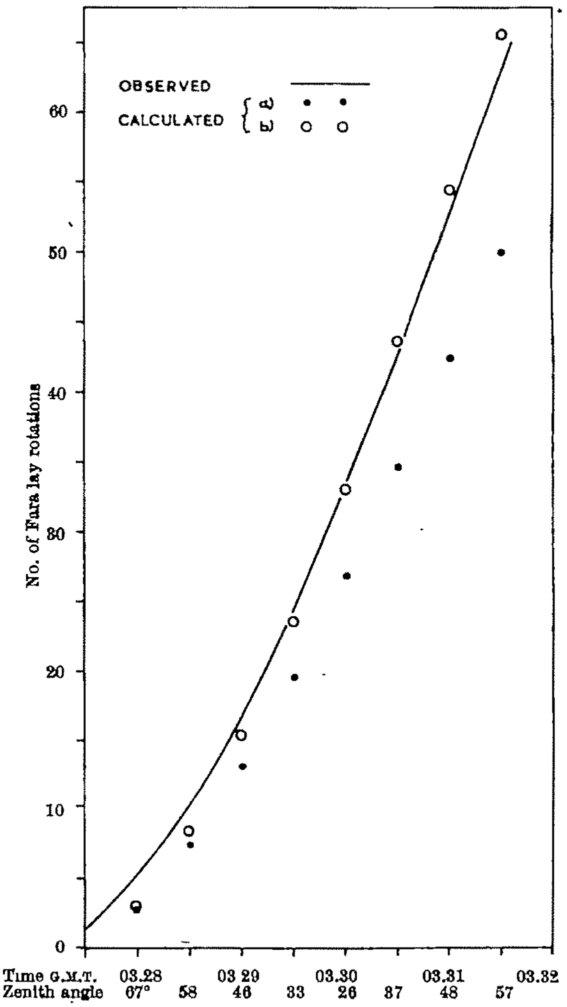


Fig. 1. 20 Mc./s. Faraday rotation, 1957α2/*Sputnik* I, 20/10/57

occasion the satellite was slightly above the $F2$ layer peak at closest approach, so that the profile assumed for the layer above the peak has little effect on the calculated rotation curve.

The points (*a*) were calculated assuming spherical stratification of the ionosphere, using the electron density profile deduced from the Slough ionograms up to the peak, and a semi-parabolic distribution above it. The points (*b*) were calculated from the same electron density profile taking account of the horizontal variation estimated from the Slough and Inverness ionograms. The improved agreement with the observed rotation curve in case (*b*) is quite marked.

Several records of satellite passes well above the $F2$ peak have been analysed, making due allowance for the horizontal variations in the ionosphere as deduced from ionograms, and it has been found that self-consistent results can be obtained from a very simple model of the upper ionosphere. These results are as follow.

Above the $F2$ layer peak the electron density falls off with a scale-height of approximately 230 km., which is of the same order as that found by Bowles[1], and the average ratio of the total electron content above the peak to that below is 3·4 to 1, which agrees well with measurements made by the Moon-echo technique, and measurements using the radio rise and set of artificial satellites by Al'pert *et al.*[2].

Observations made during an ionosphere storm showed a considerable decrease in the total electron content up to the satellite, with little apparent change in the ratio of the contents above and below the peak.

D. McL. A. Wilson

Cavendish Laboratory,
Cambridge.

---

[1] Bowles, K. L., U.S. National Bureau of Standards, Rep. 6070 (1959).

[2] Al'pert, Ya. L., Chudesenko, E. F., and Shapiro, B. S., *Uspekhi Fiz. Nauk.*, 65, 161 (1958).

PHYSICS

Growth of Surface Instabilities in a Linear Pinched Discharge

Recent experiments at the Imperial College of Science and Technology, London, have been concerned with the growth of instabilities in a linear pinched discharge in argon. These discharges were produced in a tube 15 cm. in diameter and 50 cm. long at pressures of 0·1–1 mm. mercury and with currents of 40–150 k.amp. The experiments have revealed the presence of surface instabilities of the type shown in Fig. 1, which is typical of many single-shot photographs of the discharge taken through the side of the tube with a Kerr cell camera. The irregularities on the plasma surface first appear when the column is expanding from the first axial bounce, and grow while the plasma is being accelerated towards the axis of the discharge tube between the first and second 'bounces'. In Fig. 2 the diameter of the column, together with the amplitude of the instability, and its mean wave-length, are shown as functions of time for a particular set of initial conditions. In this diagram the diameter of the column has been found by taking the mean of fifty measurements of the local diameter at different points along the tube axis. A numerical estimate of the amount of instability was obtained from the standard deviation of these measurements about their mean.

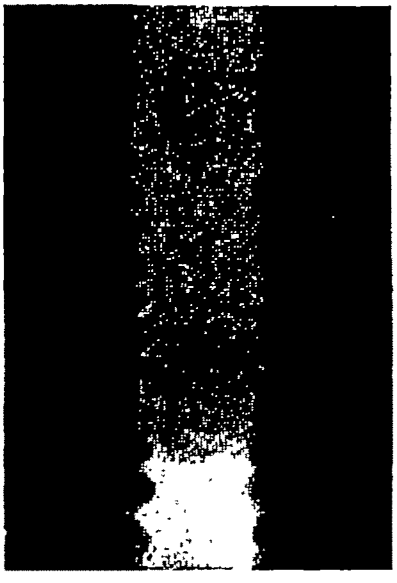


Fig. 1. C, 1,900 μF.; V_c, 5 0 kV.; L, 300 mμH.; p, 330μ. Photograph taken with exposure of 0 4 μsec., 18 μsec. after first pinch

It is suggested that these instabilities are associated with the acceleration of the plasma boundary and are analogous to the Rayleigh–Taylor instabilities[1,2] found when a heavy incompressible fluid is supported against gravity by a lighter one. In the plasma case the magnetic field behaves as the lighter fluid, and the instability grows, as expected, when the plasma is being accelerated by the field.

For plane surfaces the growth should be exponential of the form $\exp(\omega t)$, where the growth-rate ω is given

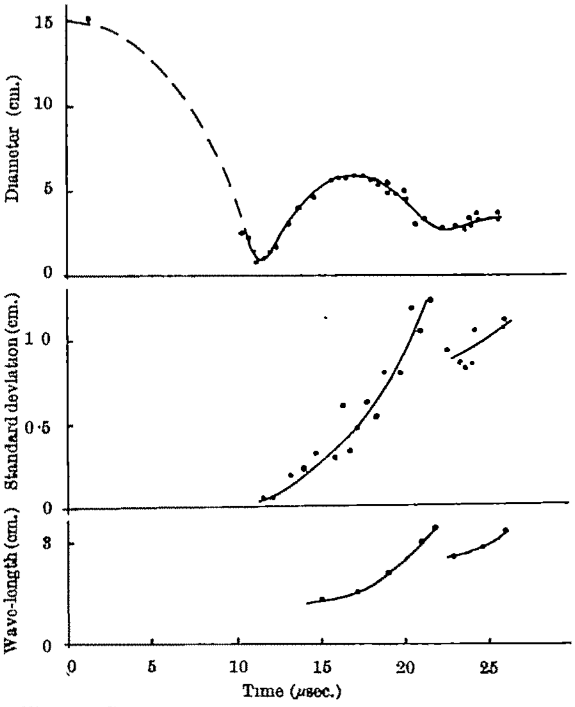


Fig. 2. C, 3,900 μF; V_0, 2·5 kV.; L, 100 mμH.; p, 200μ

by $\omega^2 = gk$, g being the acceleration and k the wave number $(2\pi/\lambda)$ of the disturbance.

Under various initial conditions the measured accelerations and observed wave-lengths allow the growth-rates to be calculated. The values obtained experimentally from the standard deviation curves are about a factor of two smaller than those expected from the above expression. The finite compressibility of the plasma and the cylindrical geometry of the discharge system have not been taken into account and may well influence the numerical comparison.

When dissipative processes such as viscosity[3–5] and resistivity[6], or effects of finite amplitudes[7], are included in the analysis a dominant wave-length should occur. Our experiments suggest that the plasma viscosity is too small to explain the observed wave-lengths.

In the interpretation of the present experiments it has not been found necessary to allow for the growth-rate of $m = 0$ instabilities arising on a steady-state configuration[8–11]. It is suggested that this results from the fact that a likely perturbation will not be axisymmetric in the early stages of growth. In this case the plasma will be either stable or in neutral equilibrium as the increase in B_θ normally associated with a local decrease in r (and vice versa) will not occur.

The shape of the boundary as shown in Fig. 1 is very similar to that observed experimentally[12] for the Rayleigh–Taylor instabilities in fluids, having a rounded convex surface towards the plasma and cusps projecting into the magnetic field.

A detailed account of this work will be published elsewhere.

R. Latham
J. A. Nation
F. L. Curzon
A. Folkierski

Department of Physics,
Imperial College of Science and Technology,
London, S.W.7.

---

[1] Lord Rayleigh, *Proc. Lond. Math. Soc.*, **14**, 170 (1883).
[2] Taylor, G. I., *Proc. Roy. Soc.*, A, **201**, 192 (1950).
[3] Bellman, R., and Pennington, R. H., *Quart. App. Math.*, **12**, 151 (1954).
[4] Chandrasekhar, S., *Proc. Camb. Phil. Soc.*, **51**, 162 (1955).
[5] Hide, R., *Proc. Camb. Phil. Soc.*, **51**, 179 (1955).
[6] Colgate, S. A., "Magnetohydrodynamics", 104 (Stanford Univ. Press, 1957).
[7] Frieman, E. A., *Astrophys. J.*, **130**, 18 (1954).
[8] Kruskal, M., and Schwarzschild, M., *Proc. Roy. Soc.*, A, **223**, 248 (1954).
[9] Tayler, R. J., *Proc. Phys. Soc.*, B, **70**, 31, 1049 (1957).
[10] Shafranov, V. D., *J. Nuclear Energy*, **5**, 86 (1957).
[11] Kruskal, M., and Tuck, J. L., *Proc. Roy. Soc.*, A, **245** 222 (1958).
[12] Lewis, D. J., *Proc. Roy. Soc.*, A, **202**, 81 (1950).

Use of an Auxiliary Grid to stabilize the Gain of a Photomultiplier

We have recently examined the possibility of reducing the sensitivity of a photomultiplier to changes in supply voltage by means of feedback to an auxiliary grid.

An eleven-stage tube (Electrical and Musical Industries type 6097) was provided with a grid between cathode and first dynode through the co-operation of the manufacturers. The dynodes were connected to one another and to the cathode by the usual resistor chain. Instead of grounding the cathode directly, however, it was connected to Earth through a feedback resistor, normally of the order of some thousands of ohms. An appropriate d.c. bias of the order of a few volts was applied to the grid. A definite fraction of any variation in the extra high-tension supply voltage is thus fed back to the cathode and hence effectively to the grid, with the result that the anode current can be maintained substantially constant.

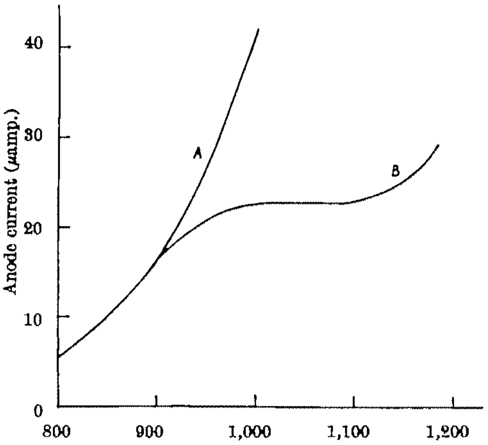


Fig. 1. Direct-current operation

Fig. 1 shows how, under conditions of constant cathode illumination, the anode current of the photomultiplier varies with extra high-tension voltage, *A* when the tube is used conventionally with the grid strapped to the cathode, and *B* with feedback present. It can be seen that quite an appreciable plateau exists. The voltage at which the plateau appears can be shown, both theoretically and experimentally, to be inversely proportional to the value of the feedback resistor. The d.c. bias which must be applied to the grid is found to be effectively constant over a wide range of extra high-tension voltages.

To test the performance of the tube for pulse work it was used as a gamma-ray spectrometer in conjunction with a sodium iodide crystal, low-gain amplifier and single-channel analyser. Curves *C* and *D* of Fig. 2 show how the position of the cæsium-137 photopeak shifts when the extra high-tension voltage is changed from 890 to 980 volts with the tube used conventionally. Curves *E* and *F* were obtained with feedback present and show how the position of the photopeak remains practically unaltered as the extra high-tension voltage is changed from 1,040 to 1,140 volts.

One would expect that the resolution of the peak would worsen with the introduction of feedback,

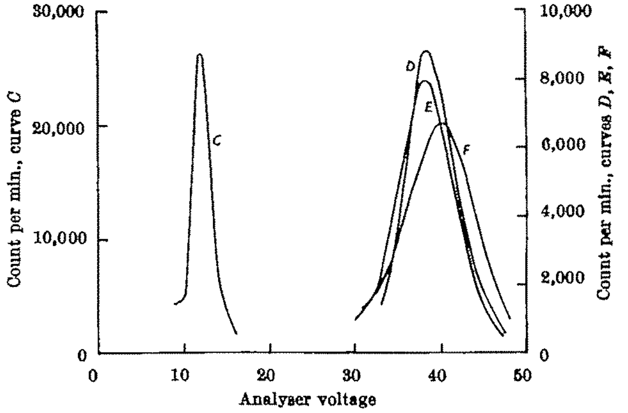


Fig. 2. Pulse operation

since this is equivalent to a reduction of the cathode sensitivity. The value for the cathode sensitivity for the tube used was 26 μamp./lumen, and for this value one would expect under ideal conditions a resolution of about 10 per cent. Due to the fact that neither the tube, crystal nor associated electronics were specially selected for spectrometry, the actual resolution was found to be 17 per cent, when the tube was used conventionally. With feedback the resolution worsened to 20 per cent at one end of the plateau and 24 per cent at the other for the curves of Fig. 2. While this is obviously unsatisfactory, it must be remembered that at the cathode sensitivity of 26 μamp./lumen of the present tube, the resolution worsens very rapidly with decreased cathode sensitivity[1]. With a tube of, say, 100 μamp./lumen sensitivity the resolution varies only slowly with cathode sensitivity, and the introduction of feedback should make little or no difference to it.

In conclusion, it should be remarked that the stability of the feedback resistor chain and to a lesser extent of the bias battery must be of a high order. This, however, is a small price to pay if a relatively simple power supply may be used in place of the ultra-stable supplies at present required for precision work.

It is hoped to publish a fuller account of this work in the near future.

C. F. G. DELANEY
A. J. WALTON

Physical Laboratory,
Trinity College,
Dublin.

[1] Sharpe, J., and Thomson, E. E., Proc. Second United Nations Int. Conf. on the Peaceful Uses of Atomic Energy, 14, 311 (1958).

Coherence and Band-width of a Gas Discharge Harmonic Generator

RECENT work has shown that a microwave gas discharge is an efficient harmonic generator[1-3]. These results are of interest since they show promise of producing a reasonable quantity of power in the 1-mm. wave-length region. This would be extremely useful for spectroscopy, especially if the radiation were narrow-band and coherent. Two experiments have been performed to see whether this is so.

Fig. 1 is a diagram of the first experiment, designed to measure coherence. The two harmonic generators were simple neon-filled discharge tubes in wave-guide mounts as previously described[3]. The gas discharge was maintained in both tubes by power from a 2 kW. 3-cm. klystron amplifier, arranged to give pulses of 3-m.sec. duration. By suitable tuning of the discharge tube mounts the fourth harmonic (in the 8-mm. band) was selected. It was passed through low-Q wave-meters to remove other harmonics present. The two 8-mm. band signals were combined in the magic-T and fed to a single crystal detector. By adjusting the 8-mm. wave-guide attenuator and phase shifter a minimum in the output signal could be maintained. This was less than 0·25 mV. across the crystal detector. The corresponding maximum when the two signals were added in phase (by adjusting the phase shifter to give a maximum with the attenuators unaltered) was 50 mV. Hence the coherent signal/noise ratio was at least 100/1.

This cancellation experiment also indicated that the signal was narrow-band since the length of 8-mm. guide before the magic-T made the system dispersive. The second experiment confirmed this. The output from one of the harmonic generators was fed into an 8-mm. superhet receiver. The local oscillator frequency was swept so that the input spectrum could be displayed on a cathode-ray oscillograph. This gave a pulse 1 Mc./s. wide which corresponded closely to the measured intermediate frequency band-width of the receiver. Hence the band-width of the signal was less than 1 Mc./s.

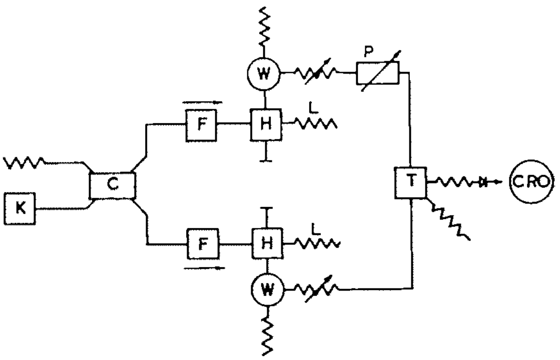


Fig. 1. Block diagram of the experimental apparatus. *K*, 2-kW. X-band klystron; *C*, 3 d.b. directional coupler; *F*, X-band ferrite isolator; *H*, harmonic generator; *L*, X-band water load; *W*, low *Q* wave-meter (*Q*-band); *T*, magic-*T*; *P*, phase shifter

These experiments show that the harmonic generator output is coherent and narrow-band. It is a true line source comparable to a reflex klystron.

We wish to acknowledge the advice and encouragement of Mr. I. M. Ross and Dr. H. Motz during the course of this work. In so far as two of us (N. R. B. and D. W.) are concerned, this work was sponsored in part by U.S. Air Force contract No. *AF* 61 (514)-1183 and for the participation of the third (J. C. V.) this work is published by permission of the Admiralty.

N. R. BIERRUM
D. WALSH

Engineering Laboratory,
University of Oxford.

J. C. VOKES

Services Electronics Research Laboratory,
Harlow, Essex.

[1] Uenohara, M., *et al.*, *Proc. Inst. Rad. Eng.*, **45**, 1419 (1957).

[2] Baird, J. R., and Coleman, P. D., Symposium on Millimetre Waves, Brooklyn Polytechnic (April 1959).

[3] Bierrum, N. R., and Walsh, D., *J. Electronics and Control* (to be published).

Transistor Modulators for Low-level Direct Current Signals

WE have considered in some detail the problem of using germanium and silicon transistors as choppers in thermocouple-amplifier and other low- and medium-impedance applications. In the past, several circuits have been described using asymmetrical transistors with switching drives which are symmetrical or asymmetrical with respect to the emitter and collector of the transistor. Many of these circuits require careful adjustment and/or selection of transistors to reduce the equivalent input drift with temperature to an acceptable level.

A circuit has been developed in our laboratories, in which a symmetrical transistor is used with a symmetrical drive, giving drift-rates of not greater than 1·5 μV./° C. over a temperature-range of −40° C. to + 100° C. with no adjustment or selection whatsoever.

This has been made possible by the development by Semiconductors, Ltd., of a symmetrical silicon alloy transistor to our specification. This is at present an experimental type, but is available in limited quantities.

It is hoped that it will be possible to publish a full account of this work in due course.

J. F. Evans

Smiths Aircraft Instruments, Ltd.,
Cheltenham.

ENGINEERING

A Systematic Method for the Construction of Error-correcting Group Codes

Slepian[1] has pointed out that all systematic binary codes of length n form a sub-group of the group of all binary words of length n. The problem of choosing a systematic code for correcting a given set of errors is thus equivalent to finding a sub-group such that each error to be corrected for lies in separate cosets. Fire[2] has pointed out that the sum modulo 2 of two parity check sequences corresponding to two error patterns is the same as the parity check sequence corresponding to the sum modulo 2 of the same two error patterns. Also, each parity check sequence is uniquely associated with one coset. This sets up an isomorphism between the group of parity check sequences and the quotient group of the code group in the group of all words.

This consideration has led to a systematic method of generating group codes for correcting an arbitrary set of errors. The method has been applied to the generation of maximal two-error correcting codes of length 5–11, which coincides with the groups indicated by Slepian. The method is as follows: (1) Choose a set A of linearly independent error patterns which span the set of all 'allowable' error patterns, that is, error patterns to be corrected. (2) Choose two arbitrary parity check sequences to represent the first two of this set A of error patterns. Let us call this set of sequences B. (3) By modulo-two addition of members of B, generate the set of parity check sequences of all error patterns spanned by B. (4) Write down all parity check sequences so generated as well as the modulo-2 sums of those pairs of parity check sequences at least one of which forms an allowable error pattern by addition-modulo two with the next member of A. (5) Choose a parity check sequence outside the set generated in step (4) to represent the next error pattern in A and append this to the set B. (6) Repeat steps (3), (4) and (5) until all possible error patterns have been spanned.

In the case of the two-error correcting code mentioned earlier, the set A may be conveniently chosen as the set of all single errors, and the initial two parity check sequences can be conveniently chosen as the binary 1 and 2, that is, 000 . . . 01 and 000 . . . 10.

In this case step (4) simply reads: (4), Write down all parity check sequences of double errors generated by the single errors in B as well as the sum modulo 2 of pairs of these parity check sequences at least one of which is a single error parity check sequence. It may be interesting to record that the time taken to generate all two-error correcting codes of 5–11 bits long was 4 hr. by hand.

I am at present setting up a computer programme to generate the parity check sequences for longer blocks of binary digits. After getting the parity check sequences, it is a simple matter to generate the group codes and parity check rules.

I expect to publish the results of the computer data with a more detailed description of the method and its theoretical basis elsewhere.

R. B. Banerji

University of New Brunswick,
Fredericton,
New Brunswick,
Canada.

---

[1] Slepian, D., *Bell Syst. Tech. J.*, 35, 203 (1956).

[2] Fire, P., Technical Report No. 55, Stanford Electronics Laboratories, Stanford University (April 24, 1959).

MINERALOGY

Predehydroxylation State of Kaolinite

The loss of water of constitution from kaolinite with increasing temperature under atmospheric pressure is illustrated in Fig. 1. This loss is very low, up to about 450° C., where it increases very rapidly. The infra-red spectrum of an unheated sample shows a hydroxyl vibration band about equally divided into three transmission minima the frequencies of which are located respectively at 3,700 cm.$^{-1}$, 3,663 cm.$^{-1}$ and 3,627 cm.$^{-1}$.

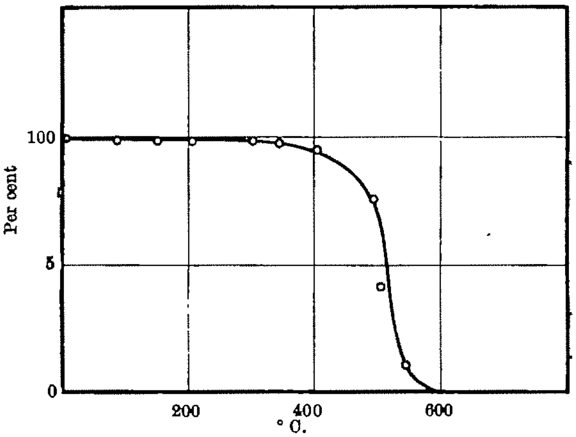


Fig. 1. Relative water content of kaolinite as a function of the temperature under atmospheric pressure

The last one is slightly larger than the other two, the differences being, however, rather small: relative absorbances are 0·91 : 0·92 : 1. When a clay film is heated, the infra-red spectrum undergoes several modifications: the resolution into three components disappears progressively with increasing temperature and, above 400° C., a band only may be observed at about 3,680 cm.$^{-1}$. Beyond this point, relative intensities remain unchanged and, after cooling, the initial shape of the band is restored. Fig. 2 shows the hydroxyl bands observed during a heating and cooling cycle. The process is thus obviously reversible. Fig. 3 gives the changes in frequencies.

One may conclude that, before dehydroxylation starts, kaolinite is modified and brought into a new structural state characterized by the fact that the three initial minima of the hydroxyl vibration band are 'fused' into a single transmission minimum.

As soon as this structural state obtains, dehydroxylation may start, but there is no longer a perfect

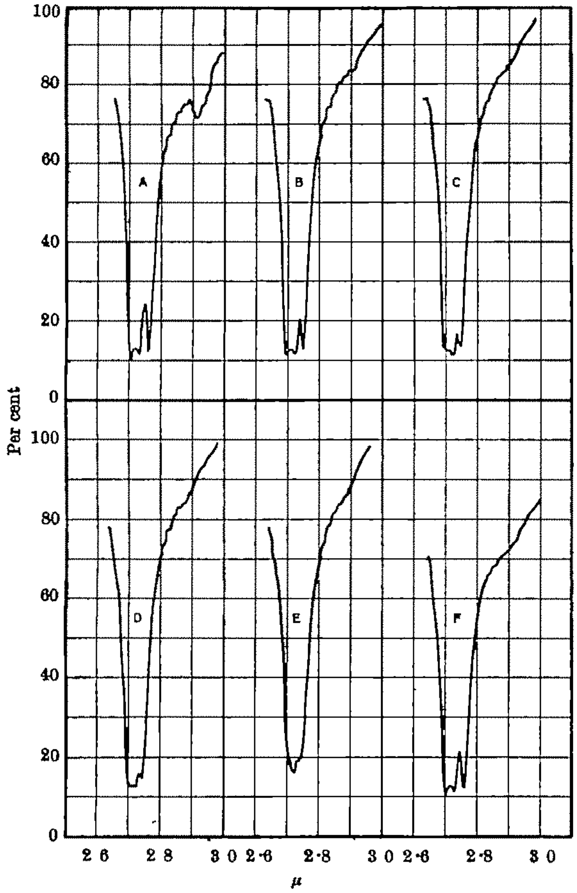


Fig. 2. Hydroxyl bands observed during a heating and cooling cycle before the beginning of dehydroxylation. *A*, 20° C.; *B*, 85° C.; *C*, 210° C.; *D*, 310° C.; *E*, 450° C.; *F*, 20° C.

reversibility of the phenomenon. The absorbance decreases with the water content; the three components of the band reappear when the film is cooled but are shifted about 10–20 cm.$^{-1}$ toward higher frequencies (Fig. 3). In order to represent the progressive mixing of the three components, the height (h) of the barrier between the low- and medium-frequency components, particularly well separated, is given as a function of the temperature as follows:

Temperature	h (in absorbance units)
20° C.	0·295
100° C.	0·175
200° C.	0·095
300° C.	0·040
400° C.	0·02

These values are taken from Fig. 2.

Stubičan[1] has recently studied by infra-red spectroscopy the changes produced in kaolinite by dehydroxylation and has compared the spectra of kaolinite and *meta*kaolinite. He has worked at temperatures which passed the 'predehydroxylation state' here described.

J. J. Fripiat
F. Toussaint

I.N.E.A.C., Laboratoire des colloïdes des sols Tropicaux,
Agronomic Institute of the University of Louvain,
Héverlé, Louvain.

Stubičan, V., *Min. Mag.*, **32**, 38 (1959).

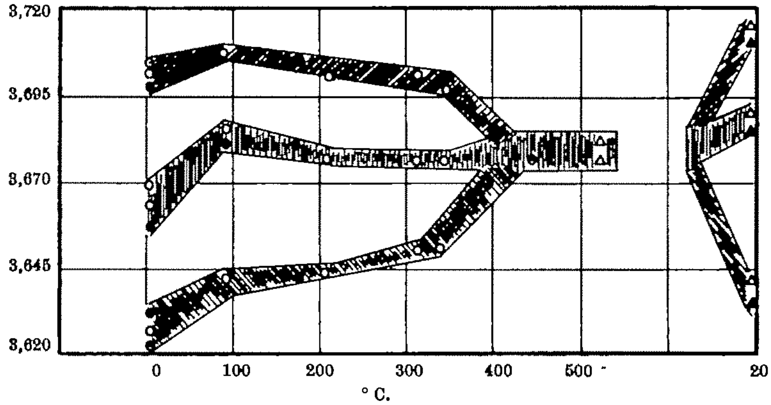


Fig. 3. Frequency shifts of the three transmission minima during heating and cooling cycles. ○, First cycle, 20–310° C.; ●, second cycle, 20–180° C.; ○, third cycle, 20–450° C.; △, fourth cycle, 20–520° C.; ▲, fifth cycle, 20–560° C.

CHEMISTRY

Microquantitative Infra-Red Analysis: Application to Gas Chromatographic Fractions

The need to study infra-red absorption spectra of small quantities of sample has led to the development of new micro-sampling devices and techniques. These have been particularly useful in the qualitative identification of gas chromatographic fractions. Their use has now been extended to quantitative analysis of unresolved chromatographic fractions.

Experimental work was done using Beckman *IR*–4 and *IR*–5 spectrophotometers with beam condensers[1] and a *GC*–2 gas chromatograph. Liquid samples were run in a sealed cell (0·1 mm. thick, 2 μl. vol.) or a very thin demountable cell with grooved windows[2] (0·002 mm. thick, 0 02 μl. vol.), gaseous samples in a miniature folded-path gas cell[3] (60-cm. path, 20-ml. vol.), and solid samples in potassium bromide pellets pressed in aluminium foil[4], in solution, or as melted liquids. The effluent from the chromatograph is condensed on the cooled walls of a tube, concentrated at the bottom of the tube by centrifugation, and transferred to the liquid cells by using a fine capillary tube. Vapours are sampled from the space above the liquid or by passing the effluent directly through the gas cell.

Certain peculiarities of microquantitative techniques have led to measuring procedures which might not be the most desirable in the case of macro-samples. In the transmittance-ratio method for two-component mixtures, the transmittance is measured at two appropriate wave-lengths, and the logarithm of the ratio is plotted against the concentration of one of the components, usually providing a straight line of greater slope than single wave-length measurements. In the absorbance-ratio method, the ratio of the absorbances at two wave-lengths is plotted against the ratio of the concentrations, yielding a straight line provided there is no band overlap. Because the absorbance-ratio method deals with concentration ratios, it does not require close control of cell thickness, solvent concentration, or vapour pressure.

A number of two-component mixtures have been studied using these experimental techniques.

m- and p-Xylene: Spectra of blends of *m*- and *p*-xylene were recorded in the 12–14μ region using the 0·002 mm. cell. Analysis for the *meta* and *para* isomers was based on bands at 13·0 and 12·59μ respectively, using the transmittance-ratio method. A linear calibration plot was obtained. A study of the precision of the method, based on repeated cell fillings with the 1 : 1 mixture, revealed an overall uncertainty in concentration of ± 0·5 per cent and a standard deviation of ± 0·15 per cent. A practical example of the use of this analysis occurs in the gas chromatographic determination of a mixture of benzene, toluene, and *o*-, *m*-, and *p*-xylene. Although it is possible to separate *m*- and *p*-xylene chromatographically, it is not always convenient to establish the necessary conditions. In this case benzene, toluene, *o*-xylene, and combined *m*- and *p*-xylene are determined from the chromatogram, the *meta* and *para* isomers are collected and transferred to the micro-cell, and the relative proportions are then determined spectrophotometrically. The concentrations are found to agree satisfactorily with the true concentrations of the blend (Table 1).

Table 1. TYPICAL COMBINED *GC–IR* ANALYSIS

Component	Known concentration	Determined concentration *GC*	*IR*
Benzene	6·9	7·0	
Toluene	16·0	16·1	
o-Xylene	22·1	21·7	
m-Xylene	36·5	55·2	36·1
p-Xylene	18·5		19·1

To study the effectiveness of the absorbance-ratio method, solutions of the *m*-, *p*-xylene blends in *cyclo*hexane were observed in the 0·1 mm. micro-cell. The plot of concentration ratio versus absorbance ratio yielded a straight line. No attempt was made to control the extent of dilution in solvent beyond ensuring that the xylene peaks were measurable. The effect of variation in dilution was investigated by preparing solutions of the 1 : 1 *meta*-to-*para*-xylene blend in varying amounts of *cyclo*hexane. In the spectra of these solutions the transmittance of the *para*-xylene band varied from 19 to 79 per cent, corresponding to a sevenfold variation in dilution. The measured absorbance ratios were constant to within a small random error amounting to an uncertainty in concentration of ± 0·5 per cent.

Spectra of about 4 μmoles of each of the *m*-, *p*-xylene blends were observed as vapour sampled from above the liquid phase. Because no quantitative control could be exerted over the combined xylenes trapped in this way, the absorbance-ratio method was used. The resulting curve showed considerable deviation from a straight line because of the strong overlap by the rotational branches of the bands, but was nevertheless a useful calibration curve.

Occasionally, it is not practical to perform an analysis in the usual rock-salt region between 2 and 15μ. Because the beam condenser used in the present study has potassium bromide lenses, it can be used at wave-lengths as long as 25μ. *Meta*- and *para*-xylene have bands in this region at 23·13 and 20·7μ, respectively, which can be used for quantitative measurements. Spectral absorption curves were made using cæsium bromide prisms, and satisfactory transmittance-ratio and absorbance-ratio plots were constructed. The uncertainty in the measurements was somewhat greater than in the measurements at 13·0 and 12·59μ because of increased amplifier gain. The noise can be reduced at the expense of longer scanning time.

m- and p-Cresol: This system is another practical case which occurs because of the difficulty encountered in separating *meta*- and *para*-cresol by gas chromatography. A transmittance-ratio plot, based on the *m*- and *p*-cresol bands at 12·88 and 12·23μ respectively, gave a straight line with the same precision as in the case of the xylenes.

2,6-Xylenol and o-Cresol: This mixture is interesting because 2,6-xylenol is solid at room temperature. Blends were studied in a heated micro-cell at a temperature of about 55° C. Measurements were made at the 8·04 and 8·34μ bands of *o*-cresol and 2,6-xylenol respectively and plotted on a transmittance-ratio basis. Departures from linearity found at high concentrations of each component are very likely due to the influence of hydrogen bonding and could be avoided by use of dilute solutions in a non-polar solvent.

Anthracene and Phenanthrene: Solid mixtures of phenanthrene and anthracene were studied by mixing about 100 μgm. of sample with 10 mgm. of potassium bromide and pressing a 1 mm. × 5 mm. pellet. Measurements were made at 11·31 and 12·22μ for anthracene and phenanthrene, respectively. Difficulty in handling these small samples without loss makes the transmittance-ratio method unsuitable. In the case of phenanthrene–anthracene, it is possible to construct a base-line between the wave-lengths of 10·95 and 12·99μ providing a satisfactory basis for absorbance measurements and a straight line calibration curve.

These experiments demonstrate that satisfactory infra-red quantitative analysis can be performed on 20–100 μgm. of sample in liquid, solution, solid, or gas phase.

Portions of this work were discussed at the Rocky Mountain Spectroscopy Conference (August 12, 1958), the American Chemical Society Southwest Regional Meeting (October 25, 1958), and the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy (March 6, 1959).

J. E. STEWART
R. O. BRACE
T. JOHNS
W. F. ULRICH

Beckman Instruments, Inc.,
Fullerton, California.

[1] White, Weiner, Alpert and Ward, *Anal. Chem.*, 30, 1694 (1958).
[2] Davison, W. H. T., *J. Opt. Soc. Amer.*, 45, 227 (1955).
[3] White, Alpert, Ward and Gallaway, *Anal. Chem.*, 31, 1267 (1959).
[4] Clark, D. A., and Boer, A. P., *Spectrochim. Acta*, 12, 276 (1956).

Mechanism of the Oxidation and Reduction of Metal Ions by Hydrogen Atoms

RECENT demonstrations[1-3] that metal hydrides such as CuH^+, AgH^+ and AgH are formed as intermediates in the reduction of metal ions by molecular hydrogen in aqueous solution suggest that similar species may be involved in the oxidation and reduction of metal ions by hydrogen atoms, for example, in the well-known reactions :

$$Fe^{2+} + H + H^+ \rightarrow Fe^{3+} + H_2 \qquad (1)$$

and

$$Fe^{3+} + H \rightarrow Fe^{2+} + H^+ \qquad (2)$$

These and related reactions between hydrogen atoms and metal ions have now been observed in aqueous solutions in which hydrogen atoms were generated in a variety of ways[4-6] or introduced from the gas phase[7,8]; but their mechanisms are still uncertain and the subject of considerable controversy.

For the oxidation of Fe^{2+} (reaction 1) we propose the following mechanism:

$$Fe^{2+} + H \underset{k_{-3}}{\overset{k_3}{\rightleftharpoons}} FeH^{2+} \qquad (3)$$

$$FeH^{2+} + H^+ \underset{k_4}{\rightarrow} Fe^{3+} + H_2 \qquad (4)$$

A detailed kinetic analysis[9] shows this mechanism to be in quantitative accord with the observed[7] dependence of the rate on the Fe^{2+} and H^+ concentrations and yields values of 6×10^4 l. mole^{-1} sec.$^{-1}$ for k_3 and 0·22 for k_{-3}/k_4 at 4°. The mechanism is also consistent with the pH independence, over a wide range, of the relative rates of competing reactions of H with Fe^{2+} and other substrates, for example, oxygen[10] or methanol[11]. It is noteworthy that the oxidation of I^- by hydrogen atoms, where analogous hydride formation is unlikely, proceeds by a different mechanism, namely, electron transfer to H_2^+ (ref. 12). While a similar mechanism has been considered[5,6] for the oxidation of Fe^{2+} its contribution apparently is unimportant because of the slowness of formation of H_2^+ ($k_{H+H^+ \rightarrow H_2^+} = 10^3$ l. mole^{-1} sec.$^{-1}$) (ref. 12) compared to reaction 3. The absence of an efficient acid-promoted isotope exchange reaction[13] is also in accord with this. The two other mechanisms which have been considered previously for the oxidation of Fe^{2+}, namely, the direct termolecular process (reaction 1) and hydrogen abstraction from the hydration shell of the ferrous ion[14,15], also cannot be reconciled readily with all the experimental facts[9].

The proposed oxidation step (4) is analogous to the back-reaction (−5) which is known[1] to occur in the reduction of Cu^{2+} by H_2:

$$Cu^{2+} + H_2 \rightleftharpoons CuH^+ + H^+ \qquad (5)$$

$$CuH^+ + Cu^{2+} \rightarrow 2Cu^+ + H^+ \qquad (6)$$

and which leads to the prediction of a mechanism analogous to that described by (3) and (4) for the oxidation of Cu^+ by hydrogen atoms. It seems likely that oxidation of other metal ions will also occur through this type of mechanism.

Reduction of metal ions by hydrogen atoms may proceed by electron transfer (probably through a bridging anion) or by ligand abstraction[16], for example, the reduction of $FeCl^{2+}$ and $FeOH^{2+}$ the rates of which are 10^2–10^3 higher than that of Fe^{3+} aq.[7,10,17]. The very fast reduction of $Fe(CN)_6^{3-}$ ($k = 10^6$–10^7 l. mole^{-1} sec.$^{-1}$) also is almost certainly by electron transfer[16,19]. In other cases, however, hydride intermediates may be involved. This is particularly likely with metal ions such as Ag^+ or Cu^+ the homogeneous reduction of which by electron transfer (that is, to silver or copper atoms) is unfavourable but which form stable hydride complexes. The observed[3] activation energy of 15 kcal. for the reaction:

$$2Ag^+ + H_2 \rightarrow 2AgH^+ \qquad (7)$$

implies considerable stability for AgH^+ (with respect to dissociation into either $Ag^+ + H$ or $Ag + H^+$)[18] and suggests both that the reaction:

$$Ag^+ + H \rightarrow AgH^+ \qquad (8)$$

will be rapid and that it will occur in preference to electron transfer. It thus seems likely that (8) is the first step in the efficient reduction of Ag^+ by hydrogen atoms followed by dissociation of AgH^+ into H^+ and metallic silver; the latter step is likely to be the slower one and probably involves heterogeneous catalysis. In the reduction of ions such as Fe^{3+} and Cu^{2+} or their complexes there is less reason to believe that initial hydride formation will occur in preference to electron transfer.

J. HALPERN*

University Chemical Laboratory,
Cambridge.

G. CZAPSKI
J. JORTNER
G. STEIN

Department of Physical Chemistry,
Hebrew University, Jerusalem.

* On leave from the Department of Chemistry, University of British Columbia, Vancouver, Canada.

[1] Halpern, J., Macgregor, E. R., and Peters, E., *J. Phys. Chem.*, **60**, 1455 (1956).
[2] Webster, A. H., and Halpern, J., *J. Phys. Chem.*, **61**, 1239, 1245 (1957).
[3] Halpern, J., *J. Phys. Chem.*, **63**, 398 (1959); "Adv. in Catalysis", **11**, 301 (1959).
[4] Rigg, T., and Weiss, J., *J. Chem. Phys*, **20**, 1194 (1952)
[5] Weiss, J., *Nature*, **165**, 728 (1950).
[6] Rigg, T., Stein, G., and Weiss, J., *Proc. Roy. Soc.*, A, **211**, 375 (1952).
[7] Czapski, G., and Stein, G., *J. Phys. Chem.*, **63**, 850 (1959).
[8] Davis, T. W., Gordon, S., and Hart, E. J., *J. Amer. Chem. Soc*, **80**, 4487 (1958).
[9] Czapski, G., Jortner, J., and Stein, G. (to be published).
[10] Rothschild, W. G., and Allen, A. O., *Rad. Res.*, **8**, 101 (1958).
[11] Baxendale, J. H., and Hughes, G., *Z. physik. Chem.*, N.F., **14**, 323 (1958).
[12] Czapski, G., Jortner, J., and Stein, G., *J. Phys. Chem.*, **63**, 1769 (1959).
[13] Friedman, H. L., and Zeltman, A. H, *J. Chem. Phys.*, **28**, 878 (1958).
[14] Uri, N., *Chem. Rev.*, **50**, 376 (1952).
[15] Lefort, M., and Douzou, P., *J. Chim. Phys.*, **53**, 536 (1956).
[16] Stein, G., *Disc. Farad. Soc.*, **29** (in the press).
[17] Schwarz, H. A., and Hritz, J. M., *J. Amer. Chem. Soc.*, **80**, 5636 (1958).
[18] Halpern, J., "Adv. in Catalysis", **9**, 302 (1957).
[19] Czapski, G., and Stein, G., *J. Phys. Chem.*, **64**, 219 (1960).

Infra-red Spectra of Ammonia adsorbed on Silica–Alumina Catalysts

In an extension of kinetic studies of the catalytic decompositions of hydrocarbons, infra-red spectra of ammonia chemisorbed upon silica–alumina catalysts have been obtained. The techniques employed were similar to those described previously by Eischens *et al.*[1]. A Perkins–Elmer model 112 *C* infra-red spectrometer utilizing calcium fluoride and lithium fluoride optics was modified by mounting the glowbar source in a position above the infra-red cell housing the catalyst deposit held in a horizontal manner.

Thin films of silica–alumina (87 per cent silicon dioxide) were prepared by sedimentation methods: approximately 1 gm. of the 'fluid' catalyst was suspended in 10 ml. of water by vigorously shaking the mixture in a tube and withdrawing the finer particles by means of a small pipette. Sufficient quantities of the suspension of fine particles were placed in a medicine-type throat atomizer and then sprayed on to a calcium fluoride plate oriented vertically over a small hot-plate, namely, with the flat surface perpendicular to the plane of the laboratory desk top. This technique was important in obtaining uniform catalyst films and preventing puddling. Each application of the aqueous suspension to the calcium fluoride plate was allowed to approach dryness before additional spraying commenced. The density of the catalyst deposits was of the order of 2–3 mgm./cm.^{2}. Final pretreatment of the silica–alumina consisted of dehydration at 450–500° C. for 16 hr.

Infra-red spectra of ammonia tenaciously adsorbed upon a catalyst having a surface area of 600 m.^{2}/gm. were observed at room temperature. These spectra exhibit considerable differences from similar investigations reported by Mapes and Eischens[2]. In the current study a series of infra-red absorption bands were resolved in the vicinity of 3,300–3,170 cm.$^{-1}$ attributable to ammonia adsorbed on Lewis acid sites. A second set of absorption frequencies were noted between 3,025 and 2,900 cm.$^{-1}$ ascribable to the reaction products of ammonia and Brønsted sites. From band-widths and band-intensities it was estimated that the concentrations of Lewis to Brønsted sites are in the ratio 3/2, respectively, near room temperature and the ratio increases with rising temperature. A minimum of three discrete energy-levels of Lewis acids and four definite energy-levels of Brønsted sites was detectable. The multitude of infra-red bands exhibited in the stretching region of the spectrum diminished in intensity with decreasing surface coverage in such a manner as to provide further evidence for adsorption sites of differing energies. That is, the ratios of band-intensities changed perceptibly as the ammonia was removed by pumping and elevation of temperature.

The kinetic results of Franklin and Nicholson[3] showed a compensation effect whereby high values of energy of activation corresponded to high values of the frequency factor, and vice versa. The kinetic results could be correlated on the assumption of a logarithmic relationship between the frequency factor and the energy of activation. This observation is suggestive of a distribution of catalytic centres according to their acid strength. The spectroscopic results cited above provide independent confirmation of the distribution of adsorption site energies on the silica–alumina catalyst. The optical spectra suggest that even though the energy distribution may be somewhat continuous in nature, a preponderance of the chemisorption of ammonia occurs upon a small number of spots in an energetic sense.

D. E. NICHOLSON

Manufacturing Department,
Humble Oil and Refining Co.,
Humble Division,
Research and Development Division,
Baytown, Texas.

---

[1] Eischens, R. P., Francis, S. A., and Pliskin, W. A., *J. Phys. Chem.*, 60, 194 (1956).

[2] Mapes, J. E., and Eischens, R. P., *J. Phys. Chem.*, 58, 1059 (1954).

[3] Franklin, J. L., and Nicholson, D. E., *J. Phys. Chem.*, 60, 59 (1956).

Addition Compounds between Copper Complexes and Organic Bases

In a recent communication[1], Graddon interpreted the formation of an addition compound between copper complexes such as cupric acetylacetonate and pyridine or other bases as due to formation of a 5 co-ordination complex of the copper atom. This is not the only possible interpretation, nor the most probable one.

The investigations of Lowry *et al.*[2] showed that such bases, together with *p*-cresol, alcohol and probably acetone, can act as catalysts for the mutarotation of beryllium benzoyl camphor and aluminium benzoyl camphor dissolved in carbon tetrachloride or chloroform. In these compounds the metal atoms are showing maximum co-ordination, and the only likely interaction between the catalyst and substrate is by the former replacing one of the points of attachment of the chelate group to the metal atom, the mutarotation becoming possible when the second chelate group (in the beryllium compound) is also detached at one end by thermal energy, amounting to about 20,000 cal./mole. This is supported by the increase in optical rotatory power shown by solutions containing *p*-cresol. It would therefore seem likely that the bases used by Graddon are similarly able to detach part of a chelate group. It is not clear, however, why only one molecule of the base has been found to be attached to a metal atom.

It may further be noted that Graddon used chloroform as solvent in some of his experiments. Lowry *et al.* also showed that beryllium benzoyl camphor forms crystals from chloroform solution containing two molecules of chloroform to each metal atom, and that when these are dissolved in carbon tetrachloride the optical rotatory power differs from those of either the unsolvated material or of the equilibrium mixture: they postulated that it contained equal proportions of the two optically active isomers. It may be interpreted as formed by the replacement of one end of each chelate group by a chloroform molecule, probably attached through a chlorine atom to the metal atom, and also forming a hydrogen bond with the oxygen atom of the detached group. The possibility of similar effects in solutions of copper complexes in chloroform should not be overlooked.

R. C. TRAILL

Royal Melbourne Technical College,
Melbourne, Victoria.

---

[1] Graddon, D. P., *Nature*, 183, 1610 (1959).

[2] Burgess, H., and Lowry, T. M., *Trans. Chem. Soc.*, 125, 2081 (1924). Lowry, T. M., and Faulkner, I. J., *ibid.*, 127, 1080 (1925). Lowry, T. M., and Traill, R. C., *Proc. Roy. Soc.*, A, 132, 398 and 416 (1931). Traill, R. C., *Phil. Mag.*, 13, 225 (1932).

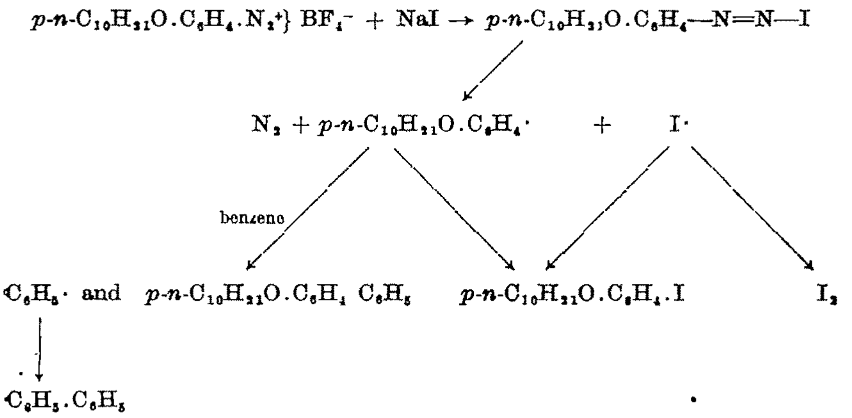
Reaction of *p-n*-Decyloxybenzenediazonium Fluoborate with Sodium Iodide in Benzene

In an earlier communication[1] it was shown that several diazonium salts belonging to the series, $RO.C_6H_4.N_2^+\}X^-$, reacted with β-naphthol in benzene containing an equivalent amount of pyridine to form normal azo-compounds. With Grignard reagents, however, *p-n*-decyloxybenzenediazonium salts gave not only the expected azo compounds but also *p-n*-decyloxydiphenyl and *n*-decyloxybenzene which must have been formed from *n*-decyloxyphenyl radicals produced at an earlier stage. A further instance of the occurrence of radical reactions in the chemistry of diazonium salts has now been found in the reaction of *p-n*-decyloxybenzenediazonium fluoborate in benzene with sodium iodide dissolved in a small volume of dry acetone. Addition of the sodium iodide solution at the room temperature produced a yellow colour followed by the evolution of nitrogen and formation of *p*-iodo-*n*-decyloxybenzene and, in addition, free iodine, an equivalent amount of *p-n*-decyloxydiphenyl, and a trace of diphenyl. The *p-n*-decyloxydiphenyl must have arisen by production of *n*-decyloxyphenyl radicals and their subsequent reaction with the medium. The formation of diphenyl requires the intermediate production of phenyl radicals, presumably by reaction of *n*-decyloxyphenyl radicals with benzene. When the volume of benzene was increased the yield of *p*-iodo-*n*-decyloxybenzene was reduced, but both iodine and *p*-*n*-decyloxydiphenyl were found in increased, and equivalent, amount.

Using *p*-*n*-decyloxybenzenediazonium fluoborate (7·050 gm.) in dry benzene and sodium iodide (3·832 gm.) in dry acetone (25 ml.) the yields obtained were :

Volume of benzene (ml.)	Mol of *p*-iodo-*n*-decyloxybenzene (per cent)	Mol. of *p*-*n*-decyloxydiphenyl (per cent)	Mol. of iodine (per cent)	Total diazonium salt accounted for (per cent)	Total iodine accounted for (per cent)
200	60	14	15	74	75
600	46	26	26	72	72

The following sequence of reactions would explain the results obtained :



p-n-$C_{10}H_{21}O.C_6H_4.N_2^+\}$ BF_4^- + NaI → p-n-$C_{10}H_{21}O.C_6H_4$—N=N—I
N_2 + p-n-$C_{10}H_{21}O.C_6H_4\cdot$ + I·
benzene
$C_6H_5\cdot$ and p-n-$C_{10}H_{21}O.C_6H_4$ C_6H_5
p-n-$C_{10}H_{21}O.C_6H_4.I$
I_2
$C_6H_5.C_6H_5$

W. BRADLEY
J. D. THOMPSON

Clothworkers Research Laboratory,
University of Leeds. March 22.

[1] Bradley, W., and Thompson, J. D., *Nature*, 178, 1069 (1956).

Radiation Labelling with Carbon-14 of Aliphatic Hydrocarbons

RADIATION labelling techniques have been successfully developed to introduce tritium atoms in a number of organic molecules[1]. Such a method may also be applied to preparation of carbon-14-labelled compounds, taking advantage of radiation-induced reaction between an organic substance and that containing the radioisotope. Preliminary reports[2] describe the identification of a number of radioactive carboxylic acids in mixtures containing hydrocarbons (or heterocyclic compounds) and carbon-14 dioxide irradiated with X- or beta-rays. Substantially better results, as regards the amount of radioactivity incorporated into the reaction products, have been now attained in the radiation labelling of aliphatic hydrocarbons promoted by high doses of gamma-rays (from spent elements of nuclear fuel) in gaseous systems containing labelled methane as the source of radiocarbon, a saturated hydrocarbon of low molecular weight and an inert gas. Typical experimental conditions were as follows : a mixture of 0·75 m.mole of radioactive methane (specific activity 0·5 mc./m.mole), 0·75 m.mole of propane and 3·0 m.moles of xenon was irradiated in a sealed 'Pyrex' ampoule (125 c.c. approximate capacity). Addition of xenon increased considerably the energy transfer from ionizing radiation to the hydrocarbon mixture, as shown by preliminary runs. The irradiation dose was estimated to be 0·99 × 10^8 rads.

The contents of the vessel were then frozen in liquid nitrogen, the methane pumped away and the residue thoroughly outgassed by the conventional melting-freezing technique. Gas chromatographic methods were employed to separate the radioactive hydrocarbons in the irradiated sample, a mixture of ethylene, propane, butane and *iso*butane, pentane and *iso*pentane, and hexane carriers having been previously added. The gas chromatographic apparatus employed for the analysis was equipped with a conventional thermoconductivity detector, in series with a 100-ml. ionization chamber, connected to a vibrating reed electrometer[3]. Thermoconductivity cell and electrometer responses were registered on synchronized recorders for simultaneous chemical and radiochemical analysis. Satisfactory efficiency in chromatographic separation was attained using two different columns for the analysis of C_2-C_5 and C_6 hydrocarbons : columns containing as stationary phase acetonylacetone on 'Celite *C* 22' and dinonylphthalate on 'Celite *C* 22', respectively 6 m. and 4 m. long, were chosen for analysis of lighter hydrocarbons, with nitrogen as carrier gas, the temperature being 15° C. (Fig. 1). A column of dinonylphthalate on 'Celite *C* 22', at 55° C., was adopted for C_6 compounds.

The radioactivity of each compound was evaluated by integrating the area of the corresponding radiochemical peak. Total radioactivity was determined by two independent methods : (i) calculating the activity corresponding to the sum of the radiochemical peaks ; and (ii) counting known amounts

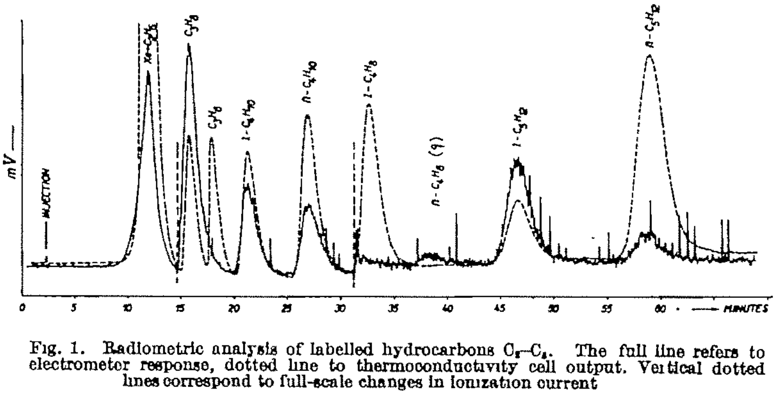


Fig. 1. Radiometric analysis of labelled hydrocarbons C_2–C_5. The full line refers to electrometer response, dotted line to thermoconductivity cell output. Vertical dotted lines correspond to full-scale changes in ionization current

Table 1*

Compound	Activity (μc)†
Ethane‡	14·80
Propane	2·40
Propylene	—
i-Butane	0·96
n-Butane	0·92
i-Butene	—
Unknown§	0·11
i-Pentane	0·51
n-Pentane	0·15
i-Hexane	1·14
n-Hexane	0·49
Total	21·48 μc

* The activity of methane in irradiated mixture was 0·370 mc.

† Radioactivity data were obtained as the mean value of several measurements, the standard deviations being less than 5 per cent.

‡ Radioactive ethylene may be contained in the ethane peak, due to the poor separation in the presence of large excess of xenon.

§ Probably unsaturated linear butenes.

of the radioactive mixture, introduced into a 250-c.c. ionization chamber of the Borkowsky modified type.

The results obtained are summarized in Table 1. It can be seen that a comparatively high percentage of methane radioactivity is contained in the reaction products. Further, the specific activity of the labelled hydrocarbons—except propane—is very high before dilution with carriers. It should also be pointed out, in evaluating the practical interest of the results summarized in Table 1, that the activity of labelled compounds could be substantially increased—in about the ratio 20 : 1—simply by irradiating a mixture containing methane of the maximum available specific activity. Finally, it is worth mentioning that, despite the high dose of gamma-rays absorbed by the gaseous system, only a small amount of the radioactivity was found in unsaturated hydrocarbons.

This work was supported by the Comitato Nazionale Ricerche Nucleari. We also thank Prof. G. Giacomello for valuable suggestions, and Mr. R. Cipollini for some of the chromatographic analysis.

FULVIO CACACE
ANGELO GUARINO

Istituto di Chimica Farmaceutica
dell 'Università,
Centro di Chimica Nucleare
del C.N.R.,
Rome.

Feb. 15.

[1] Wilzbach, K. E., *J. Amer. Chem. Soc.*, 79, 1013 (1957).

[2] Cacace, F., Ciranni, G., Giacomello, G., and Zifferero, M., *Ricerca Sci.*, 28, 2131 (1958). Turton, C. N., Proc. Second Conf. Peaceful Uses of Atomic Energy, 20, 91 (1958). Cacace, F., Guarino, A., and Possagno, E., *Gazz. Chim. Ital.*, 89, 1837 (1959). Aliprandi, B. and Cacace, F., *ibid.*, 89, 2268 (1959).

[3] Cacace F., and Inam-Ul-Haq, *Science*, 131, 732 (1960).

BIOCHEMISTRY

Electrophoretic Components of the Proteins in Honeybee Larval Food

THE proteins of the larval food of the honeybee, *Apis mellifera* L., have been resolved into a number of components by zone electrophoresis[1–3]. The total protein content of larval food (royal jelly) given to female larvæ being reared in queen cells remains fairly constant throughout the feeding period. However, a marked drop in total protein occurs in the food given to worker larvæ midway in the feeding period[4]. It has been observed that larvæ from worker cells can develop into fully mature adult queens if transferred to queen cells (receiving queen larval food or royal jelly) during the first three days of larval life[5]. The purpose of this communication is to note the relation of electrophoretic pattern of larval food proteins to the age and caste of the larvæ receiving the food.

Larval food was gathered from brood cells containing old larvæ (4–6 days of larval life) and young larvæ (less than 3 days) of each caste. Care was taken in obtaining the food samples to avoid contamination from materials clinging to the sides of the cells. The samples were kept at −40° C. until a pool of each caste and age-group was collected. They were obtained during the height of brood rearing from the colonies maintained in the University apiary.

The pools were thawed, stirred, and 1-gm. samples (fresh weight) withdrawn. Each sample was extracted by stirring in 10 ml. of water followed by centrifuging. This was repeated with successive amounts of water until no more protein was found in the supernatant as judged by the biuret test. These were the water extracts. The residue from each sample was then further extracted with alkali (0·5 per cent sodium carbonate) to the same end-point. These were the alkali-soluble extracts. The extracts from each sample and treatment, respectively, were pooled and dialysed against water (changed twice daily) until the dialysate was negative to ninhydrin (about 4 days). The extracts were then pervaporated to 2 ml. volume.

20 μl. of each sample were spotted on Munktell 20*S* paper at a line 14 cm. from the cathode buffer reservoir of an *LKB* model 3276 electrophoresis apparatus. The reservoirs were filled with *M*/10 barbital buffer, *p*H 7·4. Current (4·3 V./cm.) was applied for 18 hr. The sheets were removed, dried with a hair-dryer, and stained with bromphenol-blue[6].

The distribution of water-extracted stained proteins is shown in Fig. 1. There is no qualitative difference apparent between the proteins in the food of young larvæ of queen, worker, and drone castes. Spots 1 and 3, however, are not found in the old worker and drone larval food. A single zone with a migration equivalent to that of spot 3 was present in alkaline extracts of all food samples examined. Thus it is apparent that the qualitative change of the protein constituents of worker and drone larval food is restricted to the water-soluble fractions.

A bluish fluorescent zone not associated with any of the proteins was visible on unstained electro-

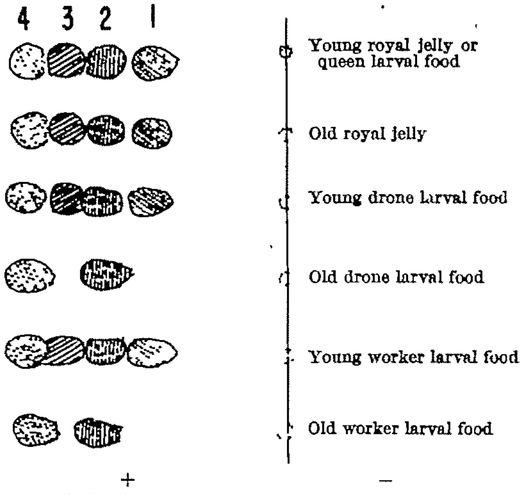


Fig. 1. Electrophoretic patterns (drawn to scale) of proteins from food of honeybee larvæ of different age and caste

phorograms of food of younger worker and drone larvæ and of food of both ages of queen larvæ. The fluorescence may indicate the presence of biopterin[7], which has been associated with queen larval food.

The source of brood-food proteins was sought in adult worker bees: 16 pairs of each of the mandibular, hypopharyngeal and thoracic glands were dissected from (*a*) 6-day post-emergence nurse bees; (*b*) newly emerged bees. The glands were macerated in 0·5 ml. phosphate (M/10, pH 6·0) and electrophorograms prepared as above. The electrophoretic pattern obtained from the hypopharyngeal glands of the 6-day post-emergence adults was similar to that of queen larval food, whereas other glands and glands of newly emerged bees contained a single, immobile spot. The source of young brood-food protein appears to reside in the fully active pharyngeal gland.

Thus the divergence of maturation of the fully fertile queen from that of the infertile worker coincides chronologically with the qualitative change in protein composition of brood-food given to the larvæ of the latter caste. A more concerted study of the changes occurring in the brood-food at this time could help explain the mechanism of this divergence. For example, Ammon and Zock[2] localized cholinesterase activity in their alpha fraction and acid phosphatase in their gamma fraction, corresponding to our spots 2 and 4. It is possible that loss of other biological or nutritional activity is associated with loss, in the older worker larval food, of spots 1 and 3. Such a loss could be related in some way to the subsequent sexually incomplete development of the worker caste.

N. G. PATEL
M. H. HAYDAK
T. A. GOCHNAUER

Department of Entomology and
Economic Zoology,
University of Minnesota,
St. Paul 1.

[1] Gontarski, H., *Z. Bienen-Forsch.*, 2, 163 (1954).

[2] Ammon, R., and Zock, E., *Artzneim. Forsch.*, 7, 699 (1957).

[3] Habowski, J. E. J., M.S. thesis, University of Toronto (1958).

[4] Shuel, R. W., and Dixon, S. E., *Canad. J. Zool.*, 37, 803 (1959).

[5] Ribbands, R., "The Behaviour and Social Life of Honeybees" (Bee Research Association, London, 1953).

[6] Block, R. J., Durrum, E. L., and Zweig, G., "Paper Chromatography and Paper Electrophoresis" (Academic Press, New York, 1955).

[7] Butenandt, R. H., *Hoppe-Seylers Z. physiol. Chem.*, 311, 79 (1948).

Desalting of Urine by Electrodialysis

THE electrodialyser previously described[1] has been used for desalting samples of urine prior to chromatography. This apparatus (obtainable from Shandon Scientific Co., Ltd., 6 Cromwell Place, London, S.W.7) was used successfully in the desalting of tissue extracts; but Smith[2], using a modified version of the desalter, reported considerable losses of amino-acids during desalting of urine. It was considered desirable to repeat the experiments in the original apparatus by plotting the 'desalting curve' and submitting samples desalted for varying lengths of time to two-dimensional chromatography.

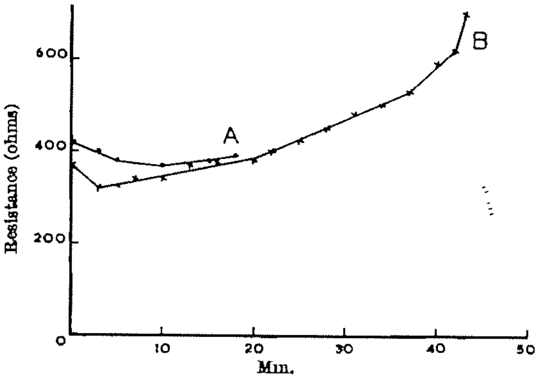


Fig. 1. Ordinates: resistance of the cell. Abscissæ time in min. Runs *A* and *B* are indicated

The urine was part of a 24-hr. sample from a patient at the Royal Alexandra Hospital for Children, Sydney. 10-ml. portions were diluted with 10 ml. of water and placed in the centre compartment of the cell and tap-water was run through the electrode compartments. The current was switched on and the voltages adjusted periodically to maintain the current flowing at 0·200 amp. for the greater part of the run. After 43 min. the resistance of the cell had begun to rise steeply, and the removal of ions was substantially complete (run *B*).

The plot of resistance against time is shown in Fig. 1. Initially, the resistance of the cell falls as salt begins to pass through the membranes; after 20 min. the greater part of the inorganic salts has been removed, and more of the current is being carried by organic ions, as shown by the increase in gradient; finally, the curve rises steeply as the solution becomes exhausted of ions.

Runs *A* (and *C*) were carried out in the same way but were terminated after 18 min. and 10 min. respectively.

The solutions from runs *A*, *B* and *C*, and the original urine were brought to dryness under reduced

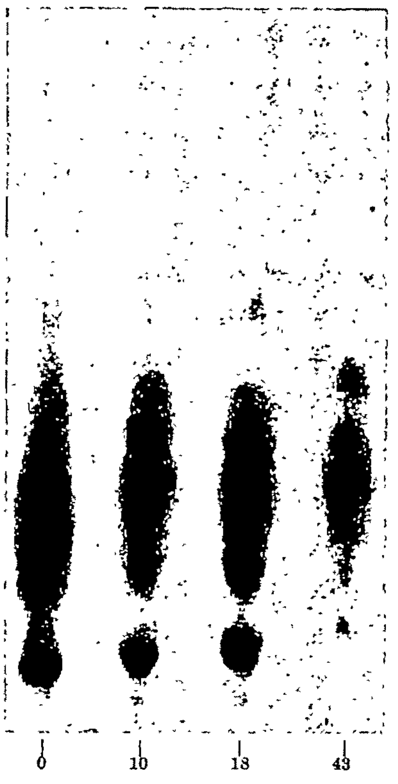


Fig. 2. One-dimensional chromatogram in butanol/acetic acid of the amino-acids in samples of urine withdrawn at zero time and after 10, 18, and 43 min.

pressure and diluted to 2 ml. with 10 per cent v/v *iso*propanol. Equal amounts of each sample were chromatographed in butanol/acetic acid[2] (ascending) followed by phenol/ethanol[2] on Whatman No. 1 paper and developed with ninhydrin. Two-dimensional chromatograms of the urine desalted for 10 min. gave good discrete spots compared with the original urine. A one-dimensional chromatogram of samples withdrawn at various times during the run is shown in Fig. 2.

It is evident from the results that, provided a 'desalting curve' for the urine is plotted, it is possible to stop the run at a time when most of the salt has been removed but little or no amino-acid has been lost. It is also suggested that a procedure of 'total desalting' might be useful in clinical laboratories to measure the total amount of electrolyte in urine, since this is directly proportional to the average current × time.

T. Wood

Biochemistry Department,
University of Sydney,
New South Wales.

[1] Wood, T., *Biochem. J.*, 62, 611 (1956).

[2] Smith, I. (ed.), "Chromatographic Techniques, Clinical and Biochemical Applications" (Heinemann, London, 1958).

Biosynthesis of Flavonoids

Several workers have shown that lignin and the '*B* ring' of flavonoids are formed *in vivo* from shikimic acid and certain C_6C_3 compounds. The latter compounds are frequently encountered in plant tissues[1]. The '*A* ring' of flavonoids appears to arise from acetate units[2]. However, the occurrence of the free '*A* ring' or simple derivatives of it have rarely been reported. We have found that on acid treatment kinos yield phloroglucinol, but bark and wood polyphenols do not

Concentrated hydrochloric acid was added to an aqueous ethanolic (1 : 1) solution (5 ml.) of the kino (0·2 gm.), until the strength was 3 *N*. The open test-tube containing the solution was heated in boiling water for 1 hr., and the reaction products examined by two-way chromatography in butanol/acetic acid/water (6 : 1 : 2) and 6 per cent acetic acid. All the kinos examined produced phloroglucinol, which was identified by co-chromatography, its appearance under ultra-violet light while fuming with ammonia (s.g. 0·88) and its colour reaction to diazotized *p*-nitroaniline[3] and vanillin-hydrochloric acid[4].

Phloroglucinol was isolated from *Pterocarpus marsupium* kino (5 gm.) by treating in a similar manner, adding sodium carbonate to the filtered reaction products until the acid strength was about 1 *N*. The resulting liquor was placed on a polyamide column[5] and, after washing with water, the column was developed with ethanol/water (3 : 7) and the phloroglucinol recovered from the appropriate fractions in 0·5 per cent yield. The crystals did not depress the melting point of authentic phloroglucinol and possessed the same infra-red spectrum.

When the kinos were treated with butanol – hydrochloric acid, the anthocyanidins produced by the leucoanthocyanins present were identified chromatographically using Forestal[6] and formic acid – hydrochloric acid – water[7] solvents, and they all contained a phloroglucinol '*A* ring'. In addition, *Eucalyptus* and *Angophora* kinos gave gallic acid, and some kinos gave methyl gallate and protocatechuic acid which were identified by co-chromatography on 2-way chromatograms.

The kinos examined, and the principal anthocyanidins produced with acid, were as follows: *Eucalyptus calophylla* (pelargonidin and cyanidin), *E. camaldulensis* (cyanidin), *E. consideniana* (delphinidin), *E. corymbosa* (cyanidin), *E. elaeophora* (delphinidin), *E. gigantea* (delphinidin), *E. macrorrhyncha* (delphinidin), *E. obliqua* (delphinidin), *E. polycarpa* (cyanidin), *E. radiata* (delphinidin), *E. regnans* (delphinidin), *E. sideroxylon* (pelargonidin, cyanidin, delphinidin), *E. sieberiana* (delphinidin), *Angophora intermedia* (cyanidin), *Pterocarpus marsupium* (cyanidin), *Butea frondosa* (cyanidin).

The material yielding phloroglucinol with acid treatment was insoluble in ether, and formed unresolved streaks on the solvent axes. When solutions of *E. elaeophora* and *P. marsupium* kinos in aqueous ethanol (1 : 1) were made 2 *N* with sodium hydroxide, kept at room temperature for 2–4 hr., then acidified, phloroglucinol was not detected, so that esters of it are absent. Sugars could not be detected in the acid reaction products.

In contrast, extracts of the wood and phloem tissues of several of the above eucalypts which had formed kinos did not yield phloroglucinol on acid treatment. Extracts from the wood of *E. wandoo*, and the barks of *E. astringens* and *Rhizophora mucronata* which are rich in leucoanthocyanins containing a phloroglucinol '*A* ring' also failed to yield phloroglucinol. Thus, kinos contain phenolic components which are absent in the phloem and woody tissues, and consequently kinos appear to be formed *in situ* from other materials. Further evidence[8] indicates that the polyphenols in kinos and in the tissues of trees are formed from carbohydrates which have been translocated or stored as starch.

I am indebted to Miss E. Gloss for experimental assistance.

W. E. Hillis

Division of Forest Products,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne.

[1] Bate-Smith, E. C., *Sci. Proc. Roy. Dublin Soc.*, 27, 165 (1956).

[2] Watkin, J. E., Underhill, E. W., and Neish, A. C., *Canad. J. Biochem. Physiol.*, 35, 229 (1957). Geissman, T. A., and Swain, T., *Chem. and Indust.*, 984 (1957). These contain references to earlier work.

[3] Swain, T., *Biochem. J*, 53, 200 (1952).

[4] Bate-Smith, E. C., and Swain, T., *Chem. and Indust.*, 377 (1953).

[5] Hoerhammer, L., Wagner, H., and Leeb, W., *Naturwiss.*, 44, 513 (1957).

[6] Bate-Smith, E. C., *Biochem. J.*, 58, 122 (1954).

[7] Harborne, J. B., *J. Chromat.*, 1, 473 (1958).

[8] Hillis, W. E., and Carle, Ann, *Biochem. J.* (in the press).

PHYSIOLOGY

Œstrogen–Insulin Interaction on the Uterus of the Rat

The physiological activity of a specific hormone may be greatly modified by the presence or absence of other hormones, as evidenced, for example, by the Houssay effect[1]; the inhibitory action of adrenal cortical hormones on the response of the rat uterus to œstrogens[2]; the interaction of the various œstrogens on uterine growth[3]; the synergistic effect of growth hormone and thyroxine on body-growth in hypophysectomized animals[4], etc. Of more immediate relevance to the subject to be treated here is the finding that the response of the mouse vagina to œstrogen is heightened by local application of insulin[5]; analogies between the effects of œstrogen and those of insulin on the mitotic activity of mouse ear epidermis have been pointed out by Bullough[6]. Other similarities between the generalized action of insulin and the specific effects of œstrogens on their target organs include an increased potassium uptake by the responding tissue[7–9], and a heightening of glycogenesis and lipogenesis[10–14]. The foregoing observations, together with the fact that except in a few specific preparations œstrogens are ineffective *in vitro*[15], and in large doses produce a transient diabetes[16], suggest a possible interaction between insulin and œstrogen.

The investigations described here were designed to establish whether diabetes and insulin-induced hypoglycæmia would affect the response to œstrogen based on the 6-hr. Astwood assay[17]. This would presumably indicate whether insulin plays a part in the action of œstrogen, and whether the blood glucose is also involved.

Twenty-one- to twenty-two-day old albino rats weighing 40–50 gm. were employed in this study. Diabetes was induced by partial pancreatectomy followed by the subcutaneous injection of 1 c.c. of a 40 per cent glucose solution; 1 hr. after the administration of glucose the animal received 0·5 μgm. of œstrone in 0·1 c.c. of sesame oil subcutaneously; autopsy was performed 6 hr. after the injection. Œstrogen-treated and un-treated non-operated, sham-operated, operated but glucose-uninjected controls were also provided. The extent of the diabetes was determined by the use of the Lilly diabetic test tape; all partially depancreatized glucose-treated animals exhibited at least a ++++ response, that is, a urine sugar content of at least 2 per cent, at autopsy.

Table 1. EFFECTS OF HYPER- AND HYPO-GLYCÆMIA ON THE UTERINE RESPONSE TO ŒSTROGEN

Group	Uterine water (per cent)*	No. of animals
1 Unoperated, untreated controls	81·4 ± 0·2	22
2 Received 0·5 μgm. œstrone	86·8 ± 0·1	12
3 Received 0·5 μgm. œstrone 12 hr. after injection of 2 units of protamine zinc insulin	81·6 ± 0·4	5
4 Received 0·5 μgm. œstrone 12 hr after injection of 2 units of 'Lente' insulin	83·1 ± 0·5	8
5 Received 2 units 'Lente' insulin 18 hr. before autopsy	81·5 ± 0·4	7
6 Received 0·5 μgm. œstrone 2 hr. after partial pancreatectomy	86·0 ± 0·6	7
7 Received 0·5 μgm. œstrone 1 hr. after injection of 1 c.c. of 40 per cent glucose solution	86·8 ± 0·5	9
8 Received 0·5 μgm. œstrone 2 hr. after sham partial pancreatectomy and 1 hr. after injection of 1 c.c. of 40 per cent glucose solution	85·8 ± 0·8	8
9 Received 0·5 μgm. œstrone 2 hr after partial pancreatectomy and 1 hr. after injection of 1 c.c. of 40 per cent glucose solution	81·1 ± 0·6	10
10 Received 0·5 μgm. œstrone 2 hr after partial pancreatectomy and 1 hr. after injection of 1 c.c. of 40 per cent mannose solution	82·4 ± 0·2	6
11 Received 0·5 μgm. œstrone 2 hr. after partial pancreatectomy and 1 hr. after injection of 1 c.c. of 40 per cent fructose solution	81·9 ± 0·3	9
12 Received 0·5 μgm. œstrone 2 hr. after partial pancreatectomy and 1 hr. after injection of 1 c.c. of 40 per cent galactose solution	83·5 ± 0·9	8

* Mean ± standard error of the mean

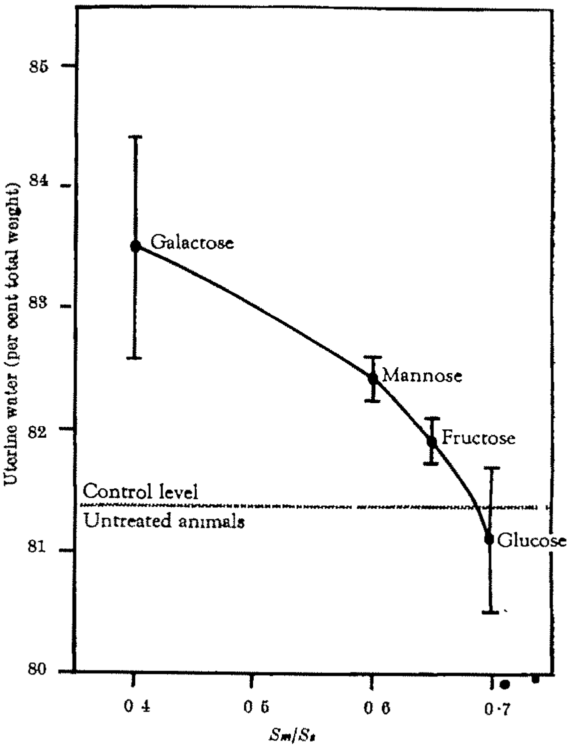


Fig. 1. Relation between S_m/S_s and uterine water uptake in depancreatized diabetic immature rats

None of the other animals in this set of experiments exhibited any evidence of glucosuria.

Hypoglycæmia was induced by injection of insulin 12–14 hr. before the administration of œstrone. Uterine wet weights were determined immediately upon removal of the organ; the tissue was then placed in a pre-weighed aluminium pan and dried at 90° C. for 72 hr.

Additional pancreatectomized groups were provided in which glucose was replaced by fructose, mannose, or galactose; some of the pancreatectomized sugar-treated animals exhibited mild glucosuria.

From the results presented in Table 1 it is evident that the response to œstrogen was dependent upon the physiological integrity of the test animal; the absence as well as the excess of insulin inhibited the action of œstrone. It is difficult to determine whether the inhibition due to lack of insulin was a direct one; diabetic animals exhibit a marked polyuria, and recent studies have indicated that the 6-hr. response to œstrogen is diminished in 'Diamox'-treated animals, which lose a great deal of water[18]. Adrenal involvement in the reduction of the œstrogen response in glucose-treated partially depancreatized animals appears minimal in view of the results obtained with sham-operated glucose-treated controls. It is noteworthy that not all the sugars tested are equally effective in blocking the action of œstrone under identical experimental conditions; Fig. 1 relates the extent of the inhibition to the degree to which normal rat muscle takes up sugar under a given dose of insulin; this parameter was derived from the work of Park *et al.*, who express it as the ratio of the free sugar in the tissue to the sugar concentration in the blood serum $(S_m/S_s)^{19}$. The inverse relation between the extent of œstrogen stimulation and the 'insulin demand' of muscle is highly suggestive.

The fact that insulin-pretreated animals do not respond to œstrogen does not conclusively point to a direct involvement of the blood glucose in the response phenomenon, as the inhibition might be ascribed to increased adrenal secretion in response to the stress of hypoglycæmia. This hypothesis is rather difficult to check in view of the extreme sensitivity of adrenalectomized hyperinsulinized animals.

In view of the results obtained it seems worth while to speculate on the inhibition of œstrogen-induced water uptake observed in the uteri of eviscerated animals. Some reports have explained this phenomenon as resulting from the absence of liver tissue[20]. The results reported here would point to the absence of pancreatic tissue as a prime factor in this inhibition.

R. MICHEL ZILBERSTEIN*

Biological Laboratories,
Harvard University,
Cambridge, Mass.

---

* Present address Straw Road, Hopkinton, New Hampshire.

[1] Houssay, B. A., *et al.*, *Endocrinol.*, **15**, 511 (1931).

[2] Velardo, J T., Hisaw, F. W , and Bever, A. T., *Endocrinol* , **59**, 165 (1956).

[3] Hisaw, F. L., Velardo, J T., and Goolsby, C. M , *Fed. Proc.*, **12**, 68 (1953).

[4] Ray, R. D., Simpson, M. E., Li, C H , *et al* , *Anat. Rec.*, **86**, 479 (1956).

[5] Claringbold, P. J., *J. Endocrinol.*, **11**, 36 (1954).

[6] Bullough, W. S., Ciba Foundation Colloquia in Endocrinology, **6**, "Hormonal Factors in Carbohydrate Metabolism", 278 (1956).

[7] Maney, J. F., Gourley, D. R. H., and Fisher, K. C , *Canad. J. Biochem. and Physiol.*, **34**, 893 (1956).

[8] Kamminga, Chr. E., Willebrands, A. F., Groen, J., and Blickman, J. R., *Science*, **111**, 30 (1950).

[9] Daniel, E. E , and Daniel, B. N., *Canad. J. Biochem. and Physiol.*, **35**, 1205 (1957).

[10] Bo, W. J., and Atkinson, W. B., *Anat. Rec.*, **113**, 91 (1952).

[11] Walaas, O., *Acta Endocrinol.*, **10**, 175 (1952).

[12] Boettiger, C. B., *J. Cell. and Comp. Physiol.*, **27**, 9 (1946).

[13] De Duve, C., Ciba Foundation Colloquia on Endocrinology, **9**, "The Internal Secretion of the Pancreas", 203 (1956).

[14] Andrews, F. N., Stob, M., *et al.*, *J. Animal Sci* , **15**, 685 (1956).

[15] Villee, C. A., *J. Biochem.*, **215**, 171 (1955).

[16] Rodriguez, R. R., *Rev. Soc. Argentina de Biologia*, **26**, 205 (1950).

[17] Astwood, E. B., *Endocrinol.*, **23**, 25 (1938).

[18] Goodman, M., Einstein, R., and Ringler, I., *Proc. Soc. Exp. Biol. and Med.*, **96**, 725 (1957).

[19] Park, C. R., Post, R. L., Kalman, C. F., *et al.*, Ciba Foundation Colloquia on Endocrinology, **9**, "The Internal Secretion of the Pancreas", 240 (1956).

[20] Szego, C. M., and Roberts, S., *Rec Prog. Hormone Res.*, **8**, 419 (1953).

Intracellular Potentials in Rat Atria during and after Vagal Stimulation or Acetylcholine Administration

RECENTLY, Vaughan Williams[1] observed that the shortening of the duration of the intracellularly recorded action potential in rabbit atria following vagal stimulation or acetylcholine administration is not always associated with diminished atrial contractions. In fact the association between the two phenomena as observed by Burgen and Terroux[2] might be coincidental. The question arose whether the slowing-up of the atrium which will result from vagal stimulation or acetylcholine administration is always connected with a shortening of the duration of the atrial action potential. The right atrium of adult Wistar rats was impaled with glass microelectrodes filled with 3 *M* potassium chloride, their tip diameter being $< 0\cdot5\mu$ and their resistance 20–35 MΩ. After retrograde insertion of a plastic cannula in the thoracic aorta, the heart and both vagi were perfused *in situ* with normal Tyrode solution. The vagi were stimulated with rectangular current pulses of varying intensity. The pulses had a frequency of 10 c./sec. and a duration of 0·5 m.sec. In a few experiments we succeeded in recording intracellular atrium potentials from artificially ventilated animals that had an intact circulation. The results obtained with perfused rats and with rats with an intact circulation did not differ.

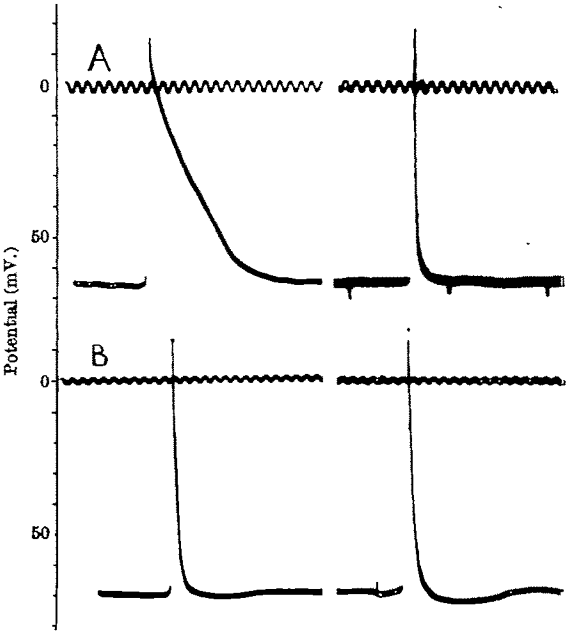


Fig 1. Effect of vagal stimulation and acetylcholine administration on atrial potentials. *A*, left, normal atrial potential; right, atrial potential during vagal stimulation. *B*, left, atrial potential shortly before cardiac arrest as caused by acetylcholine administration; right, potential of driven atrium during acetylcholine administration. Time marks, sine wave of 100 c./s. Stimulus artefacts are visible in right-hand records

During vagal stimulation or during the administration of acetylcholine to the perfusion fluid or to the venous blood the duration of the atrial potential decreased from 100 to about 20 m.sec. The degree of slowing-up of the atrium and the shortening of the atrial action potential were found to be dependent equally upon the intensity of the vagal stimulation and the concentration of acetylcholine in the perfusion fluid or in the blood. Immediately after the arrest of vagal stimulation the heart frequency rose to its original value within 1 sec. In most experiments post-vagal acceleration of heart frequency was observed.

The shortening of the duration of the action potential, however, did not disappear as quickly as the atrial slowing and reached its original value only after 7–15 sec. after the arrest of vagal stimulation. The same observation was made when perfusion with Tyrode solution containing acetylcholine was suddenly replaced by perfusion with normal Tyrode.

In a further series of experiments cardiac arrest was established by perfusing the heart with a Tyrode solution containing 20γ acetylcholine/ml. As an atrium under these conditions will still respond with a contraction to an electrical stimulus[1], the atria were electrically driven up to their original frequency. Despite this frequency of contraction, the duration of the atrial potential remained considerably shortened so long as the acetylcholine administration was continued. On discontinuing the acetylcholine perfusion the duration of the atrial potential gradually rose to its original value.

Consequently we have come to the conclusion that shortening of the duration of the auricular potential during vagal stimulation does not depend upon the rate of the atrial contractions.

We are indebted to the Dutch Organization for Pure Scientific Research for its financial support.

P. A. Biersteker
J. Th. F. Boeles
L. N. Bouman

Department of Physiology,
University of Amsterdam.

[1] Vaughan Williams, E. M., *J. Physiol.*, **147**, 325 (1959).

[2] Burgen, A. S. V., and Terroux, K. G., *J. Physiol.*, **120**, 449 (1953).

Effect of Methylpentynol on Acetylcholine in the Rat's Brain

Recent observations that methylpentynol, a sedative-hypnotic agent, interferes with transmission in certain cholinergic synapses[1], have led to the demonstration by Marley and Paton that this action is due in part to a reduction in the output of acetylcholine, at least from the superior cervical ganglion of the cat[2]. In the course of work in this and other laboratories on the influence of a number of appropriate neuro-pharmacological agents on the acetylcholine content of the rat's brain, it became apparent that the administration of depressants of the central nervous system in general is followed by a rise in brain acetylcholine (unpublished work and ref. 3). It seemed essential, therefore, for us to include methylpentynol in our survey, because this central-depressant might, in the light of the findings of Marley and Paton, depress the output of acetylcholine by the brain, possibly leading to a depression of the total level of acetylcholine. On the other hand, if release of acetylcholine alone, and not its synthesis, were interfered with, one might expect an accumulation and an increase in the amount of acetylcholine in the brain.

Adult male rats (150–250 gm.) were given intraperitoneal injections of methylpentynol in doses varying from 200 to 500 mgm./kgm. At a time shortly after loss of the righting reflex, when the animals were believed to be at the point of greatest central depression, the rats were decapitated, their whole brains (without olfactory lobes and pituitaries) quickly removed and extracted for acetylcholine by the method of Smallman and Fisher[4]. The content of acetylcholine in these extracts was determined by bioassay on the frog's rectus abdominis muscle preparation. Methylpentynol has no direct effect on this preparation in concentrations up to 20 μgm./ml. (approximately seven times the maximal amount expected in the extracts), nor does it sensitize the muscle to acetylcholine. The results are shown in Table 1.

The animals given the lower doses were all lightly depressed, and their acetylcholine-levels were only slightly higher than those of the two control animals. On the other hand, those animals given 500 mgm. of methylpentynol per kgm. were deeply depressed and the levels of acetylcholine in the brain were considerably higher than those of the control animals. It appears that, in rats, methylpentynol causes a rise in the level of acetylcholine in the brain, and that the extent of this rise is related to the degree of depression induced by the administration of the agent. If methylpentynol causes a rise in brain acetylcholine by reducing the output of that substance at certain central synapses, these results would indicate that there is no interference with the synthesis of acetylcholine. It has already been established that methylpentynol does not inhibit cholinesterase (unpublished work).

Table 1. Effect of Methylpentynol on Acetylcholine Content of the Rat's Brain

Intraperitoneal dose (mgm./kgm.)	Killed (min. after onset of anæsthesia)	Acetylcholine in brain (μgm./gm. ± *S.E.*)
None (2 animals)	—	2·77
200 + 100	4	3·08
300	3	3·19
300	2·8	2·80
300	2·5	3·15
		Mean 3·04 ± 0·17
None (6 animals)	—	3·05 ± 0·23
500	12	5·88
500	15	5·08
500	12	5·83
500	15	4·55
500	12	4·60
500	12	5·10
500	12	5·00
500	12	5·66
		Mean 5·20 ± 0·52

Since preparing this communication, we have conducted experiments to show that there is no difference in the synthesis of acetylcholine by slices of cerebral cortex from brains of untreated rats and by those from brains of rats under anæsthesia induced by methylpentynol (in a dose of 500 mgm./kgm.).

This work was aided by grant *B*-940 from the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.

Giancarlo Pepeu
Nicholas J. Giarman

Department of Pharmacology,
Yale University School of Medicine,
New Haven, Conn.

[1] Nicholls, J. G., and Quilliam, J. P., *Brit. J. Pharmacol.*, **11**, 151 (1956). Quilliam, J. P., *Med. Press*, **238**, 121 (1957); and *Brit. J. Pharmacol.*, **14**, 277 (1959). Marley, E., *ibid.*, **14**, 284 (1959).

[2] Marley, E., and Paton, W. D. M., *Brit. J. Pharmacol.*, **14**, 303 (1959).

[3] Feldberg, W., in "Metabolism of the Nervous System", 493, edit. by Richter, D. (London and New York, Pergamon Press, 1957).

[4] Smallman, B. N., and Fisher, R. W., *Can. J. Biochem. and Physiol.*, **36**, 575 (1958).

Effect of Severing the Olfactory Bulbs on the Intake and Excretion of Water in the Rat

Ecologists and experimental workers maintain that the sense of smell plays an important part both in the search for food and the regulation of alimentary reactions[1–3]. In recent investigations we studied the significance of olfactory signalization for the intake and excretion of water.

Adult male rats in groups of eight or more were used. The skull was trephined above the olfactory bulbs and the bulbs severed with a scalpel: the experiments were begun after a period of 1–2 months. Control animals were sham operated. During the experiment animals were housed individually in metabolism cages, and the intake and excretion of water together with food intake and body-weight were determined.

In the animal house operated animals drink 71 per cent more water a day than normal animals, and the same result was obtained during the experimental period: after their olfactory bulbs had been cut, rats drank 60 per cent more water in a day than the control animals and also excreted 60 per cent more urine. Thus water exchange was the same for both groups.

In order to determine whether increased water intake or increased water loss was the primary mechanism concerned the following experiment was performed. Animals housed in metabolism cages were deprived of food and water for 24 hr. and the amount of urine excreted was measured. It could be shown that operated animals lost 65 per cent more water than control animals during that period.

It seemed possible to explain the above findings by assuming a defect similar to diabetes insipidus. In order to confirm this assumption, adiuretic activity was determined in the blood of our animals using the method of Heller[4]. Its activity was found to be significantly lower in the blood of operated animals than in that of the controls. Exclusion of other sensory receptors (enucleation, severing of the trigeminal nerve) has no effect on water metabolism. Thus severing the olfactory bulbs significantly affects the intake and output of water. It has no effect on food intake and body-weight.

In further experiments it was shown that normal rats make up for the deficit in water due to the 24-hr. period of starvation and thirst by increasing their intake of water on the next day. Operated animals react quite differently. They drink the same amount of water as before the period of thirst. After 24 hr. without access to food and water, control rats excrete urine in the normal fashion. Operated rats under the same conditions urinate less than normally. Only on the next day and afterwards do we find the high excretion of water observed before the period of starvation and thirst. This was also confirmed by a further experiment. Animals were again deprived of food and water for 24 hr. and then given a quantity of water at 38° C. through a stomach tube corresponding to 5 per cent of their body-weight. 3 hr. after the administration of water it was found that more water was retained by the operated rats than by the control ones, the former excreting 40 per cent less water than the latter. It may be concluded that intact rats regulate a water deficit by an increased intake of water, while operated animals react by decreasing urine excretion. Thus these animals, although having less adiuretic activity in their blood, are capable of regulating the volume of their body-fluid.

The changes described do not appear immediately after the operation and on the average become permanent after 20 days. This demonstrates that they are not due to surgical trauma or exclusion of olfactory signalization. It is assumed that they depend on degenerative changes in the olfactory tracts leading to the hypothalamus whence collaterals pass to hypothalamic nuclei. This will have to be verified.

V. Nováková
H. Dlouhá

Institute of Physiology,
Czechoslovak Academy of Sciences,
Praha 6.

---

[1] Kalabukhov, *Zoologicheski Z.*, 31, 564 (1952).

[2] Ponugayeva, A. G, *Zoologicheski Z.*, 33, 869 (1954).

[3] Le Magnen, J., *C.R. Soc. Biol.*, 150, 32 (1956).

[4] Heller, J., and Štulc, J., *Cs. Fysiol*, 7, 406 (1958).

Interrelation of Tryptophan and Nicotinic Acid in Man during the First Month of Life

In the fœtal liver of mammals there is little or no activity of the following enzymatic systems: glucose-6-phosphatase[1], uridine diphosphoglucose dehydrogenase, and glucuronyltransferase[2], phenylalanine transaminase, tyrosine transaminase and phenylalanine hydroxylase[3]. Hence these enzymes reach the normal levels of activity during the first period of extra-uterine life, and for some of them it seems that this process is regulated or accelerated by the adrenocortical hormones.

A similar behaviour has been demonstrated in the rat, in the guinea pig, and in the rabbit as regards the tryptophan peroxidase activity[4]: in the fœtus and newborn of these animals, the conversion of tryptophan into nicotinic acid is diminished or completely eliminated.

We have recently begun an investigation of the tryptophan metabolism in sucklings. In the work to be described in this communication, our particular interest was to examine, in newly born children and sucklings 1 month old, the excretion in the urine, both spontaneous and after administration of L-tryptophan, of the intermediary metabolites of the conversion of this amino-acid to nicotinic acid.

We examined urine samples of normal newly born children and of normal sucklings. The urine was taken every other day, from the first to the thirtieth day of life. For the chromatographic analysis of the urinary metabolites involved in the tryptophan–nicotinic acid system the Dalgliesh technique[5] was used.

Urine samples of 5 breast-fed and of 5 hand-fed children, without administration of L-tryptophan, have been examined systematically during the whole of the first month of life.

In this way, three types of excretory picture, occurring in succession, were observed. The first is characterized by the absence of the metabolites looked for, and lasts from the first to the fourth–eleventh day, varying from child to child; the second phase lasts from the fifth–twelfth day to the seventh–twenty-eighth day and is characterized by the appearance of numerous conjugates of 3-hydroxykynurenine and kynurenine (R_F 0·1–0·15), and of the kynurenine; in 7 out of 10 cases, of 3-hydroxyanthranilic acid; in 2 cases also of anthranilic acid and of 3-hydroxykynurenine; in some of the children the conjugates and the kynurenine appeared before the 3-hydroxyanthranilic acid. The third phase was characterized by the progressive disappearance from the urine of all these metabolites.

However, of the 10 children examined, one excreted with the urine only traces of the conjugates of 3-hydroxykynurenine and of kynurenine (R_F 0·1–0·15), but never the other metabolites looked for. No significant difference in the excretory picture was found between breast-fed and hand-fed children, with the techniques used.

Finally, 2 children were given L-tryptophan *per os* (the first child 150 mgm. and the second 400 mgm.) in single doses on the second, eighth and thirteenth day of life. Their urine was collected for 24 hr. after administration of the drug. In both subjects the dose given on the second day provoked high urinary excretion of L-tryptophan (detected on paper also with the xanthydrole reaction[6]), without the appearance of any other metabolite in the urine. On the eighth and thirteenth day large quantities also appeared of kynurenine, N-α-acetyl-kynurenine, and 3-hydroxyanthranilic acid.

Our results could be, perhaps, explained by the variations during the first month of life of the renal threshold for tryptophan metabolites; or, more probably, by deficiency of the tryptophan–peroxidase activity during the first days of life. There should be, in succession, within the first month, activation of the tryptophan–peroxidase and of other enzymes which catalyse the conversion of the amino-acid into vitamin; if this should happen, during the first days of life the synthesis of nicotinic acid from tryptophan would be completely, or at least partly, inhibited. As is already known, this metabolic route provides in the adult person the synthesis of some tissue pyridine coenzymes[7].

S. AURICCHIO
E. QUAGLIARIELLO
A. RUBINO

Institute of Biochemistry
and
Department of Pediatrics,
University of Naples.

[1] Auricchio, S., and Rigillo, N., *Biochim. App.*, 6, 57 (1959)
[2] Dutton, G. J., *Biochem. J*, 71, 141 (1959).
[3] Kretchmer, N., *Pediatrics*, 23, 606 (1959)
[4] Nemeth, A. M., *J. Biol. Chem.*, 234, 2921 (1959).
[5] Dalgliesh, C. E., *J. Clin. Path.*, 8, 73 (1955)
[6] Dickman, S. R., and Crockett, A. L., *J. Biol. Chem*, 220, 957 (1956)
[7] Williams, J. N., Feigelson, P, and Elvehjem, C A., *J. Biol. Chem.*, 187, 597 (1950).

Coenzyme *A* Content of Adipose Tissue

ADIPOSE tissue, long considered an inert storehouse, has recently been shown to have intense metabolic activity. In spite of the importance of coenzyme *A* in fat metabolism, the existence of coenzyme *A* activity had not been demonstrated in adipose tissue. The present communication does so and in addition directs attention to the differences in this respect between normal and obese animals and, among the latter, between animals with 'regulatory' obesity and animals with 'metabolic' obesity[1,2].

The mice used were hereditarily obese hyperglycæmic mice[1,2], approximately five months of age, weighing 51–71 gm., with a blood glucose ranging from 175 to 301 mgm. per cent (av. 242); their thin litter-mates (weight 21–27 gm., blood glucose 82–130 mgm. per cent, av. 93); and thin litter-mates in which hypothalamic obesity had been induced by an intraperitoneal injection of goldthioglucose (crystalline aurothioglucose-*GT*-7-*D*-7-11, Schering Corp., Bloomfield, New Jersey) (1 mgm. per 1 gm body-weight) two months prior to death (weight 44–58 gm., blood glucose 100–245 mgm. per cent, av 168)[1-3]. The first two groups were females, the goldthioglucose groups half males, half females (no sex difference in coenzyme *A*-levels was noted).

All animals were kept in separate cages at 26° C., under regular illumination, maintained on 'Purina chow'. Food intakes were checked during the twenty-four hour period preceding death to ensure that animals were in the fed state.

The coenzyme *A* assay method of Novelli[4] was used. This technique is based on the *in vitro* acetylation of sulphanilamide in an artificially defined medium in which coenzyme *A* is the limiting factor. The enzyme source is a bicarbonate extract of a pigeon liver acetone preparation obtained from Cambridge Biochemicals. The animals were killed by a sharp blow on the head; the abdominal fat was quickly excised, weighed, chilled and homogenized in ten volumes of iced water. The homogenate was boiled for 5 min., cooled (ice bath), centrifuged (10 min. at 1,800 r.p.m.), the lipoid foam discarded and the supernatant stored at –4° C. until assayed. Dry weight was determined by the constant-weight method (90° C. oven); nitrogen content (water-soluble) by alkaline nesslerization[5] of an aliquot of the homogenate removed before the boiling using a 45-min. digestion with a modified Arnold–Gunning digestion mixture (sulphuric acid, 20 ml.; potassium sulphate, 10 gm.; copper sulphate, 0 1 gm.), followed by addition of alkaline Nessler's solution (Fisher Scientific dil. 1 : 2 with 10 per cent sodium hydroxide). Solutions are read at 420 mμ. Results are given in Table 1.

Table 1. COENZYME *A* LEVELS IN ABDOMINAL FAT TISSUE OF MICE

Type of animal (number per group)	Weight when killed (gm.)	Coenzyme *A* levels (Lipmann units)		
		per gm. wet weight	per gm. dry weight	per 100 mgm. nitrogen (water-soluble protein)
Goldthioglucose obese (9)	45 ± 6	50·89 ± 10·50	62·03 ± 21·30	30·26 ± 6·20
Obese-hyperglycæmic (9)	62 ± 8	40·96 ± 8·26	51·07 ± 20·35	38·80 ± 3·20
Non-obese litter-mates (8)	26 ± 3	79·12 ± 11·08	108·56 ± 25·65	20·59 ± 6·23

Figures after ± are standard deviations.

It was found that: (1) the coenzyme *A* is present in considerable amount in adipose tissue; (2) the coenzyme *A* activity per mgm. nitrogen is significantly greater in goldthioglucose obese mice than in non-obese litter-mates; (3) the co-enzyme *A* activity per mgm. nitrogen is significantly greater in the hereditarily hyperglycæmic obese than in non-obese litter-mates made obese by goldthioglucose administration. The last fact is in accord with the known extreme activity of adipose tissue in this syndrome[6].

If values previously obtained for body composition in non-obese mice and mice with the two obese syndromes[7] are accepted, and if it is assumed that the adipose tissue of the animals is homogeneous with respect to the coenzyme *A* concentration, the total coenzyme *A* content (Lipmann units) would be: non-obese 100–150 units, obese-hyperglycæmic approximately 1,200 units and goldthioglucose mice 600–700 units.

An attempt was made to demonstrate the presence of the entire acetylation system (enzyme and co-factors as well as coenzyme) in adipose tissue. The procedures of Lipmann[8] and of Luukkainen[9] were used. No activity could be demonstrated in intact tissue 'cuttings' or in 'unfortified' homogenates. Some activity was seen when a 10-vol. homogenate was incubated for 2 hr. with the 'assay mix' fortified with adenosine triphosphate prepared according to the coenzyme *A* method of Novelli[4].

This work was supported in part by grants-in-aid from the National Institutes of Arthritis and Metabolism (grant No. *A*-49), Public Health Service, Bethesda; the Nutrition Foundation, New York;

and the Fund for Research and Teaching, Department of Nutrition, Harvard.

MARILYN M. THOMPSON
JEAN MAYER

Department of Nutrition,
Harvard University School of Public Health,
Boston, Mass.

[1] Mayer, J., *Nutrition Abstr. and Rev.*, Part *K*, 25, 597; Part 2, 25, 871 (1955).

[2] Mayer, J., *Metabolism*, 6, 435 (1957).

[3] Marshall, N. B., Barrnett, R. J., and Mayer, J., *Proc. Soc. Exp. Biol. Med.*, 90, 240 (1955).

[4] Novelli, G. D., "Methods in Enzymology", 3, 913, edit. by Colowick, S. P., and Kaplan, N. O. (Academic Press, New York, 1957).

[5] Weng, S. Y., *J. Biol. Chem.*, 55, 481 (1923).

[6] Christophe, J., Jeanrenaud, B., and Mayer, J., *Fed. Proc.*, 18, 521 (1959) (and in the press)

[7] Bates, M. W., Mayer, J., and Nauss, S. F., *Amer. J. Physiol.*, 180, 304 (1955).

[8] Lipmann, F., *J. Biol. Chem.*, 160, 173 (1945)

[9] Koiuvsalo, M., and Luukkainen, T., *Acta Physiol. Scand.*, 45, 278 (1959).

Control of Colour Change in Amphibians

THE adaptation of colour in anurans to the background is controlled by hormones. Direct innervation of the melanophores is of little or no importance in controlling the degree of dispersion of the melanin-containing granules within the melanophores[1]. It is generally agreed that a melanin-dispersing hormone is produced in the pars intermedia of the hypophysis and that this hormone, intermedin, is responsible for the darkening of the skin. It is, however, controversial whether the paling upon transfer to a white, illuminated background is due to the disappearance of intermedin from the blood, or to the secretion of a whitening hormone.

Hogben *et al.* argue for the participation of a whitening hormone in the colour response to the background[2]. Their theory can be summarized as follows: light-stimulation of the ventral area of retina causes reflex liberation of intermedin; light-stimulation of the dorsal area of the retina causes liberation of whitening hormone. An amphibian (for example, *Xenopus laevis* on which most of their experiments have been made) kept on a black, light-absorbing background and illuminated from above is therefore dark due to liberation of intermedin. When transferred to a white, light-scattering background the animal becomes pale, because now both the ventral and dorsal retina are stimulated, and whitening hormone secreted in addition to the intermedin. The whitening hormone should thus be capable of completely over-riding the melanin-dispersing activity of intermedin. The whitening hormone is assumed to be produced in the pars tuberalis of the hypophysis[2,3] But also the adrenal medulla[4] and the pineal gland[5] have been considered as sites of origin of a whitening hormone.

In order to decide whether a whitening hormone does or does not participate in the normal control of the colour response to a white, illuminated background, we denervated the neuro-intermediate lobe in *Bufo bufo* and *Xenopus laevis* by cutting, in its entire width, the thin wall of the third ventricle which separates the neuro-intermediate lobe from the median eminence and infundibulum. In some operations, part of the neuro-intermediate lobe was extirpated; in others the lobe was transplanted to an eye muscle. So in all the operations the structures supposed by Hogben *et al.* to control the liberation of the whitening hormone were left intact. The operations exclude a nervous regulation of intermedin secretion, whereas a nervous regulation of secretion of the whitening hormone should still be possible—provided the whitening hormone is not secreted by the neuro-intermediate lobe. If a whitening hormone is released into the blood stream when operated animals are transferred from a black to a white illuminated background, and if the secretion is inhibited on retransfer to a black background, such fluctuations in the rate of secretion might be detectable by observation of the state of the melanin within the melanophores.

Table 1. MELANOPHORE INDEX IN *Xenopus laevis* ON ILLUMINATED WHITE OR BLACK BACKGROUND

		Melanophore index. Background White	Melanophore index. Background Black
X.1 *X*.2 *X*.3 *X*.4	Neuro-intermediate lobe denervated	3·6 3·8 4·0 2·2	3·8 3·8 3·6 3·8
X.5 *X*.6 *X*.7 *X*.8	Neuro-intermediate lobe denervated + partly extirpated	2·4 1·7 4·0 4·0	2·0 1·0 4·3 4·2
	Average of five normal *Xenopus*	1·1	4·3

Readings of the melanophore index were made according to Hogben. Melanophore index of 1 stands for maximally concentrated and of 5 for maximally dispersed melanin within the melanophores. The animals were kept for 24 hr. or more on the white or black background before the melanophore index was read. The background was changed repeatedly, mostly every day. In Tables 1 and 2 each melanophore index represents the average of readings from six or more changes of background.

It appears from Tables 1 and 2 that in seven out of eight *Xenopus* and in twenty out of twenty-one *Bufo* the colour (melanophore index) was independent of the background during some weeks after operation, even when melanin dispersion was submaximal, that is, when secretion of intermedin from the denervated neuro-intermediate lobe was submaximal. (Submaximal dispersion of melanin *in vitro* is produced by

Table 2. MELANOPHORE INDEX IN *Bufo bufo* ON ILLUMINATED, WHITE OR BLACK BACKGROUND

		Melanophore index. Background White	Melanophore index. Background Black
B.1 *B*.2 *B*.3 *B*.4 *B*.5 *B*.6 *B*.7 *B*.8 *B*.9 *B* 10–*B* 16*	Denervation of neuro-intermediate lobe	4·9 4·3 4·9 4·9 1·4 4·5 3·3 4·9 1·8 3·3	5·0 3·4 5·0 5·0 1·1 4·6 3·4 4·9 3·4 3·3
B.17–*B*.19*	Denervation of neuro-intermediate lobe + partial extirpation	2·6	2·9
B.20* *B*.21	Transplantation of neuro-intermediate lobe	1·8 4·1	1·8 3·4
	Average of nine normal *Bufo*†	1·3	4·5

* 1–3 readings of melanophore index on each toad on each background.

† *B*.1–*B*.9 before operation.

high concentrations of intermedin[6]. The submaximal dispersion of melanin frequently observed in operated animals was, however, not due to excess secretion of intermedin from the denervated neuro-intermediate lobe, because injection of intermedin into such animals produced maximal dispersion of melanin.) It can therefore be concluded that if a whitening hormone is secreted in response to a white background it is present in the blood in amounts too small to modify visibly the effect on the melanin dispersion of even small amounts of intermedin. Paling upon transfer to a white background must result from the disappearance of intermedin from the blood. The fact that two animals, *X*.4 and *B*.9, did respond to the background after the operation does not necessarily disprove this conclusion. The persisting colour response can be due to incomplete denervation of the neuro-intermediate lobe.

It is generally agreed that intermedin secretion from the pars intermedia is controlled by inhibitory nerves, because lesion of hypothalamus or transplantation of the pars intermedia has been observed to darken the operated animal permanently[7]. We found, however, that the rate of intermedin secretion from a denervated neuro-intermediate lobe can vary from high to zero, as judged from the state of the melanophores. The toads especially operated during the breeding season were pale after the operation. The normal secretion of intermedin is therefore probably regulated by both inhibitory and secretory nerves.

C. BARKER JØRGENSEN
LIS OLESEN LARSEN

Laboratory of Zoophysiology,
University of Copenhagen.

[1] Hogben, L., and Slome, D., *Proc. Roy. Soc.*, B, **108**, 10 (1931). Parker, G. H., "Animal Colour Change and their Neuro-humors" (Cambridge University Press, 1948). Stoppani, A. O. M., Pieroni, P. F., and Murray, A. J., *Exp. J. Biol.*, **31**, 631 (1954).

[2] Hogben, L., and Slome, D., *Proc. Roy Soc.*, B, **120**, 158 (1936). Waring, H., and Landgrebe, F. W., in "The Hormones", 2nd ed. by Pincus, G., 427 (Academic Press, Inc., New York, 1950).

[3] Atwell, W. T., *Amer. J. Anat.*, **68**, 191 (1941). Hogben, L., *Nature*, **149**, 695 (1942).

[4] Stoppani, A. O. M., *Endocrinol*, **30**, 782 (1942).

[5] Lerner, A. B., *Nature*, **184**, 674 (1959). Simmonnet, H., Thièblot, L., and Segal, V., *Ann. Endocrinol.*, **13**, 340 (1952).

[6] Wright, P. A., *Physiol. Zool.*, **28**, 204 (1955).

[7] Etkin, W., *J. Exp. Zool.*, **86**, 113 (1941). Rowlands, A., *J. Exp. Biol*, **31**, 151 (1954).

HÆMATOLOGY

M_1, a Subdivision of the Human Blood-Group Antigen M

A 'NEW' antibody, anti-M_1, has been found as a component in six out of twenty available human anti-M sera: in one of them practically all the antibody was anti-M_1. No anti-M_1 could be detected in anti-M sera from eight rabbits and from one horse, nor in an extract of the seeds of *Iberis amara* (which contains anti-M): nor could it be found in a wide range of other antisera. We are calling the antibody anti-M_1, because in several ways it behaves like anti-A_1 of the ABO system and anti-P_1 of the P system.

The corresponding antigen, M_1, differs qualitatively from ordinary M. It is not merely strong M, because our two best anti-M_1 sera are insensitive to the greater amount of M known to be present in cells representing the genotype *MM* than in those representing the genotype *MN*; and, conversely, because two anti-M sera in our collection which are particularly sensitive to this 'dosage' difference make no distinction between M_1 and ordinary M. The Ss antigens do not appear to be playing a part in the M_1–M_2 difference.

Preliminary tests established that the antigen M_1 is commoner in Negroes than in Whites: they also showed that there is considerable variability in the strength of the antigen and that the classification of the weaker reactions may be left in doubt. Because of this difficulty we decided to confine the present report to classifications based on the results of rather laborious quantitative tests in which strictly comparable cell samples were used. When better anti-M_1 sera are available we hope it will be possible to classify routine cell samples without using quantitative methods.

Samples of blood from 32 New York Negroes and 32 Whites were taken on the same day at the Knickerbocker Foundation and sent by air to London. There they were tested against titrations of six sera containing anti-M and anti-M_1 in different proportions, and against titrations of three anti-N sera, one anti-S and one anti-s. The results given in Table 1 indicate that M_1 is about four times more frequent in Negroes than in Whites.

Table 1. RESULTS OF TESTING SAMPLES OF BLOOD FROM 32 NEGROES AND 32 WHITE PEOPLE WITH ANTI-M_1

		Negroes			Whites		
		M	MN	N	M	MN	N
Anti-M_1	+	3	5	0	2	0	0
	–	4	12	8	8	15	7

A genetic background for these antigenic differences can be provided most simply by postulating three alleles, M_1, M_2 and N, the approximate frequencies of which are:

	M_1	M_2	N
Negroes	0·18	0·35	0·52
Whites	0·03	0·52	0·45

Recombined, these figures give expectations in the five phenotype (six genotype) classes which agree very closely with the numbers observed in both the Negro and the White series. This, to say the least, does not contradict the hypothesis that two kinds of M alleles are responsible for the M_1–M_2 antigenic difference; but we hope for more direct support when appropriate families can be tested.

We wish to thank Dr. Gerald E. Fox and Sister M. Gabriel, O.S.F., of the Blood Bank, St. John's Hospital, Springfield, Illinois, for sending the serum which first attracted our attention to the M_1–M_2 difference. Other acknowledgments will be made in a more detailed account which will be submitted for publication elsewhere.

J. A. JACK

Knickerbocker Foundation, Inc.,
300 West 43rd Street,
New York 36.

PATRICIA TIPPETT
JEAN NOADES
RUTH SANGER
R. R. RACE

Medical Research Council
Blood Group Research Unit,
Lister Institute,
Chelsea Bridge Road,
London, S.W.1.

Separation of the α- and β-Chains of Globins by Means of Starch-gel Electrophoresis

THE investigation of the molecular weight and the electrophoretic behaviour of globins at pH 2–4 has led to a better understanding of the structure of the hæmoglobin molecule. At a pH less than 6 there is a progressive decrease of the molecular weight of human hæmoglobin[1]. At pH 11 the value of the sedimentation coefficient is 2·55, which points to a molecular weight of about 33,000 instead of 67,000, a value normally found[2].

In an indirect way, Singer and Itano[3] demonstrated that the dissociation at a low pH is asymmetrical. Moving-boundary electrophoresis at pH 11[2] leads to the assumption that the molecule is split into two identical halves[2].

Reichmann and Colvin[4] estimated a molecular weight of 16,000 at pH 2 for horse globin. From the electrophoretic behaviour of globin in acid medium, these authors were able to show that more than one component was present.

Haug, Smith and Wilson[5,6] were able to isolate two different components from horse globin, by fractionated precipitation with acid acetone, by moving boundary electrophoresis and by a chromatographic procedure at low pH. Hunt[7], using the same chromatographic method, separated the α- and β-chains and the α- and γ-chains, respectively, of human adult and fœtal globin. Hill and Craig[8] prepared the α- and β-chains by a counter-current distribution procedure.

This communication is a description of the separation of human adult and fœtal globin in chains by means of starch-gel electrophoresis according to Smithies[9], in formate-buffer pH 1·9 ; $\mu = 0{\cdot}02$. A potential of 120 V. was applied during 16 hr. Globins were prepared[10] from the following hæmoglobins: (*a*) normal adult ; (*b*) chromatographically pure A_1[11] ; (*c*) fœtal purified by the alkali-denaturation method of Chernoff[12].

The electrophoretic pattern of adult globin (Fig. 1*d* and *e*) demonstrates two fast-moving bands of almost equal intensity, and a third band with a smaller mobility. The fast-moving bands are the α- and β-chains of the globin ; this was proved in the following way. Globin was separated into two fractions, the α- and β-chains, using the chromatographic method of Wilson and Smith[6]. After concentration the two fractions were separately applied to the gel (Fig. 1*b*, *c*). Fraction I (α-chain) contains the slower of the two fast bands while fraction II contains the faster band.

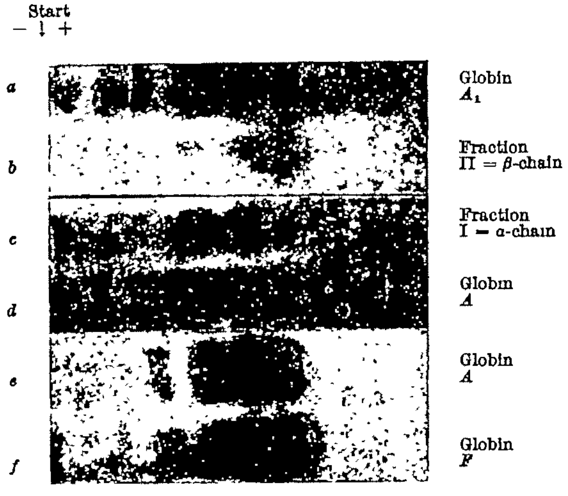


Fig. 1

The electrophoretic pattern of fœtal globin (Fig. 1*f*) compared with the pattern of adult globin (Fig. 1*e*) demonstrates that the α-chains have the same mobility. The mobilities of the β-chains, however, are different. This result is in agreement with the recent findings of Hunt[7].

The nature of the slow band that is present in both separated fractions and in the unfractionated globins is not quite clear. It is possible that they are the result of agglomeration of single chains. Interesting in this respect is the presence of the same band in the electrophoretic pattern of globin of pure hæmoglobin A_1. This excludes the possibility that it is due to the minor components present in the hæmoglobin of an adult human individual. Further research on this third fraction is in progress.

I am much indebted to Prof. J. H. P. Jonxis and Dr. T. H. J. Huisman for their advice and encouragement during this investigation. This work was supported by a grant from the Dutch Organization of Pure Research (Z.W.O.).

C. J. MULLER

Department of Paediatrics,
University of Groningen.

[1] Field, E O., and O'Brien, J. R. P., *Biochem. J.*, **60**, 656 (1955).
[2] Hasserodt, U., and Vinograd, J., *Proc. U.S. Nat. Acad. Sci.*, **45**, 12 (1959).
[3] Singer, S. J., and Itano, H. A., *Proc. U.S. Nat Acad. Sci.*, **45**, 174 (1959).
[4] Reichmann, M. E , and Colvin, J. R., *Canad. J. Chem.*, **34**, 411 (1956).
[5] Haug, A., and Smith, D. B., *Canad. J. Chem.*, **35**, 945 (1957)
[6] Wilson, S., and Smith, D. B., *Canad. J. Biochem. Physiol.*, **37**, 405 (1959).
[7] Hunt, J. A., *Nature*, **183**, 1373 (1959).
[8] Hill, R J., and Craig, L. C., *J. Amer. Chem. Soc.*, **81**, 2272 (1959).
[9] Smithies, O., *Biochem. J.*, **61**, 629 (1955).
[10] Anson, M. L., and Mirsky, A. E , *J. Gen. Physiol.*, **13**, 469 (1930).
[11] Huisman, T. H. J., Martis, E. A., and Dozy, A., *J. Lab. Clin. Med.*, **52**, 315 (1958).
[12] Chernoff, A. I., *Blood*, **8**, 413 (1953).

Haptoglobin Types in *Macaca irus*

WE have examined the haptoglobin types[1] of ten Cynomolgus monkeys (*Macaca irus*, F. Cuv.). The serum samples have been obtained from the Department of Virus Research, Karolinska Sjukhuset, Stockholm. The monkeys were not born in captivity, but were all captured from wild populations.

The sera were examined by starch-gel electrophoresis, using the discontinuous buffer system described by Poulik[2]. Hæmoglobin from the monkeys was added to the sera prior to electrophoresis, and the resultant gels were stained with benzidine and amido-black.

The resulting protein patterns were, as expected, similar to human serum protein patterns. Two different hæmoglobin-binding serum protein patterns were observed. Double runs revealed that the two patterns were identical with the *Hp* 1–1 and *Hp* 2–1 types found in man. Three of the ten individuals had the *Hp* 2–1 type. It was noted that the *Hp* 2–1 types had a much heavier concentration of haptoglobin in the fastest zone compared with the ordinary human *Hp* 2–1 ; in other words, it resembled the *Hp* 2–1 (mod), cf. Giblett[3].

Arends and Rodriguez[4] have examined the sera from 27 monkeys (23 *Macaca mulatta*, 1 *Macaca irus* and 3 *Cebus nigrivittatus*). All the monkeys were found to have type *Hp* 1–1. The authors suggested that this might be a phylogenetically significant finding, should future investigations confirm that monkeys have only one type of haptoglobin.

The slow-migrating zones of our three heterozygotes were very weak. Such weak types may be overlooked and classified as *Hp* 1–1, especially as the fastest zone is very strong.

The findings by Arends and Rodriguez[4] and our distribution (seven *Hp* 1–1 and three *Hp* 2–1) indicate that the frequency of the *Hp*–1 gene may be high in monkeys. It is then quite reasonable that no *Hp* 2–2 type has yet emerged.

It is known also that African Negroes have a high frequency of the *Hp*–1 gene (refs. 3, 5). Hence this gene might have a selective advantage in tropical areas.

We wish to thank Prof. S. Gard, of Stockholm, for supplying us with the serum samples.

Lars Beckman
Gunilla Cedermark

University Institute for Medical Genetics,
Uppsala.

[1] Smithies, O., and Walker, N. F., *Nature*, 176, 1265 (1955).

[2] Poulik, M., *Nature*, 180, 1477 (1957).

[3] Giblett, E. R., *Nature*, 183, 192 (1959).

[4] Arends, T., and de Rodriguez, M. L. G., *Nature*, 185, 325 (1960).

[5] Sutton, H. E., Neel, J. V., Binson, G., and Zuelzer, W. W., *Nature*, 179, 1287 (1956).

A Re-Evaluation of the Clotting Time of Chicken Blood

The blood coagulation mechanism of the chicken appears to differ greatly from that of mammals, in that its clotting time can exceed 1 hr. Recent literature assumes the chicken to have a blood-clotting time in a range similar to the higher mammals. Dukes[1] quotes Amendt (1922) as finding this to be 4·5 min.; Johnson and Connor[2] found an average of 6 min. 21 sec. with a range of 1–14 min.; while Didisheim *et al.*[3] query their recorded time of 9 min. in glass and 10 min. with siliconized equipment at 37° C. Howell[4], however, in 1909 infers that it is common knowledge that the blood of birds, terrapins and horses clots slowly. In 1940[5] he indicates that prolonged clotting time of hours or days in lower vertebrates (birds, reptiles and fishes) is due to the lack of "thromboplastic substance" within the vessels while prompt clotting is brought about by an active "thromboplastic tissue extract".

In a preliminary determination of clotting times on fifteen chickens using the Lee and White method[6] with plastic or siliconized glass syringes, a range of 1·5–30·0 min. was found at 42° C. It was observed that the negative pressure of the syringe caused a 'fluttering' of the fragile vein against the bevel of the needle and that the greater the degree of 'fluttering', the shorter was the clotting time of the blood. It was assumed from this that the trauma caused by the vein striking the needle released tissue thromboplastin which hastened clotting.

Blood from thirty-seven caged laying hens of three different breeds (Leghorns, Light Sussex and White Rocks) was collected utilizing precautions to minimize the release of tissue thromboplastin. This was done by venipuncture with No. 20 siliconized *B–D* vacutainer needles only. No syringe was used, the blood being allowed to flow directly into 13 mm. × 10 cm. Kimble glass tubes by very slight digital pressure on the superior portion of the brachial vein. Needle movement within the vein was minimized. Clotting times varied from wing to wing, also between the two tubes from each wing; the longest for each bird ranged from 13 to 180 min. with a mean of 69·25 min. (*S.D.* 36·6) (Fig. 1).

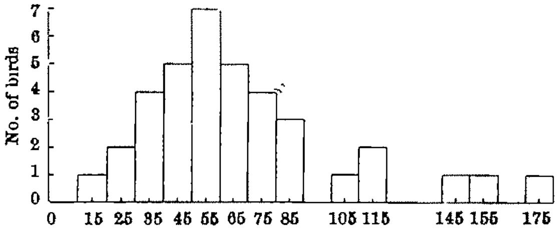


Fig. 1. Distribution of blood clotting times of thirty-seven chickens

Native blood was also timed with a stop watch following the addition of (1) 0·1 ml. of chicken brain thromboplastin prepared by the acetone dehydration method of Quick[7] and (2) 0·1 ml. of chicken thrombin (full strength) made by the technique described by Biggs and Macfarlane[8]. The results are summarized in Table 1.

Table 1. Coagulation Time at 42° C. of Chicken Blood with and without Added Thromboplastin or Thrombin

No. of birds	Material added	Clotting time (sec.)	Control Lee–White clotting time (min.)
21	Chicken thromboplastin	18·4 (11–17·8)	70
15	Chicken thrombin	30·6 (19–50)	64·5

These observations tend to confirm those of Howell[4,5] and indicate: (1) that the blood of the birds tested had generated very little plasma thromboplastin; (2) that the chicken has an efficient blood-clotting mechanism, but that it relies on an active tissue thromboplastin rather than plasma thromboplastin as do mammals; (3) that the shorter clotting times noted here and by other authors may have been due to action by vein wall tissue thromboplastin.

The apparently delayed action of the chicken thrombin in Table 1 is under investigation. A comparison of clotting times at 37° C. and 42° C. revealed only a slightly longer time at 37° C.

The assistance of Drs. Ballantyne and Carlson, Messrs. Delbecq and Baele and Miss Ohlman of the Veterinary Services Branch, Alberta Department of Agriculture, is acknowledged.

C. H. Bigland
D. C. Triantaphyllopoulos

Department of Physiology and Pharmacology,
University of Alberta,
Edmonton, Alberta.

[1] Dukes, H. H., "The Physiology of Domestic Animals", 7, 55 (Cornell University Press, New York, 1955).

[2] Johnson, E. P., and Connor, B. V., *J. Amer. Vet. Med. Assoc.*, 83, New Ser., 37, 325 (1933).

[3] Didisheim, P., Hattori, K., and Lewis, J. H., *J. Lab. and Clin. Med.*, 53, 6, 866 (1959).

[4] Howell, W. H., "A Textbook of Physiology", 3 (W. B. Saunders Co., Philadelphia, 1909).

[5] Howell, W. H., "A Textbook of Physiology", 14 (1940).

[6] Lee, R. I., and White, P. D., *Amer. J. Med. Sci.*, 145, 495 (1913).

[7] Quick, A. J., "The Hæmorrhagic Diseases" (Lea and Febiger, Philadelphia, 1957).

[8] Biggs, R., and Macfarlane, R. G., "Human Blood Coagulation and its Disorders" (Charles Thomas, Springfield, Ill., 1957).

HISTOLOGY

Neurokeratin Network of the Peripheral Nerve Fibre Myelin Sheath as a Centre of Metabolic Activity

THE neurokeratin network has long been regarded by histologists as a fixation artefact ; it is figured as such in papers and text-books. Sometimes it is shown as irregular bands radiating through the myelin sheath to the neurilemma, sometimes as a network particularly at the surface of the fibre or around the axon.

However, if fresh unfixed nerve fibres are studied under the interference microscope, an indication that similar structures are present can be seen, which suggests that a network-like structure may be present in the living nerve. Investigations of cryostat sections of fresh unfixed nerves in both transverse and longitudinal section indicated that this network is actually in the form of hexagonal prisms which have one end on the axon and radiate out through the myelin sheath to the neurilemma. The longitudinal faces of these prisms take the form of bands seen radiating through the myelin in transverse and medial longitudinal sections of nerve. The application of Baker's acid hæmatin technique showed that these faces give a positive phospholipid reaction, and osmium-fixed nerve, if extracted with turpentine, shows that the osmium tends to be retained on the faces of the prisms but is extracted from their interiors. Since electron microscopists simply stain overall with osmium tetroxide, perhaps this is why this network has not been described in electron microscope studies of the nerve fibre. On the other hand, the performic acid–Schiff reaction which is claimed to demonstrate unsaturated fats gives a reaction in the spaces which constitute the interior of the prisms. Mitochondrial preparations (Regaud and Schridde methods) of the nerve fibre show that a few bodies giving a positive stain for mitochondria are present in the axon, a number are found around the periphery of the axon and a number are found among the lipid (probably lipoprotein, also giving a positive reaction with these techniques) which forms the faces of the hexagonal prisms—no such bodies are found in the interior of these prisms. Adenosine triphosphatase preparations of fresh unfixed nerve demonstrate that this enzyme is localized in the myelin sheath in the same place as the mitochondrial reaction (that is, in the faces of the hexagonal prisms) and that every phosphate ester (about 20 were tried, including creatine phosphate) used as a substrate was dephosphorylated at the same sites as adenosine triphosphate. Acid phosphatase, on the other hand, was localized exclusively in the axon with the incubation times used. No adenosine triphosphatase or other enzyme activity was observed in the nodes of Ranvier. Studies on oxidative enzymes demonstrated that cytochrome oxidase and succinic dehydrogenase were also located in the same areas as the adenosine triphosphatase. Furthermore, we have also demonstrated that specific cholinesterase is located in and around the axon, and non-specific cholinesterase is located in the faces of the hexagonal prisms.

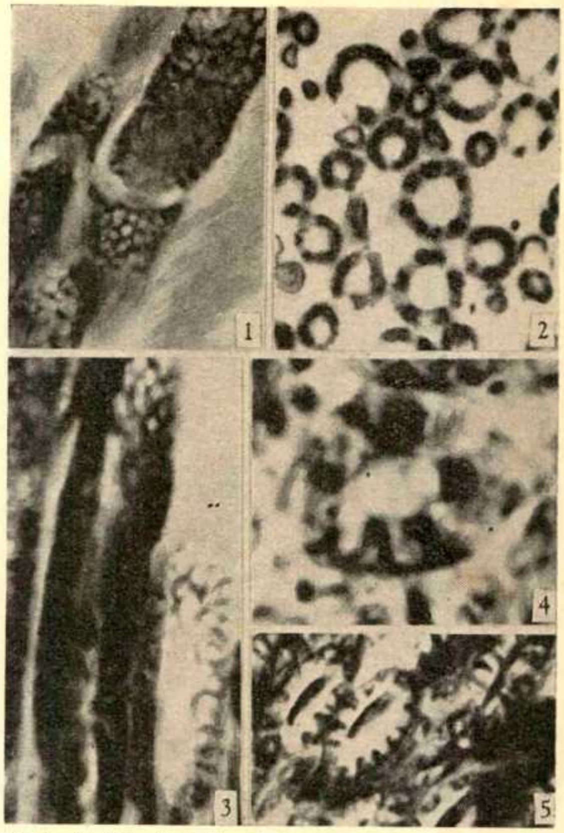


Fig. 1. 1, Adenosine triphosphatase preparation of frog myelinated nerve showing surface view of reaction localized in hexagonal network. On the right of the fibre the plane of section passes through the myelin sheath and the faces of the hexagonal prisms are shown as adenosine triphosphatase-positive bands radiating from the axon to the neurilemma. The node of Ranvier can be seen to contain no adenosine triphosphatase activity. (Preparation and photograph by David G. Shand) (× 1,050). 2, Mitochondrial preparation (Regaud's method) of myelinated nerve of rat. Transverse section. The reaction can be seen to be localized in bands which represent the faces of the hexagonal prisms (× 1,050). 3, Phospholipid preparation (Baker's method) of longitudinal section of myelinated nerve of rat. At the top of the figure the hexagonal appearance of this reaction (surface view) can be seen and further down, where the myelin sheath has been cut, the positive faces of the hexagonal prisms in the myelin sheath are visible (× 1,050). 4, Cytochrome oxidase preparation of a cryostat section of a transverse section of a single unfixed untreated nerve fibre of rat showing the reaction in the form of bands (the faces of the hexagons) radiating out from the axon to the neurilemma (× 2,100). 5, McManus sudan black *B* stain for compound lipids. Transverse sections of nerve fibres of rat. The reaction can be seen to extend in bands radiating out from axon to neurilemma (× 1,050)

The 'neurokeratin' network thus not only appears to be present in unfixed nerve but also to be a locus of major metabolic activity. The space within the neurokeratin network, although it contains lipid and ether- and alcohol-soluble material, gives no reaction with the mitochondrial techniques and contains no dephosphorylating or oxidative enzyme activity. Fig. 2 is an artist's impression of the arrangement of the metabolically active hexagonal prisms in the myelin sheath. It can be seen from this how either transverse or longitudinal sections of the nerve fibre will show the faces of the prisms as bands radiating out from the axon to the neurilemma and how, according to the point of section, some of the bands will appear thick and others thin. The faces of these prisms contain phospholipid, mitochondrial-like lipoprotein, adenosine triphosphatase, creatine phosphatase and a spectrum of other phosphatases, cytochrome oxidase, succinic dehydrogenase, and non-specific cholinesterase.

The possibility that these reactions are artefacts due to freezing, handling or other manipulation has been carefully considered. We feel that the results of our interference microscope studies indicate,

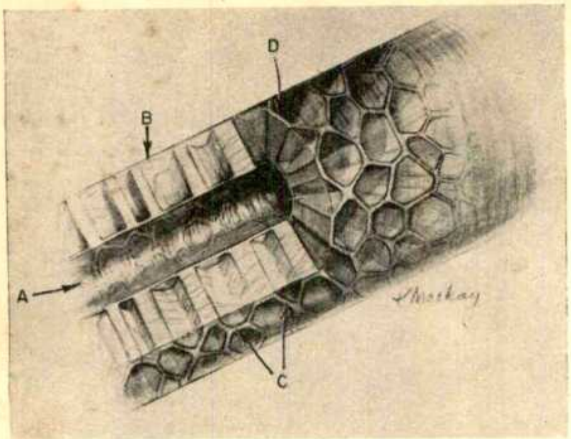


Fig. 2. *A*, Canal normally occupied by the axon ; *B*, neurilemmal sheath ; *C*, end-on view of faces of hexagonal prisms seen from surface of the nerve ; *D*, face of hexagonal prism as seen in transverse section of nerve

though not with absolute clarity, that some structure similar to what we have described may be present in the fresh nerve. Furthermore, our adenosine triphosphatase, cytochrome oxidase and succinic dehydrogenase reactions were carried out on fresh nerve which was simply removed from the animal and dropped straight into the substrate solution. However, all these processes have involved some handling and to compensate for this we have exposed the sciatic nerve in a living, anæsthetized rat without touching or stretching it and dropped buffered osmium tetroxide directly on to it as if we were preparing the material for electron microscopy. After the nerve had been well fixed *in situ*, it was removed, given further fixation in osmium tetroxide, sectioned and the sections were then extracted with turpentine and diacetin—we were able to bring up the neuro-keratin network in the form described in this communication. We feel, therefore, that the evidence for the *in vivo* existence of such a network is strong.

It is perhaps inappropriate to speculate on the significance of this structure at this time ; but perhaps we should mention that if the efflux of sodium and influx of potassium through the myelin sheath itself is important to nerve function and maintenance of membrane potentials, the faces of these hexagons are admirably adapted for this purpose. Conway[1,2] has suggested a redox system for the active transport of sodium ions by adsorption of these ions on to a catalyst molecule. The present work suggests that the catalyst molecules may be phospholipid, and it is of interest that Conway[3] has himself suggested that this may be so. Creatine phosphatase, adenosine triphosphatase and oxidative enzymes as required by Hodgkin[4] for his ion-pump mechanism are also present in these faces and their possible relationship to the physiology of the nerve fibre should therefore be carefully considered.

In the interpretation of these findings we have not taken into account the lamellæ which electron microscopists have described in the myelin sheath, although it is possible from our osmium tetroxide results that there is simply a stronger binding between the lipid and the protein components of the lamellae in the regions which we have described as the faces of the hexagons. Nerve fibres from the following animals were used in this study : frog, mouse, rat, cat, dog and human.

The work will be published in detail elsewhere. It was carried out under grant *B*-1914 from the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.

Note added April 20. While this communication was in the press Wolfgram and Rose[5] have demonstrated the presence of alkaline phosphatase, 5-nucleotidase (confirming the previous observations of Beckett and Bourne[6]) and adenosine triphosphatase in the neuro-keratin network and Koenig[7] has demonstrated the lipoprotein nature of the network.

H. B. TEWARI
GEOFFREY H. BOURNE

Department of Anatomy,
Emory University,
Atlanta 22, Georgia. Oct. 14.

[1] Conway, E. J., *Physiol. Rev.*, **37**, 84 (1957).
[2] Conway, E. J., Internat. Congr. Physiol. Soc. (1959).
[3] Conway, E. J., *Int. Rev. Cyt.*, **2**, 419 (1953).
[4] Hodgkin, A. L., Internat. Cong. Physiol., Buenos Aires (1959).
[5] Wolfgram, F., and Rose, A. S., *Neurology*, **10**, 365 (1960).
[6] Beckett, E. B., and Bourne, G. H., *J. Neuropath. and Exp. Neurol.*, **17**, 199 (1958).
[7] Koenig, H., *J. Neurochem.*, **4**, 93 (1959).

PATHOLOGY

Effect of Antibody and Complement on Volume Control in an Ascites Tumour Cell

WHEN Krebs mouse ascites tumour cells are exposed to the action of rabbit antibodies and complement, the permeability properties of the cells are altered in such a way as to permit rapid equilibration of small molecules and ions between the interior of the cells and the medium[1]. This deprives the cells of the ability to regulate their internal cation concentration, which is necessary for normal control of cell volume (ref. 2 and Tosteson, D. C., and Hoffman, J. F., personal communication). As a result, the cell volume then responds passively to whatever colloid osmotic pressure difference exists between the cell interior and the medium. In ordinary media, the colloid osmotic pressure of which is lower than that of the cells, the cells take in water[3,4]. As they swell, they lose protein and ribonucleic acid to the medium[1], probably until the colloid osmotic pressure inside the cells is reduced to that of the medium, when cell volume is stabilized at a new value.

Fig. 1 shows the result of an experiment in which rabbit anti-tumour γ-globulin and complement (fresh rabbit serum) were permitted to act on a washed suspension of ascites tumour cells in a bicarbonate-buffered balanced physiological salt solution containing varying concentrations of crystalline bovine serum albumin (Armour). After 15 min. incubation, a measured aliquot of suspension was placed in a graduated capillary sedimentation tube[5] and centrifuged at $550g$ for 30 min. at 0°. In the absence of added albumin, the antibody-complement treated cells swelled freely, as indicated by an increase of nearly threefold in packed cell volume. At increasing concentrations of albumin the swelling of the cells was progressively reduced, and at concentrations in excess of 110 mgm./ml. the cells were actually smaller than the controls. The volume of the control cells was practically insensitive to changes in albumin concentration, whether antibody was present or not. In most experiments, however, there was a slight increase in packed volume at high albumin concentrations, but this was probably due to poorer

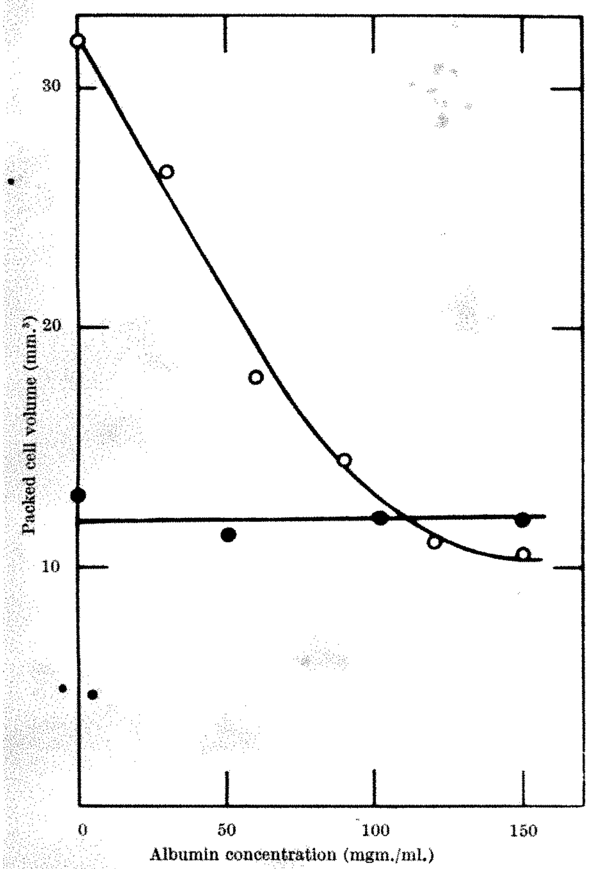


Fig. 1. Effect of albumin concentration on the packed volume of tumour cells treated with antibody plus complement.
To flasks containing 0·90 ml. of bovine albumin solutions of varying concentration were added 0·15 ml. immune rabbit γ-globulin (68 mgm./ml.), and 0·15 ml. washed cell suspension ($5·4 \times 10^7$ cells/ml.). To the experimental series 0·30 ml. rabbit complement was then added and to controls 0·30 ml. of heat-inactivated complement. After 15 min. incubation at 37°, while gently shaking in a water-bath, 1·0 ml. aliquots from each flask were placed in graduated capillary centrifuge tubes (ref. 5) and centrifuged.
○, Cells incubated in presence of antibody plus complement;
●. cells incubated in presence of antibody plus inactivated complement

packing of the cells in the denser and more viscous medium.

The decrease in the packed volume of the antibody-complement treated cells with increasing albumin concentration is not due to inhibition of the action of antibody and complement on the cells, since at high albumin concentrations the volume of these cells fell below that of the controls. Moreover, measurement by flame photometry of the potassium ions remaining in the packed cells showed a constant loss from the treated cells of most of their potassium ions over the whole protein concentration range, demonstrating that the antibody and complement had acted on the cells[1].

It appears from Fig. 1 that the colloid osmotic pressure of the cells is equal to that given by a solution containing 110 mgm./ml. serum albumin plus the proteins of the complement and immune γ-globulin. Assuming that globulins contribute half as much to the osmotic pressure as does albumin, the total colloid osmotic pressure would be equivalent to that of an albumin solution of about 130 mgm./ml.

Packed cell volume in these experiments was measured after 15-min. incubation. If, however, cells in albumin concentrations even higher than 110 mgm./ml. were observed in the phase microscope immediately after addition of antibody and complement, a transitory swelling of the cells was observed. After a very few minutes, however, this swelling was arrested and the cells shrank to a size which thereafter remained constant. This transitory swelling may be due to a temporarily more rapid influx of cations than efflux, a hypothesis suggested by Dr. John Cook and supported by the observation that the transitory swelling was largely abolished if sodium ion in the medium was replaced by an equimolar concentration of the larger, more slowly penetrating ion, choline.

It appears, therefore, that for cells which are able to regulate their cation concentrations, cell volume is not detectably sensitive to changes in the albumin concentration in the medium, for the osmotic pressure contributed by even the highest albumin concentration examined, $2·3 \times 10^{-3} M$, is negligible compared with that of the regulated cations. These cells are, of course, shrunk by relatively high molar concentrations of sucrose ($0·5 M$), to which the cell membrane is also impermeable. On the other hand, cells acted on by antibody and complement are not shrunk by sucrose, for the cell membrane becomes freely permeable to small molecules and ions[1]. For the same reason, these cells act as osmometers responding passively to the osmotic pressure of those macromolecules which are sufficiently large so that they cannot pass through the altered cell membrane.

H. GREEN
F. SILVERBLATT

Department of Pathology,
New York University–Bellevue Medical Center,
New York.

[1] Green, H., Barrow, P., and Goldberg, B., *J. Exp. Med.*, **110**, 699 (1959).
[2] Jacobs, M. H., and Stewart, D. R., *J. Cell. Comp. Physiol.*, **30**, 79 (1947).
[3] Ellem, K. A. O., *Austral. J. Sci.*, **20**, 116 (1957).
[4] Goldberg, B., and Green, H., *J. Exp. Med.*, **109**, 505 (1959).
[5] Van Allen, C. M., *J. Lab. Clin. Med.*, **12**, 282 (1926).

Changes in the Deoxyribonucleic Acid Content of Mouse Sarcoma 37 Cells following Serial Irradiation

CHANGES in the deoxyribonucleic acid content of human tumour cells following irradiation have been reported by Richards and Atkin[1] and Atkin, Richards and Ross[2]. There exists strong evidence in support of a positive relationship between modal deoxyribonucleic acid content and the degree of ploidy; this has been discussed by Atkin and Richards[3], and Richards and Atkin[4]. This communication reports changes in content of deoxyribonucleic acid in the mouse sarcoma 37 following serial irradiation.

The tumours selected for study were taken from untreated control transplants and from the twentieth untreated sub-line passage of the twelfth stage of the serially irradiated line (*B*12). Although the irradiated line at this stage varied from the control with respect to histology and cytology, no subsequent variations occurred during sub-line passages. Details of the techniques employed in establishing the irradiated line have been given elsewhere[5]. Smears of isolated cells from the cortex of actively growing tumours were prepared as described by Atkin and Richards[3]. The amount of deoxyribonucleic acid in individual cell nuclei was estimated by microspectrophotometry of Feulgen stained material. Two tumours from each group were used; 72 cells were measured in each of one pair (Fig. 1, *A* and *C*) and 45

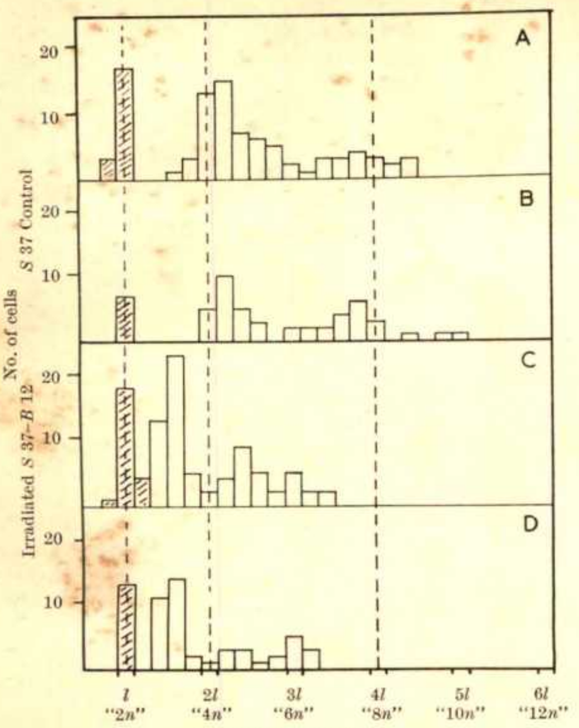


Fig. 1. Measurements of deoxyribonucleic acid in cells of sarcoma 37 and its serially irradiated line *B*12. Shaded regions, leucocytes; unshaded regions, tumour cells

cells in the second (*B* and *D*). In addition, 14–20 polymorphonuclear leucocytes and lymphocytes were measured from each tumour preparation to provide a modal value corresponding to the diploid level (the l value).

The results of these measurements are shown in Fig. 1 in the form of histograms having 10 classes between the $2l$ and $4l$ values. Control tumours exhibited a primary mode in the tetraploid region with an extensive spread to the hyperoctoploid region. Irradiated line tumours exhibited a primary mode corresponding to a triploid condition with a less extensive spread towards higher values than was found in control tumours.

It is apparent that the modal deoxyribonucleic acid value of the irradiated mouse tumour line differed from that of the unirradiated control. Radiosensitivity comparisons between the two lines, however, indicated that no changes had occurred in the tumour lethal dose; at lower dose-levels, an increased radiosensitivity was apparent in the irradiated line[5]. It seems, therefore, that the changes observed cannot be correlated with the acquisition by the irradiated line of radioresistant characteristics. In this connexion it is of interest that serial observations on the content of deoxyribonucleic acid of two human cervical carcinomata, which responded poorly to radiotherapy, strongly suggested the emergence following treatment of a stable radioresistant cell strain having in both cases a triploid deoxyribonucleic acid content from what was originally a mixed population[1]. The accumulated data on human uterine tumours[1,2] show that there is no clear-cut correlation between ploidy-level and response to radiotherapy, although near-diploid tumours appear to give rise to fewer local recurrences than do those with higher modal values of deoxyribonucleic acid.

Our thanks are due to Mr. D. Doxey for assistance with the preparation of cell smears. The deoxyribonucleic acid measurements were made in collaboration with Dr. B. M. Richards, at the Wheatstone Physics Laboratory, King's College, London.

The expenses of this research were defrayed from a block grant by the British Empire Cancer Campaign.

A. E. G. PEARSON
N. B. ATKIN

Department of Experimental Pathology,
Mount Vernon Hospital,
Northwood, Middlesex.

[1] Richards, B. M., and Atkin, N. B., *Brit. J. Cancer*, **13**, 788 (1959).

[2] Atkin, N. B., Richards, B. M., and Ross, A. J., *Brit. J. Cancer*, **13**, 773 (1959).

[3] Atkin, N. B., and Richards, B. M., *Brit. J. Cancer*, **10**, 769 (1956).

[4] Richards, B. M., and Atkin, N. B., *Acta Int. Unio contra Cancrum*, **16**, 124 (1960).

[5] Pearson, A. E. G., *Brit. J. Cancer*, **13**, 477 (1959).

BIOLOGY

Nuclear Morphology of Human Spermatozoa

THIS communication concerns observations on dried, unstained smears of human spermatozoa in phase contrast. These were made in an attempt to gain more insight into the basis for the known differential in conception and birth sex ratios.

Spermatozoa from forty men were studied. Thin smears were allowed to dry. Observations became clearer with increase in extent of drying. The dry phase objectives and condensers were used. Oil immersion and wet preparations in seminal fluid did not permit observation of nuclear detail, that is, the chromosomes accentuated their own visualization in phase contrast in the dried state. A Zeiss phase-contrast microscope with built-in accessory scope was used. A Leica camera with 'Ibso' attachment and 'Microfile' film was employed.

Under these conditions, lying horizontally, the spermatozoan heads fell into two distinct populations (Figs. 1–3). There were no intermediate types. Reflexion of light was different for the two kinds

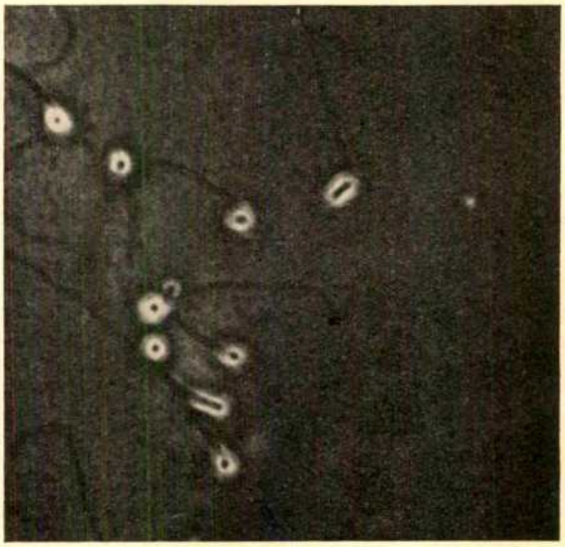


Fig. 1. Dried, unstained smear of human spermatozoa in phase contrast. (× 640)

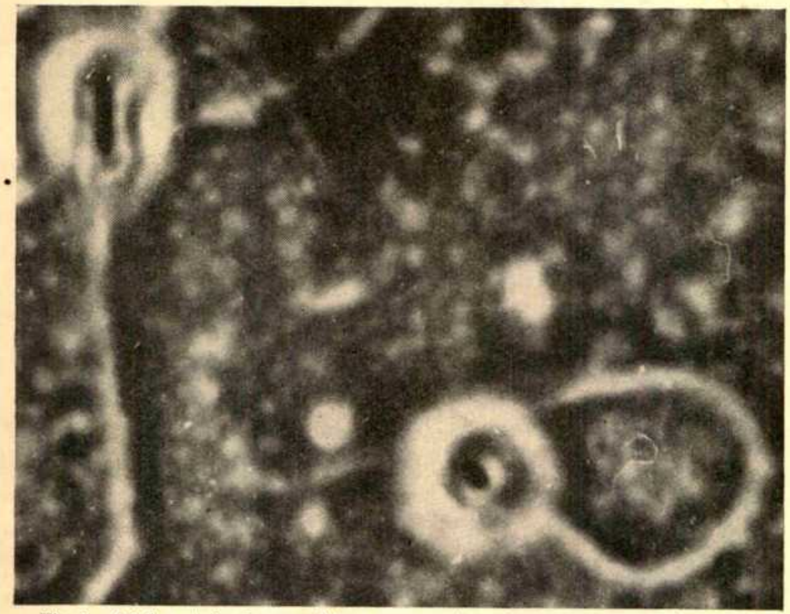


Fig. 2. Dried, unstained smear of human spermatozoa in phase contrast. (× *c.* 750)

(Figs. 1 and 2). The smaller-headed spermatozoa contained a centrally located, rounded mass, whereas the larger-headed ones had an elongated mass, centrally located. These masses lay anterior to, and in line with, the axial filament of the mid-piece. There was a definite, constant pattern of nuclear content in each type, conforming in outline to the respective, most central chromosome (Fig. 3). In the smaller-headed spermatozoa the nuclear material was arranged with circular concentricity; in the larger-headed ones, the nuclear material had an elliptical or ovoid configuration. The pattern of arrangement remained characteristic and recognizable for each of the two types of spermatozoan heads, in front and side views and while varying the focus. The nuclear content of the larger-headed spermatozoa was less compact; consequently more detail was seen at different focal levels here. In one head of this type three observers counted independently 18 discrete chromosomes at different focal levels. With proper combination of condenser and dry objective the difference in diffraction of light by the chromosomes markedly enhanced their visibility, as though they were stained differentially. This made it possible to photograph them in colour.

The most centrally situated chromosome in each type of nucleus possessed the exact size and shape relationships of the X and Y chromosomes previously observed in the primary and secondary spermatocytes at metaphase in meiosis (Fig. 3).

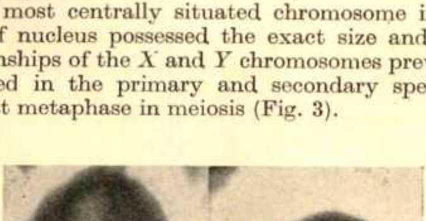


Fig. 3. Dried, unstained smear of human spermatozoa in phase contrast. (× 1,000)

Even though the characteristics were remarkably constant for the two types of spermatozoan heads within a given specimen, the overall head-size varied from individual to another. In some donors the respective head-sizes were twice as great as in others. Even though actual percentages were not ascertained for each type in each specimen, it was readily noted that the ratio was not the same in all specimens, and that there was a preponderance of the smaller-headed spermatozoa in each specimen. Further observations are being made on the ratio of the two kinds in a large number of specimens and in varied circumstances.

Any differential in migratory rate of the two kinds of spermatozoa can now be investigated with ease by means of the capillary tube method[1]. This is now being studied. With the two distinct types now recognizable, the efficacy can be checked of attempts to separate the X- and Y-chromosome-containing spermatozoa.

In summary, viewed in phase contrast, dried, unstained spermatozoa fall into two distinct populations regarding head and nuclear size, shape, diffraction of light and chromosomal pattern. With knowledge of the behaviour of the sex chromosomes at metaphase of the meiotic division of the primary and secondary spermatocytes, the relative sizes and shapes of the chromosomes in the centre of the spermatozoan nuclei indicate that the smaller heads contain the Y- and the larger the X-chromosome.

LANDRUM B. SHETTLES
Department of Obstetrics and Gynecology,
College of Physicians and Surgeons,
Columbia University, and the
Sloane Hospital for Women,
New York City.

[1] Shettles, L. B., *Proc. Soc. Exp. Biol. and Med.*, **45**, 318 (1940).

Dependence of the Sex Ratio at Birth on the Age of the Father

RECENTLY I have attempted to develop a general theory of ageing applicable to mammals[1]. This theory assumes that, during the life-time of the animal, whole chromosomes, which are contained in the somatic cells, suffer a total loss of function in a single random event. It further assumes that the probability of such an event remains constant throughout life-time and that it is the same for all individuals of a given species.

From the American life-tables I have derived, on the basis of the theory, the frequency with which such random events occur in man and found that on the average one chromosome, of the haploid chromosomal set of the somatic cell, suffers such a 'hit' in about twelve years. If we assume that this holds also for the spermatogonia in man, we should then expect that the ratio of boys and girls, at birth, decreases appreciably with the age of the father. This conclusion is based on the following notions:

We may assume that any cell of the male becomes non-functional if the *X* chromosome for which the cell is hemizygous suffers an ageing hit, that is, the absence of the *X* chromosomes is lethal for the somatic cell in the male. The absence of the *Y* chromosome is not lethal for the somatic cell and, as a matter of fact, it need not be lethal even for the zygotes; there exist individuals whose cells contain one *X* chromosome and no *Y* chromosome and these exhibit Turner's syndrome.

Accordingly, if the *X* chromosome in a spermatogonium suffers an ageing hit, then the cell is eliminated; if the *Y* chromosome in a spermatogonium suffers an ageing hit, then the cell remains fully functional and will give rise to spermatozoa, but only to spermatozoa which contain an *X* chromosome.

The length of the *Y* chromosomes amounts to about 2 per cent of the total length of the haploid set of the autosomes[2] and on this basis we may perhaps assume that an average of 2 per cent of the *Y* chromosomes of the spermatogonia suffer an ageing hit in a 12-year period.

We may assume that some spermatogonia are lost due to causes other than ageing and are replaced by other spermatogonia undergoing divisions. Then if spermatogonia which lack a functioning *Y* chromosome divide at the same rate as spermatogonia which carry a functioning *Y* chromosome, the ratio, at birth, of boys and girls would decrease by 2 per cent for a 12-years increase in the age of the father, and by 4 per cent for a 24-years increase. However, if the spermatogonia which lack a functioning *Y* chromosome undergo divisions at a somewhat lower rate, then the ratio of boys and girls would, initially, decrease with the father's age at the rate quoted above, but the ratio would approach a fixed value with increasing age of the father.

One may compute on the basis of birth data[3] for the United States, 1955, the dependence of the ratio of boys and girls on the age of the father. For the age-group of the father indicated and for the sample sizes—for boys alone or girls alone—given in brackets, the ratios are as given in Table 1.

Table 1

15–19 yr. (~ 46,000): 106·7; 20–24 yr. (~ 410,000): 105·7;
25–29 yr. (~ 590,000): 105·0; 30–34 yr. (~ 440,000): 105·0;
35–39 yr. (~ 250,000): 105·0; 40–44 yr. (~ 120,000): 104·1;
45–49 yr. (~ 45,000): 103·6

These data do not take into account the age of the mother, and there is, of course, a strong correlation between the age of the father and the age of the mother. What one would want to know is the dependence of the sex ratio at birth on the age of the father, for a fixed age of the mother. However, if one tabulates the available data on this basis the sample sizes become too small.

From the data given in Table 1 it would appear that the ratio of boys and girls does fall with increasing age of the father. It will not be possible, however, to draw conclusions which are relevant from the point of view of the theory until the data based on larger samples become available.

Leo Szilard

Enrico Fermi Institute for Nuclear Studies,
University of Chicago,
Chicago 37.

---

[1] Szilard, Leo, *Proc. U.S. Nat. Acad. Sci.*, **45**, 32 (1959).

[2] Tijo, J. H., and Puck, T. T., *Proc. U.S. Nat. Acad. Sci.*, **44**, 1929 (1959).

[3] "Vital Statistics of the U.S.", 1, 213 (1955).

Neuro-Muscular Transmission in the Earthworm

Neuro-muscular transmission was investigated in the earthworm, *Lumbricus terrestris*, by stimulating a segmental nerve with maximal shocks and recording the electrical responses from the surface of the longitudinal muscle.

A single action potential was recorded to each shock, and from latent period measurements it was calculated that conduction velocity in the motor neurones was of the order of 0·4 m. per sec. This slow velocity suggests that, unlike the situation in *Myxicola*[1] and certain other polychaetes[2], there are no rapidly conducting giant axons in the segmental nerves of *Lumbricus*.

At frequencies greater than 1 per sec. the first muscle potential was found to be consistently smaller than subsequent ones (Fig. 1). In a very few preparations there was a gradual increase in size over the first three responses. In greatly fatigued preparations the response to the first shock was much reduced, though never completely absent, and the difference between the first and second responses particularly marked.

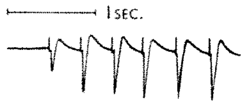


Fig. 1. *Lumbricus terrestris*: longitudinal muscle potentials in response to repetitive stimulation of segmental nerve at three shocks per sec. Tracing of original oscillograph record. Each potential preceded by upward-projecting stimulus artefact

If the frequency of stimulation is gradually increased the size of the muscle potentials also increases. For example, in one preparation (Fig. 2) the segmental nerve was stimulated initially at just less than one shock every 2 sec. and the approximate height of the muscle potentials, measured from the oscillograph trace, was 7·5 mm. The frequency was then increased to 3 per sec. and the muscle potentials rose to 13 mm., being maintained at about this height until after several seconds the frequency was decreased again.

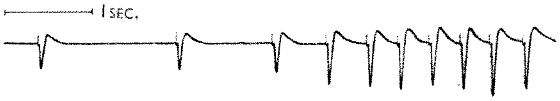


Fig. 2. *Lumbricus terrestris*: longitudinal muscle potentials in response to repetitive stimulation of segmental nerve at gradually increasing frequency. Tracing of original oscillograph record. Each potential preceded by upward-projecting stimulus artefact

With prolonged repetitive stimulation the potentials, after being maintained for a short while, undergo a gradual decline in magnitude, the number of shocks required to induce fatigue depending on the frequency of stimulation and the freshness of the preparation.

G. A. Horridge

Gatty Marine Laboratory,
St. Andrews,
Fife.

M. B. V. Roberts

Biology Department,
Marlborough College,
Wiltshire.

---

[1] Nicol, J. A. C., and Young, J. Z., *Nature*, **158**, 167 (1946).

[2] Nicol, J. A. C., *Quart. Rev. Biol.*, **23**, 291 (1948).

Determination of Physiological Age for Female *Glossina morsitans*

Recently, considerable attention has been paid to a method of determining the physiological age of female insects of economic importance by the appearance of the ovarioles after ovulation. This method, which was originally worked out by Soviet entomologists[1,2] for *Anopheles*, and has since been extended to other blood-sucking Diptera, depends upon the recognition of the number of follicular relics ('corpora lutea') appearing as dilatations of the follicular tubes. Each dilatation represents the relic of a single egg follicle and is evidence of a gonotrophic cycle. If the duration of the cycle is known it is possible to calculate the calendar age of the female, a factor of great practical application in determining the epidemiological importance of populations of insect vectors or the degree of success of control programmes. In the laboratory, Bertram and Samarawickrema[3] recognized *Mansonioides uniformis* which had completed five gonotrophic cycles by the presence of five dilatations in the follicular tubes. A study of the ovarioles of *Glossina morsitans* after ovulation has been made, and it is suggested that a similar method of determining the physiological age of female tsetse flies should be possible.

Each ovary of *G. morsitans* consists of two polytrophic ovarioles, each at a different stage of development[4]. Only one egg matures at a time, and a sequence of ovulation occurs so that the first and third eggs are ovulated from the right ovary and the second and fourth eggs from the left ovary. Subsequent eggs are produced from each ovariole in a continuation of the same sequence.

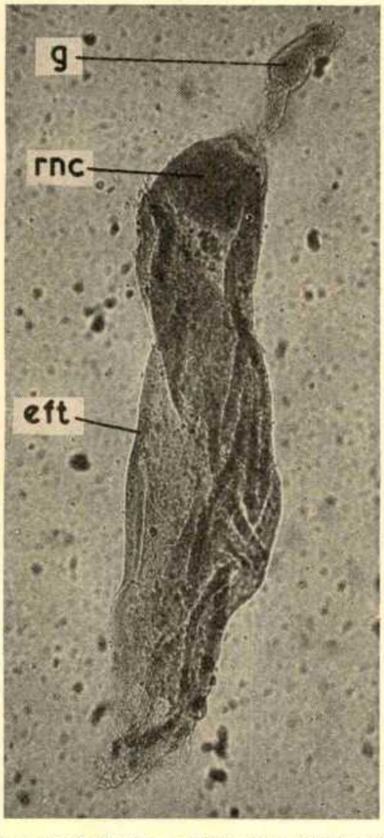


Fig. 1. Ovariole of *Glossina morsitans*, immediately after ovulation of egg. *g*, Germarium; *rnc*, remains of the nurse cells; *eft*, expanded follicular tube

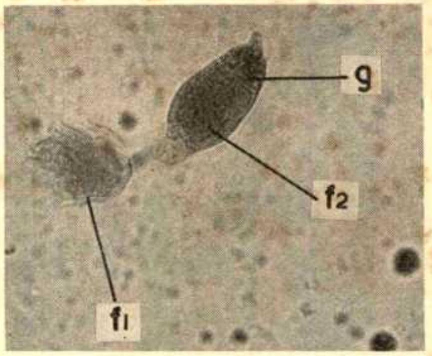


Fig. 2. Ovariole of *Glossina morsitans*, six days after ovulation. *g*, Germarium; *f2*, first signs of second egg follicle developing in the germarium; *f1*, remains of first follicle

Immediately after ovulation the follicular tube of the ovariole, which has been greatly stretched to accommodate the mature egg, is an open expanded sac which retains the remains of the nurse cells and the follicular epithelium (the follicular relic) (Fig. 1). In the next few days the follicular tube begins to contract and the follicular relic is passed out of the ovariole. A greater part of the expanded follicular tube then becomes detached, possibly because the germarium is pushed towards the anterior end of the ovary by the growth of the other ovariole. After four days all that remains of the 'dilatation' is a small piece of tissue remaining on the posterior end of the follicular tube which resembles the 'funicle stumps' of parous *Anopheles gambiae* described by Lewis[5], and is evidence of ovulation (Fig. 2). As a complete dilatation as described for *M. uniformis*[3] is not formed, serial dilatations are never found in *Glossina morsitans*, and ovarioles which have ovulated twice or more cannot be distinguished from those which have only ovulated once. The sequence of ovulation, however, enables the number of eggs produced by a female to be determined up to the production of the fourth egg; after this it is impossible to tell how many eggs have been produced.

At 26° C., the fourth egg is ovulated (from the left ovary) 40 days after the emergence of the fly and therefore, at this temperature, flies may be aged up to at least the fortieth day by the number and position of the funicle stumps and the relative sizes of the four egg follicles. After the ovulation of the first egg (eighth or ninth day at 26° C.) eggs are ovulated about every 10 days, and the uterus contains either an egg or a developing larva. Each of the latter 10-day periods, therefore, may be subdivided by the stage of the offspring *in utero*. It is suggested that a combination of these observations could be used to determine the age of wild-caught tsetse flies.

D. S. Saunders

Department of Zoology,
University of Edinburgh,
West Mains Road,
Edinburgh, 9.

[1] Detinova, T. S., Course in advanced entomological techniques applied to malaria eradication. Age grouping methods in Diptera of medical importance, World Health Organization, *WHO/Mal*/238 (Sept. 1959).

[2] Gillies, M. T., *Trop. Dis. Bull.*, **55**, 713 (1958).

[3] Bertram, D. S., and Samarawickrema, W. A., *Nature*, **182**, 444 (1958).

[4] Saunders, D. S., *Nature*, **185**, 121 (1960).

[5] Lewis, D. J., *Trans. Roy. Soc. Trop. Med. Hyg.*, **52**, 456 (1958).

Induction Phenomena in Photosynthesis of Isolated Spinach Chloroplasts

IN a number of papers concerning the induction phenomena during photosynthesis[1-5] I have determined the interrelationship between time and photosynthetic intensity as expressed by the photosynthesis time-curve. The sample plants used were mainly various species of moss[4]. In most cases the rate of photosynthesis was measured in terms of uptake of carbon dioxide ; but in a few cases the rate of oxygen given off was measured as well[3] : the determinations were made by means of the diaferometer method (the gas thermal conductivity method)[1].

Uptake of carbon dioxide sets in immediately the plant material is exposed to light, a peak appearing in the photosynthesis time-curve (Fig. 1, curve *A*). It appears to be reasonable to assume that this is due to the presence of a so-called carbon dioxide acceptor I, which is probably different from ribulose diphosphate, the latter coming into full action somewhat later and consequently being referred to as acceptor II[2,5]. It is further shown that at 15° C. the carbon dioxide taken up is normally transferred in the course of 5–6 min. to acceptor II, or, alternatively, that it enters the assimilation process proper in other ways[2,5]. If the illumination is suspended before this occurs a gush of carbon dioxide appears[2]. If the plants are heated at 40–50° C. for 3 min. prior to the measurements, the photosynthesis proper is found to have been inhibited completely. However, this is not true of the initial uptake of carbon dioxide by acceptor I. Probably a certain degree of inhibition exists in this case as well, but a very distinct peak is still found in the photosynthesis time-curve immediately following the onset of illumination. In these circumstances a gush of carbon dioxide appears when the light is switched off, its value corresponding to the amount of carbon dioxide fixed during the initial uptake. Similar reactions are found in cases where the plants are treated with cyanide, arsenate or iodoacetamide prior to the measurements, or if they are subjected to very high concentrations of carbon dioxide during the measurements[5,6].

In a number of papers, Arnon *et al.*[7-12] have demonstrated the practicability of effecting complete photosynthesis with isolated chloroplasts. They demonstrated the uptake of carbon dioxide in a suspension of chloroplasts to which had been added carbon-14, measuring the radioactivity of the dried chloroplasts[9]. In the present work the same isolation technique was used and by this means I succeeded in directly drawing the photosynthesis time-curve for a preparation of chloroplasts using the diaferometer method.

By means of the above isolation technique[9,10] the chloroplasts are obtained in the form of a suspension in 0·35 *M* sodium chloride. The uptake of carbon dioxide is reported to have been demonstrated by illuminating a mixture of this suspension with a *tris*-buffer solution (*p*H 7·4) to which have been added ascorbate and manganous chloride. Centrifugation of such a mixture in a centrifuge tube containing a piece of filter paper at the bottom results in the fixation of the chloroplasts on to the paper which can then be placed in the plant container of the diaferometer, where they are then exposed to an intensity of 6,500 lux at 15° C. in streaming atmospheric air to which has been added 3 vol. per cent of carbon dioxide. The results appear in Fig. 1. Curve *A* is the photosynthesis time-curve for an intact spinach leaf, and curve *B* is the corresponding curve for isolated spinach chloroplasts in contact with ascorbate and manganese chloride during the measurements.

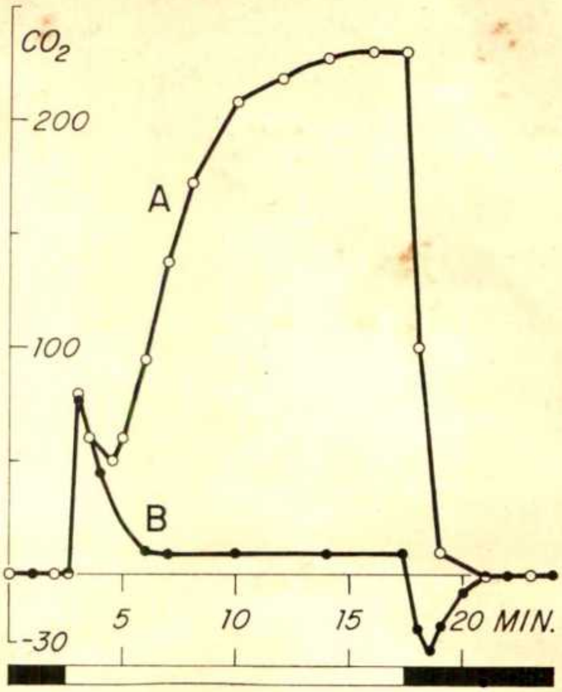


Fig. 1. Photosynthesis time-curves for an intact spinach leaf (*A*) and for isolated spinach chloroplasts (*B*) suspended in 0·35 *M* sodium chloride, added *tris*-buffer (*p*H 7·4), ascorbate and manganous chloride and fixed on to filter-paper. Ordinate, carbon dioxide uptake in arbitrary units ; abscissa, time (min.). Black and white areas indicate periods of dark and light on the plant material

This curve (*B*) is very reminiscent of the photosynthesis–time curves from intact leaves which had been exposed to heat, had been treated with cyanide, arsenate or iodoacetamide, or which during the measurements proper had been surrounded by air of an excessively high content of carbon dioxide (10–20 vol. per cent). There appear to be two possible explanations of this similarity. First, Arnon *et al.*[10] have shown that even a brief heating of the isolated chloroplasts at room temperature causes a considerable reduction of their ability to fix carbon dioxide on illumination. Hence it would appear to be conceivable that the reaction shown by intact leaves when heated for 3 min. at 40–50° C. in the chloroplast preparation experiments might occur already at lower temperatures. Secondly, although the chloroplasts were surrounded by a liquid containing ascorbate and manganous chloride during the measurements proper the experimental conditions must be considered to have been fairly unfavourable for the photosynthetic turnover[12]. Hence it appears to be permissible to a certain extent to compare them to similar ones which might be assumed to exist during certain toxic conditions when one or more steps in the mechanism of photosynthesis are paralysed.

In this connexion it is worth noting that if the chloroplasts only are suspended in a solution of buffer in 0·35 *M* sodium chloride without the addition of ascorbate and manganous chloride the photosynthesis–time curve shows only the initial peak during the light period and the gush of carbon dioxide during the terminating dark period, but no uptake of carbon dioxide after the development of the peak. One fact is conspicuous, namely, that although the photosynthesis proper in the chloroplast preparation is comparatively slight the initial peak in the time-curve is very distinct. As in the case of the whole leaves treated in any of the above ways, it may be established in this case also that the amount of carbon dioxide taken up immediately on the onset of illumination remains fixed throughout the duration of the light period, to be liberated afterwards in the form of a gush of carbon dioxide.

Hence the use of the diaferometer method offers the possibility of registering the initial as well as the subsequent uptake of carbon dioxide in isolated chloroplasts. The isotope technique used by Arnon, Allen and Whatley[10], on the other hand, allowed them to register only the amount of carbon dioxide which remains fixed even after the light has been switched off. The preliminary experiments here described appear to confirm the hypothesis mentioned concerning the function of acceptor I immediately upon the onset of illumination. They also show that this acceptor is found in the chloroplasts and that hence it must be considered to be part of the photosynthetic apparatus proper. Further photosynthesis experiments with isolated chloroplasts are in progress and will be published in detail elsewhere.

I wish to thank Prof. J. Moustgaard and Dr. A. Neimann-Sørensen of the Royal Veterinary and Agricultural College, who kindly placed at my disposal a refrigerated centrifuge. Thanks are also due to the Carlsberg Foundation for financial support of apparatus and technicians.

KNUD VEJLBY
Laboratory of Plant Physiology,
Royal Veterinary and Agricultural College,
Copenhagen. Oct. 29.

[1] Vejlby, K., *Physiol. Plant.*, **11**, 158 (1958).
[2] Vejlby, K., *Physiol. Plant.*, **11**, 866 (1958).
[3] Vejlby, K., *Physiol. Plant.*, **12**, 162 (1959).
[4] Vejlby, K., *Physiol. Plant.*, **12**, 559 (1959).
[5] Vejlby, K., *Physiol. Plant.*, **12**, 893 (1959).
[6] Gabrielsen, E. K., and Vejlby, K., *Physiol. Plant.*, **12**, 425 (1959).
[7] Arnon, D. I., Allen, M. B., and Whatley, F. R., *Nature*, **174**, 394 (1954).
[8] Arnon, D. I., Whatley, F. R., and Allen, M. B., *J. Amer. Chem. Soc.*, **76**, 6324 (1954).
[9] Allen, M. B., Arnon, D. I., Capindale, J. B., Whatley, F. R., and Durham, L. J., *J. Amer. Chem. Soc.*, **77**, 4149 (1955).
[10] Arnon, D. I., Allen, M. B., and Whatley, F. R., *Biochim. Biophys. Acta*, **20**, 449 (1956).
[11] Trebst, A. V., Tsuijmoto, H. Y., and Arnon, D. I., *Nature*, **182**, 351 (1958).
[12] Arnon, D. I., *Nature*, **184**, 10 (1959).

Hæmoglobin in the Root Nodules of *Casuarina cunninghamiana*

IN higher plants the respiratory pigment hæmoglobin has been detected only in root nodules of legumes[1,2]; it occurs there in all the species examined when nodulation is initiated by an effective nitrogen-fixing strain of the symbiont *Rhizobium*[2]. The presence of the pigment therefore appears to be possibly connected with the process of symbiotic nitrogen fixation.

Symbiotic nitrogen fixation is not, however, confined to the Leguminosae. Nine genera of Angiosperms, derived from six families, bear root nodules when an appropriate endophyte is present, and the capacity of these nodules to fix nitrogen at high rates is now well established. The quantitative work in this field has largely been carried out by Bond and his colleagues. Bond has recently reviewed the literature on the subject[4,5].

It is therefore not surprising that non-legume root nodules have been examined for the presence of hæmoglobin. Smith (quoted in ref. 6) was unable to detect the pigment in nodules of *Myrica*. Similar negative results were obtained by Egle and Munding[7] with *Alnus*, *Hippophaë* and *Myrica*, but they were able to show that the total hæmatin content of nodules of these genera, estimated as pyridine hæmochromogen, was 4–5 times greater than that of the cortex of non-nodulated roots. This work gave no indication of the manner in which the hæmatin occurs in the living cell. An opportunity to find whether it is present as a hæmoprotein, like all the known functional hæmatin compounds, was presented when Dr. G. Bond generously offered to supply nodulated material from *Alnus*, *Hippophaë*, *Myrica* and *Casuarina*. This had been obtained from plants grown in liquid culture in a medium devoid of combined nitrogen. A spectroscopic re-examination of the nodules seemed especially desirable in view of the high sensitivity of their fixation process to the presence of carbon monoxide[8].

The nodules of all four genera were found to possess a very active phenol oxidase system: the discoloration which occurred when nodules were crushed in water or dilute phosphate buffers hindered, and sometimes precluded, spectroscopic examination. It was found that this discoloration was decreased by using 0·2 *M* *tris* (2-amino-2-hydroxymethylpropane-1:3-diol) buffer, *p*H 7·4, containing 0·02 *M* sodium ethylenediamine tetraacetate. For the estimation of total hæmatin the weighed nodules were ground in this medium with the addition of sufficient sodium dithionite to exclude dissolved oxygen. The ground material was transferred to a Thunberg tube, pyridine was added to 30 per cent (v/v) and the tube evacuated. The contents of the tubes showed the spectrum of pyridine protohæmochromogen when viewed with a Zeiss pupillary spectroscope against a strong light. The concentration of hæmochromogen was estimated by comparing the spectrum of the vacuum tube contents with that of a pyridine hæmochromogen standard derived from bovine hæmin in the spectrocolorimeter described by Hill[9]. These measurements (Table 1) confirm the results of Egle and Munding[7] and extend them to the genus *Casuarina* in which the level of hæmatin was always higher than in the other genera and was, in fact, comparable with that in leguminous root nodules[3].

Spectroscopic examination of preparations of *Casuarina* nodules ground in the *tris* medium with dithionite showed a diffuse absorption band with a maximum at 562 mμ. This band is similar to that of deoxygenated hæmoglobin and is unlike the sharp α-band of a cytochrome or hæmochromogen. An attempt was made to observe the oxygenated compound by omitting dithionite from the grinding

Table 1. TOTAL HÆMATIN CONTENT OF NODULE AND ROOT TISSUES

	μmoles hæmatin/gm. fresh weight ($\times 10^2$)	
	Nodules	Root cortex
Alnus glutinosa	4·85	0·6
Myrica gale	5·5	0·5
Hippophaë rhamnoides	4·2	0·5
Casuarina cunninghamiana	12·0	0·7
Pisum sativum	10·8	—

medium. Rapid spectroscopic observation immediately after grinding then showed two absorption bands, with maxima at 580 mμ and 544 mμ, resembling those of oxyhæmoglobin. This spectrum was ephemeral and the bands rapidly faded as the tissue debris became discoloured by the phenol oxidase activity; the change might have been due to oxidation of hæmoglobin iron by quinones produced by the phenol oxidase[2]. An indication that oxidation to a compound similar to methæmoglobin had occurred was obtained by adding fluoride to the preparation, when an absorption band, resembling that of fluoride methæmoglobin, appeared at 610 mμ.

Although these observations suggested that *Casuarina* nodules contain a pigment with the spectroscopic properties of a hæmoglobin, the rapid disappearance of the oxyhæmoglobin type of spectrum in the macerated preparations made it difficult to establish that the pigment can undergo alternate deoxygenation and oxygenation without change in valency of the hæm iron. This capacity for reversible combination with molecular oxygen is the essential property of hæmoglobin and is the basis of its function as a respiratory pigment. Unequivocal evidence on this point was, however, obtained by spectroscopic examination of the intact nodules. For this purpose a small cluster of nodules was mounted in a drop of the *tris* medium in a cell on a microscope slide. When the cluster was illuminated, on the microscope stage, by the condensed light of a 500-watt projection lamp, sufficient light was transmitted by the less-opaque portions of the nodule cluster for spectroscopic examination to be made, using a 16-mm. objective with the Zeiss pupillary spectroscope as ocular.

With the untreated nodules a spectrum with two absorption bands, at 580 mμ and 542 mμ, could easily be observed. When a small amount of sodium dithionite was added to the fluid surrounding the nodules the two bands were slowly replaced by a single diffuse band at 562 mμ. What is more significant, however, is that when the dithionite solution was then replaced by fresh *tris* medium the two-banded spectrum reappeared. This sequence of events also occurred in the absence of a reducing agent if the nodules were allowed to respire the dissolved oxygen in the fluid surrounding them and air was then readmitted. Confirmation that the hæm iron of the pigment is in the ferrous state *in vivo* was obtained by treating the nodules with carbon monoxide, when two diffuse absorption bands at 572 mμ and 542 mμ replaced the characteristic spectra of either the oxygenated or deoxygenated derivative. The hæm pigment of *Casuarina* root nodules appears, therefore, to possess the essential properties of hæmoglobin.

An estimate of the proportion of the total hæmatin occurring in the form of hæmoglobin was obtained by grinding nodules in the *tris* medium with added dithionite, treating the preparation with carbon monoxide in a Thunberg tube, and comparing the spectrum of the tube contents with that of a standard solution of carboxymyoglobin prepared from sperm whale muscle. In nodules containing 0·11 μmole total hæmatin/gm. fresh weight, carboxyhæmoglobin accounted for 0·083 μmole.

The hæmoglobin of leguminous root nodules is readily extracted by aqueous solvents[2]. That of *Casuarina*, on the other hand, remains firmly bound to the cell debris under all the extraction conditions so far examined. Spectroscopic evidence was obtained that the nodules of *Alnus* and *Myrica* also contain a bound form of hæmoglobin similar to that in *Casuarina*. It is hoped to confirm this when material becomes available in the next vegetative season.

The above observations represent the second finding of hæmoglobin in higher plants; they emphasize the connexion that appears to exist between symbiotic nitrogen fixation and the presence of the respiratory pigment, but go no further towards an explanation of the nature of this connexion.

H. E. DAVENPORT

University of Bristol,
Research Station,
Long Ashton, Bristol.

[1] Kubo, H., *Acta Phytochim.*, **11**, 195 (1939).
[2] Keilin, D., and Wang, Y. L., *Nature*, **155**, 227 (1945).
[3] Keilin, D., and Smith, J. D., *Nature*, **159**, 682 (1947).
[4] Bond, G., in "Nutrition of the Legumes", edit. by Hallsworth, E. G., 216 (Butterworths Sci. Pub., London, 1958).
[5] Bond, G., in "Utilization of Nitrogen and its Compounds by Plants", Soc. Exp. Biol. Symposium No. 13, edit. by Porter, H. K., 59 (Cambridge Univ. Press, London, 1959).
[6] Bond, G., *Ann. Bot.*, N.S., **15**, 447 (1951).
[7] Egle, K., and Munding, H., *Naturwiss.*, **38**, 548 (1951).
[8] Bond, G., *J. Exp. Bot.* (in the press).
[9] Hill, R., *Proc. Roy. Soc.*, B, **120**, 472 (1936).

Occurrence of a Non-Fibrillar Elastin in the Earthworm

THE cuticle of the earthworm's gizzard is generally thought to be chitinous; but there was no experimental evidence for this view, until the observation by Rudall[1], who obtained an X-ray diffraction diagram similar to that found in *Aphrodite* bristles previously described by Lotmar and Picken[2] as a modified chitin (β-chitin). Although after purification he obtained a different diagram, he nevertheless concluded that the gizzard membrane was probably chitinous in nature. This identification is much less convincing in view of the fact that the structural proteins are always found together with a certain amount of polysaccharides[3].

As a part of a more comprehensive study of the earthworm gut[4], I have tried to ascertain the chemical nature of the gizzard cuticle by means of histochemical, physical and chemical methods.

(1) *Histochemical results:*

(*a*) *Polysaccharides.* No specific polysaccharide test gave any truly positive results. The periodic acid–Schiff reaction gives the cuticle a rose tinge, and alcian blue stains it only after oxidation by the acid permanganate reagent.

(*b*) *Elastins and collagens.* Whereas the ectodermal cuticle and the epithelial basement membrane show the same affinities as the collagens, the gizzard cuticle responds positively to tests for elastin. No other structure in the earthworm shows the same combination of tinctorial properties (Table 1).

(2) *Physical and chemical results*: The properties of the gizzard cuticle isolated by dissection are the same as those of vertebrate elastin, except for birefringence and autofluorescence (Table 2). These last properties are probably connected with the

Table 1

Test	Elastin (vertebrate)	Collagen (vertebrate)	Cuticle (gizzard)
Tetrazotized benzidin	brown	purple-brown	brown
The same, after moderate benzoylation	yellow	purple	yellow
Gomori (following Gabe)	violet	blue	violet
Van Gieson	yellow or rose	red	rose
Weigert's resorcin	violet	rosish	violet
Orcein	red	brownish	red

Table 2

Test	Vertebrate elastin	Vertebrate collagen	Arthropod chitin	Earthworm skin cuticle	Gizzard cuticle
Birefringence	weak	positive		positive	negative
Autofluorescence	positive	negative		negative	negative
'Solubility' in 5 per cent pot. hydrox. at 100° C. in 24 hr.	insoluble	soluble	insoluble	soluble	insoluble
'Solubility' in 6 *N* hydrochloric acid at 20° C.	insoluble	soluble	soluble	soluble	insoluble
'Solubility' in 2 per cent acetic acid	insoluble	soluble	insoluble	soluble	insoluble
Pepsin	very resistant	soon attacked	fully resistant	soon attacked	not attacked after 6 hr.
Trypsin	very resistant	attacked after mechanical mincing	fully resistant	soon attacked	not attacked after 6 hr.

particular physical structure of these cuticular membranes. In fact, they do not show any fibrillar structure, whether examined by ordinary or phase-contrast microscopy.

(3) *Chromatographic results:* 12 gizzard cuticles from the earthworm *Lumbricus rubellus* were purified and hydrolysed following a modification of the technique described by Neumann and Logan[5]. The hydrolysate was run on a circular chromatogram with the mixture butanol/acetic acid/water (4 : 1 : 1), and visualized with ninhydrin. Although no quantitative analysis was made, proline, valine and glycine seem to be particularly abundant. Hydroxyproline, typical of collagens and elastin, was detected on a separate chromatogram by the 'dipping' method of Jepson and Smith[6].

I conclude, therefore, that histochemical, physical and chemical evidence agrees with the view that the cuticle of the earthworm gizzard is an elastin in nature. This particular one is a 'non-fibrillar' elastin, analogous to the secreted collagens previously described in some invertebrates, notably in the ectodermal cuticle of *Lumbricus*[7]. I suggest calling it a 'secreted elastin'.

P. Van Gansen-Semal

Laboratoire de biologie animale,
Université libre de Bruxelles,
Belgique.

---

[1] Rudall, K. M., "The Distribution of Collagen and Chitin", 49 (1955).

[2] Lotmar, W., and Picken, L. E. R., *Experientia*, **6** (2), 58 (1950).

[3] Kendrew, J., in "The Proteins", **2** B, edit. by Neurath and Baily (1954).

[4] Van Gansen-Semal, P., *Ann. Soc. Roy. Zool. Belg.*, **89** (in the press).

[5] Neuman, R. E., and Logan, M. A., *J. Biol. Chem.*, **186**, 549 (1950).

[6] Jepson, J. B., and Smith, I., *Nature*, **172**, 1100 (1953).

[7] Watson, M. R., *Biochem. J.*, **68** (3), 416 (1958). Watson, M. R., and Silvester, N. R., *ibid.*, **71** (3), 578 (1959).

RADIOBIOLOGY

Fall-out Radioactivity in Southern Sweden

A high enrichment of radioactive fall-out products was recently reported in plant ash from southern Sweden[1]. The highest values were recorded in plants growing near the coast or upon pronounced hills, while plants growing in lowland regions at greater distances from the sea gave the lowest values. In all the samples examined the natural radioactivity was quite subordinate to the radioactivity caused by fall-out.

With the view of a more detailed investigation of the distribution of fall-out radioactivity in the soil and in the vegetation, the ash of different parts of a spruce taken from an area of comparatively high fall-out radioactivity was examined by means of a Geiger counter (Table 1).

Table 1. Relative Radioactivity Values (Background, 1·0) of Ash of Different Parts of 6 m. High Spruce from Romeleasen (120 m. above Sea-level), Southern Sweden, collected and analysed in October 1959

	Age	Ash (per cent)	Relative radioactivity
Needles	1 year	3·6	1·2
Needles	2 years	3·6	1·8
Needles	3 years	4·7	1·8
Live twigs	1 year	3·2	1·6
Live twigs	2 years	2·0	3·6
Live twigs	3 years	2·3	3·8
Dead twigs		1·8	3·3
Trunk, bark		2·8	1·8
Trunk, wood	1 year	0·7	1·0
Trunk, wood, central		0·3	1·0
Root, bark		3·1	1·0
Root, central		0·3	1·0
F-layer soil profile		12·8	1·3
Mineral soil		—	1·0

It appears from these figures that there is a marked enrichment of radioactive substances in both the twigs and the needles. On the other hand, no increase of radioactivity was found in the woody parts of the trunk or of the root or in the bark of the root.

Some γ-spectrometric analyses of parts of the spruce (ashed samples) have been carried out through the courtesy of Dr. K. Edvarson at the Swedish Research Institute for National Defence. These analyses revealed that the percentage of cæsium-144 and niobium–zirconium-95 was more than ten times higher in 1·5-year-old twigs and needles than in those of age 0·5 year. The radioactivity of the central woody part of the trunk was far below that of the exposed parts of the tree and was dominated by potassium-40. The γ-spectrometric analyses demonstrate the decrease in fall-out radioactivity during the last season and also the almost complete absence of fall-out products in the woody parts of the tree.

Additional Geiger-counter measurements have shown that dead parts of trees and plants (dry twigs, etc.) often have as high a radioactivity as live parts, even if they have been dead for several years. The decrease in radioactivity with time is the same for these dead parts as for the live parts of the plants, and it is evident that this radioactivity is due to the presence of relatively short-lived radioactive isotopes. This indicates, when considered together with the observations reported above, that the fall-out radioactivity, or at least the dominating part of it, has been mainly taken up by exposed parts of the plants directly from the air and only to a very small extent from the soil through the root-system of the plant. This observation is in line with what is mentioned by Gorham[2], namely, that certain small plants which have a low ash content and a corresponding large surface show a considerable enrichment in fall-out products.

It is thus evident that the main part of the fall-out radioactivity is now concentrated in the vegetation and in the uppermost layer of the soil where decaying plant parts dominate. This is especially the case with the more short-lived fission products, whereas the long-lived ones will possibly reach a higher enrichment through a more complete soil–plant–soil cycle.

Autoradiographic exposures of plants, plant parts, and of ashed-plant samples demonstrate the same distribution of radioactivity as mentioned above. There is a marked blackening of the photographic film by needles, leaves, twigs, and bark, contrary to the wood which does not affect the photographic film. The autoradiographs show, furthermore, that there are two kinds of radioactive influence. The first and general type causes a slight blackening of the photographic film. The second type is found when examining more recent samples, and it causes the development of small, intensely black dots on the film. These autoradiographic analyses signify that there are at present two sizes of fall-out particles, one very fine-grained and the other more coarse-grained, the latter representing a highly concentrated radioactivity.

PONTUS LJUNGGREN

Geological Institute,
Lund.
March 10.

[1] Ljunggren, P., *Nature*, **184**, 912 (1959).

[2] Gorham, E., *Nature*, **181**, 1523 (1958); *Can. J. Bot.*, **37**, 327 (1959).

Calcium Binding in Homogenates of Ehrlich Ascites Tumour Cells

WE have recently been attempting to determine the amount of bound (non-diffusible) calcium in the cells of the mouse Ehrlich ascites tumour. Results not yet published indicate that more than 50 per cent of calcium-45 incorporated *in vivo* by the cells is removed by briefly washing them three times in calcium-free balanced salt solution.

In order to investigate further the bound calcium, we disrupted the cells and examined the homogenate. This was done by suspending the cells, which had been labelled *in vivo* with calcium-45, in ice-cooled buffered isotonic salt solution, and then disrupting them by exposure to ultrasonic vibrations of about 20 kc./s. for 2 min. with the *M.S.E.*-Mullard apparatus. The resulting homogenate was subjected to a conventional dialysis procedure at 4–6° C. against a calcium-free solution. Initially calcium-45 was lost from the homogenate very slowly, as indicated by the slight increase in the radioactivity of the solution against which it was dialysed (Fig. 1). This phase lasted about 90 min., after which calcium was lost rapidly, as shown by the steep portion of the curve of radioactivity of the dialysing solution. A similar curve is obtained even if the isotope is added to homogenized cells *in vitro*. A totally different curve is obtained on dialysing ascitic fluid, in which there is a bound, but exchangeable, calcium fraction. In this case, the increase in radioactivity of the solution against which the labelled fluid is dialysed shows a steep rise from zero time, and flattens only when equilibrium is nearly attained (Fig. 1).

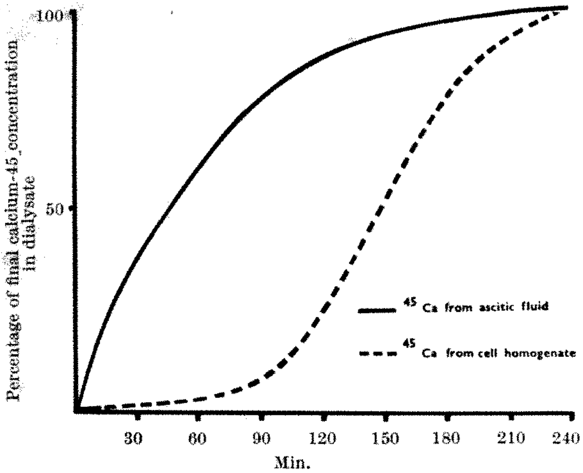


Fig. 1

Preliminary experiments also indicate that the total amount of calcium-45 removed from the labelled homogenate by dialysis, even after 4 hr., is considerably less than that extracted by quickly washing the cells in calcium-free solution, and probably amounts to less than 20 per cent of that initially present.

This increase of binding of calcium-45, and hence of total calcium, is corroborated by the very slow migration of the tag towards the cathode from the point of application of the labelled homogenate, when this is subjected to paper electrophoresis.

It appears that, as a result of the disintegration, a number of new calcium-binding sites have been made available. The increase in base-binding capacity may be accounted for, *inter alia*, by (*a*) molecular damage produced by subjection to the ultrasonic vibrations, or (*b*) by existing groups, previously inaccessible to the base, being made available by disruption of the cells.

Clearly, a study of the normal distribution of calcium in different cell fractions would be falsified by the increase in the proportion of bound calcium produced by ultrasonic disruption. We are therefore investigating further the nature of the binding in whole cells and in homogenates.

R. SCHOFIELD
D. THOMASON

Christie Hospital and Holt Radium Institute,
Withington, Manchester 20.

VIROLOGY

Purification and Properties of Cauliflower Mosaic Virus

STRAINS of cauliflower mosaic virus occur very commonly throughout North America and Europe. Previous attempts to determine the morphology of the virus[1], and to obtain an antiserum to it[2], were unsuccessful. Following the recent purification of cucumber mosaic virus[3], an attempt was made to purify cauliflower mosaic virus using similar procedures.

The cabbage virus *B* strain of the virus, described by Walker *et al.*[4], was mechanically inoculated to leaves of young tendergreen mustard plants (*Brassica perviridis* Bailey). Two to three weeks after inoculation, systemically infected leaves were harvested and homogenized in a Waring blendor in 0·5 *M* potassium phosphate buffer (*p*H 7·5) containing 0·1 per cent thioglycollic acid, at the rate of 12 ml. of buffer for each 10 gm. of leaf tissue. The homogenate was strained through cheese-cloth and *n*-butanol added dropwise with constant stirring to give a final butanol concentration of 8 per cent. The mixture then was stirred for 1 hr., after which it was centrifuged for 15 min. at 5,000 r.p.m. in a model *SP* Servall centrifuge. The clear supernatant was filtered through glass-wool and centrifuged for 2 hr. at 30,000 r.p.m. in a No. 30 rotor of a Spinco model *L* ultracentrifuge. Following ultracentrifugation, the supernatant was discarded and the pellets resuspended in 2–3 ml. of distilled water, and placed on a mechanical shaker for 8–10 hr. The pellet suspension was then centrifuged for 1 min. at 25,000 r.p.m., and the pellet discarded. All operations were carried out at 2–4° C.

Electron microscopic examination of grids sprayed with the final supernatant revealed particles of two sizes, 18 mμ and 50 mμ, while healthy leaf extracts processed in the same manner contained only the smaller particles.

Further purification was achieved by density gradient centrifugation. 1-ml. aliquots of the partially purified virus were layered on to tubes containing 30 ml. of a 5–40 per cent sucrose gradient and centrifuged in a Spinco *SW*-25 rotor for 2 hr. at 25,000 r.p.m. Examination of the gradient tubes under a beam of light revealed an opalescent band midway down the tubes. No such band was present in healthy preparations treated in a similar manner. The material within the bands was carefully withdrawn with a hypodermic needle through the side of the tubes, and dialysed for 12 hr. against distilled water. These virus preparations were assayed for infectivity on tendergreen mustard and typical symptoms of the disease appeared 10–20 days following inoculation, the time varying with the dilution of the virus preparation. These preparations were infectious up to dilutions of 10^{-5}. Aliquots of these preparations were sprayed on collodion-coated electron microscope grids, freeze-dried, and shadowed with uranium. When examined with the electron microscope, the grids sprayed with the virus showed numerous uniform spheres with an average diameter of 50 mμ. None of the smaller particles observed in partially purified preparations was present (Fig. 1).

The purified virus, suspended in 0·02 *M* sodium phosphate buffer (*p*H 6·0), was found to have a sedimentation coefficient of approximately 222 *S* at 20° C. when centrifuged in a Spinco model *E* ultracentrifuge at 17,980 r.p.m.

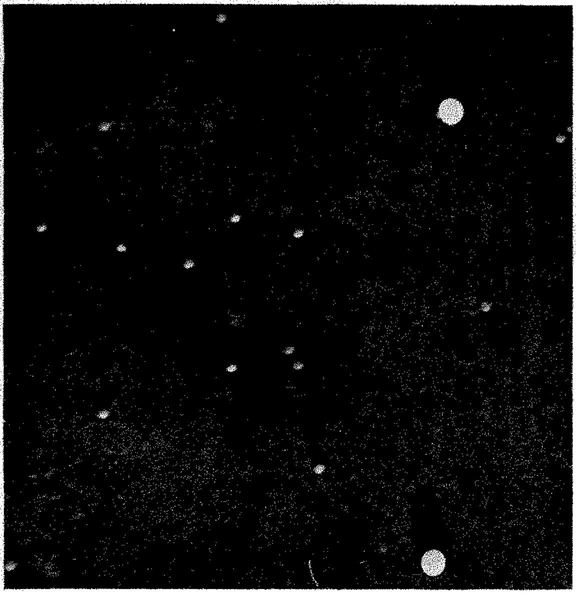


Fig. 1. Electron micrograph of purified cauliflower mosaic virus (× 24,490). The large white spheres are polystyrene latex particles, 122·5 mμ in diameter

Purified preparations of the virus were injected into rabbits intramuscularly, using Freund's adjuvant, and intravenously, at 7–10 day intervals for a total of 6 injections. The rabbits were bled 10 days after the last injection. Serum used in ring tests with the virus gave positive reactions at serum dilutions up to 1/512. The virus did not react with normal serum, or with antisera of turnip yellow mosaic or turnip mosaic viruses. Purified preparations of turnip yellow mosaic and turnip mosaic viruses gave no reaction when tested against cauliflower mosaic virus antiserum.

We wish to express our thanks to Dr. P. J. Kaesberg, Dr. J. J. Kelley and Mrs. Selma Sachs of the Department of Biochemistry, University of Wisconsin, for their assistance with the electron microscope and sedimentation coefficient studies.

THOMAS P. PIRONE
GLENN S. POUND
ROBERT J. SHEPHERD

Department of Plant Pathology,
University of Wisconsin,
Madison.

[1] Bawden, F. C., Rep. Rothamsted Exp. Sta., Harpenden, 1949, 59 (1950).

[2] Larson, R. H., Matthews, R. E. F., and Walker, J. C., *Phytopath.*, **40**, 955 (1950).

[3] Tomlinson, J. A., Shepherd, R. J., and Walker, J. C., *Phytopath.*, **49**, 293 (1959).

[4] Walker, J. C., LeBeau, F. J., and Pound, G. S., *J. Agric. Res.*, **70**, 379 (1945).

Decarboxylation of Glutamic Acid in Tobacco Leaves inoculated with Tobacco Mosaic Virus

THE process of decarboxylation of glutamic acid has been a subject of interest since the discovery in many plants of γ-amino-butyric acid in large quantities[1-3].

Since proteins do not contain these acids, the role of the process of decarboxylation is not quite clear. But the appearance of the process at all the stages of development suggests that its role in plant metabolism may be more general[4,5].

I have examined the intensity of decarboxylation in *Nicotiana tabacum* var. White Burley, inoculated with tobacco mosaic virus. Typical results are given in Table 1. The results show that at certain stages of the mosaic disease the activity of the process increases.

Table 1. ACTIVITY OF GLUTAMIC ACID DECARBOXYLASE IN TOBACCO LEAVES HOMOGENATES

Days since inoculation	Carbon dioxide (μl.) in 30 min. at 30° C.		Activation (per cent)	Atmosphere
	Sound	Infected with tobacco mosaic virus		
6–8	51·8	57·1	110	Air
	56·4	89·3	158	
6–8	47·8	67·0	141	Nitrogen
	51·9	73·0	140	
11–14	47·8	100·6	210	Air
	51·9	116·0	220	
11–14	46·8	67·7	144	Nitrogen
	35·5	76·1	214	

5 gm. of the tissue with 15 ml. 1/15 *M* phosphate buffer *p*H 5·6 was ground until a homogeneous suspension was obtained. 0·2 ml. homogenate and 1 ml. glutamic acid in concentration 0·02 *M* were poured into a Warburg apparatus.

The greatest intensity of decarboxylation in leaf homogenates was found in young leaves when the mosaic began to appear (11–14 days after infection)—the activation reaching 200 per cent. The second maximum of the decarboxylation of glutamic acid was observed several days after inoculation (140 per cent).

To explain the increase in decarboxylation of glutamic acid found in tobacco leaves inoculated with tobacco mosaic virus, I suggest the phenomenon is connected with destructive metabolism because maximum intensity of the process occurs when the disorder symptoms begin to appear, or it may be involved in the synthesis of virus proteins.

The second view is backed by indirect results of other workers. Analysing free amino-acids in the coconut endosperm, Baptist found that the γ-amino-butyric acid appears in the period of intensive protein synthesis[6]. Pekka and Virtanen have shown that metabolism of γ-amino-butyric acid is strictly connected with glutamine, which is assumed to play an important part in protein synthesis[7]. The examination of the process and its role in virus synthesis is being continued.

M. S. GUBAŃSKI

Department of Plant Physiology,
University of Lodz,
Poland.

[1] Gubański, M. S., *Acta Soc. Bot. Poloniae*, **27**, 291 (1958).

[2] Steward, F. C., Thomson, J. F., and Dent, C. E., *Science*, **110**, 439 (1949).

[3] Thomson, J. E., Bolard, J. K., and Steward, F. C., *Plant Physiol.*, **28**, 41 (1953).

[4] Pekka Linko, and Milner, M., *Plant Physiol.*, Supp. 33, **13** (1958).

[5] Warburg, O., and Krippakl, G., *Z. Naturforsch.*, **12**, 10 (1957).

[6] Baptist, N. G., *Nature*, **178**, 1403 (1956).

[7] Pekka Linko, and Virtanen, A. I., *Acta Chem. Scand.*, **12**, 68 (1958).

BACTERIOLOGY

Streptomycin-induced Lysis of Penicillin-treated *Staphylococci*

WHEN growing cultures of *Escherichia coli* are exposed to bactericidal concentrations of penicillin, lysis of the cells occurs after 20–30 min.[1]. This lysis appears to be caused by the inhibition by penicillin of synthesis of cell wall mucopeptide with continuing synthesis of other cell constituents, resulting in 'bursting' of the cells[2]. Other cases of lysis of bacteria due to such a reduced differential rate of synthesis of cell wall mucopeptide are known, and have recently been reviewed[3,4].

When penicillin, at a minimally bactericidal concentration (0·06 μgm./ml.), is added to growing cultures of *Staphylococcus aureus* (strain Duncan), rapid lysis of the cells does not occur although the synthesis of cell wall mucopeptide ceases after about 15 min.[5]. Only a very slow fall, continuing for more than 24 hr., is observed in the optical density of such cultures, and it is not clear why the rate of lysis in these *Staphylococci* is so low compared, for example, with penicillin-treated *E. coli*[1,2] or lysine-deficient *Streptococcus faecalis*[6]. One possibility which suggests itself is that, due to the reduced activity of amino-acid-accumulating systems in *Staphylococci* which follows contact with penicillin[5,7], the rates at which cell constituents other than the cell wall can be synthesized are reduced, so that 'bursting' occurs more slowly.

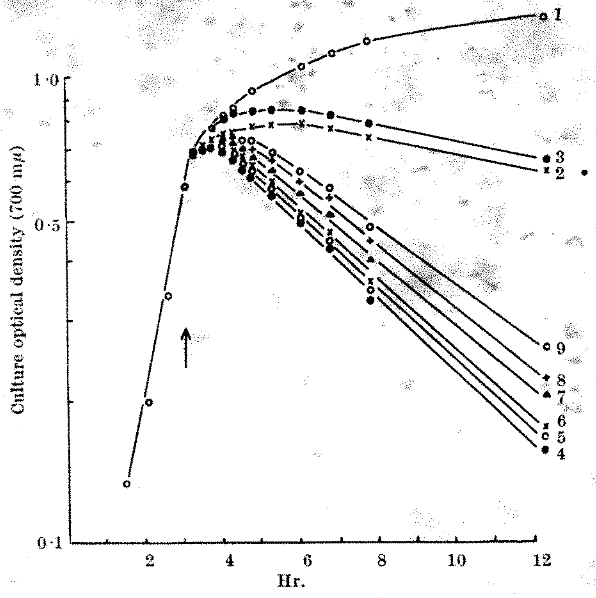


Fig. 1. To identical cultures of *Staphylococcus aureus* (strain Duncan) growing in *PG* medium (ref. 9) at 37° in shake flasks, additions were made (at the time indicated by the arrow) of streptomycin (10 μgm./ml.) (*S*) and/or penicillin (0·06 μgm./ml.) (*P*) as follows. *S* (curve 1); *P* (curve 2); *S* followed after 30 min. by *P* (curve 3); *P* and *S* together (curve 4); *P* followed by *S* either after 10 min. (curve 5), after 20 min. (curve 6), after 30 min. (curve 7), after 40 min. (curve 8), or after 50 min. (curve 9)

During investigations of the effects of streptomycin on *S. aureus*, I have recently observed, however, that addition of streptomycin together with penicillin (each at minimally bactericidal concentrations) to exponentially growing cultures brings about rapid lysis (Fig. 1). This lysis begins at *c.* 30 min. after addition of streptomycin, even when this is delayed up to 50 min. after addition of penicillin. Although the rate of lysis is independent of the concentration of streptomycin when this is greater than 10 μgm./ml., lysis commences earlier at higher streptomycin concentrations. Lysis is induced only by those derivatives of streptomycin which possess antibacterial activity (dihydrostreptomycin, mannosido-

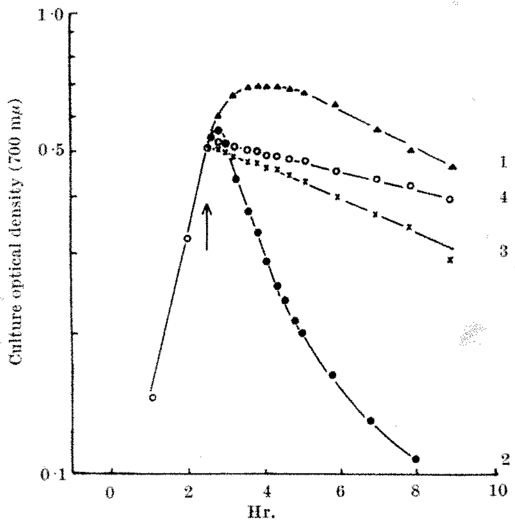


Fig. 2. To cultures growing as in Fig. 1 were added (at the time indicated by the arrow): penicillin (0·06 μgm./ml.) (curve 1); penicillin (0·06 μgm./ml.) + streptomycin (10 μgm./ml.) alone (curve 2), or together with chloramphenicol (50 μgm./ml.) (curve 3), or together with 8-azaguanine (500 μgm./ml.) (curve 4)

streptomycin) and not by streptidine or streptomycinic acid; it does not occur under anaerobic conditions, when the bactericidal effect of streptomycin on this organism is also much reduced. Essentially similar results have also been obtained using strain *H* of *S. aureus*.

When the growth-rate of a culture, previous to addition of penicillin and streptomycin, is reduced by decreasing the concentration of peptone in the growth medium, the rate of subsequent lysis is reduced proportionally. Lysis can be almost completely prevented by addition, simultaneously with penicillin and streptomycin, of chloramphenicol (50 μgm./ml.) or 8-azaguanine (500 μgm./ml.) (Fig. 2). However, chloramphenicol can prevent the bactericidal effect of streptomycin on *S. aureus* (Hancock, R., unpublished results), so that this finding does not necessarily indicate that lysis under these conditions is a result of 'unbalanced synthesis' of other cell constituents relative to cell wall. The possibility that lysis may be caused by cell wall-degrading enzymes of the type found in *Staphylococci* by Mitchell and Moyle[8] seems unlikely since we have not been able to detect any activity of these enzymes in cells after growth for 30 min. in the presence of streptomycin.

I am grateful to Mr. F. McManus for valuable technical assistance, and to the Distillers Co. and to Merck and Co., Inc., for gifts of streptomycinic acid and streptidine, respectively.

R. HANCOCK

Department of Bacteriology,
University of Manchester.

[1] Harrington, M. G., thesis, National University of Ireland, Cork (1954) (data quoted in ref. 3).

[2] Hahn, F. E., and Clak, J., *Science*, **125**, 119 (1957).

[3] McQuillen, K., *J. Gen. Microbiol.*, **18**, 498 (1958).

[4] McQuillen, K., Colloquium on Growth Chemistry of Homofermenting Bacteria, Fourth Int. Cong. Biochem., Vienna (1958).

[5] Hancock, R., *Biochem. J.*, **70**, 15 *P* (1958).

[6] Shockman, G. D., Kolb, J. J., and Toennies, G., *J. Biol. Chem.*, **230**, 961 (1958).

[7] Gale, E. F., and Taylor, E. S., *J. Gen. Microbiol.*, **1**, 314 (1947).

[8] Mitchell, P., and Moyle, J., *J. Gen. Microbiol.*, **16**, 184 (1957).

[9] Hancock, R., *Biochim. Biophys. Acta*, **28**, 402 (1958).

Influence of Light on Bacterial Flora of Roots

ALTHOUGH considerable work has been done on the influence of various factors such as type, moisture content, reaction and treatment of the soil and kind and age of plant on the microflora of the rhizosphere[1], very little has appeared concerning the response of the normal rhizosphere micropopulation to the changes in plants growing under different light intensities. The studies that have been made deal primarily with specific phenomena such as symbiotic nitrogen fixation[2], mycorrhizal development[3] and susceptibility of roots to infection[4]. However, Rovira[5] has recently reported that "the numbers of bacteria in the rhizosphere of tomato were reduced by 60 per cent when plants were shaded to 40 per cent of full sunlight"; the conditions under which the plants were grown were not given. We have recently completed experiments on the influence of light on the microbial population of wheat roots. These were selected for analysis rather than the soil adhering to them because it was considered that the organisms in intimate contact with the roots would reflect more accurately the changes produced in the plant by differences in illumination than would the organisms in the rhizosphere soil, where a dilution of the effect would probably occur. Certain of our findings relating to the bacterial flora are presented here. Full details of these experiments will be published elsewhere.

Wheat was planted in field soil in large rectangular tanks in the greenhouse. The plants were grown under 'normal light' for two weeks after which a cheesecloth cage was placed over half of them, thus reducing the light from approximately 1,000 to about 300 foot-candles. The temperature at the soil-level showed little significant variation between the illuminated and 'reduced light' sets. Moisture was maintained at about 70 per cent of the soil-moisture holding capacity by regular sprinkling. Composite root-samples were obtained three weeks after shading by removing plants from four locations in each treatment. The roots were thoroughly washed for 5 min. by shaking in sterile water and then washed aseptically in three changes of water prior to homogenization in a sterile Waring blendor. The homogenate was analysed microbiologically using methods described in previous publications from this laboratory[6,7]. The results of a typical experiment are summarized in Table 1.

Table 1. INFLUENCE OF ILLUMINATION ON THE BACTERIAL FLORA OF WHEAT ROOTS*

Bacteria	Illumination (ft.-candles)	
	1,000	300
Plate count	7.9	3.9
Methylene blue reducers	50.0	6.0
Glucose fermenters		
Acid producers	3.0	0.38
Gas producers	0.8	0.06
Ammonifiers†	16.0	0.2
Incidence of amino-acid requiring bacteria (per cent)	65	30

* Numbers in thousand million per gm. oven dry roots; methylene blue reducers, glucose fermenters and ammonifiers were estimated by the ultimate dilution procedure (ref. 7).

† These results were derived from a later experiment.

A distinct reduction in bacterial count and in numbers of methylene blue-reducing organisms (as an index of the overall activity on the root surface) as well as of glucose-fermenting bacteria occurred on the roots of plants grown under low light intensity. Further tests revealed that numbers of ammonifying bacteria were also reduced on these roots. Nutritional studies on isolates from the plates used for counting showed a marked reduction in the percentage incidence of bacteria requiring amino-acids for maximum growth from about 65 per cent to 30 per cent. Taxonomic studies with these isolates are in progress. The results suggest that there is both a quantitative and a qualitative change in the substances excreted by these roots which normally stimulate the microflora at or near the root surface and produce the 'rhizosphere effect'[1]. Of course the reduced amounts of these materials, particularly of amino-acids, at the root surface may be due partly to the decrease in the total bacterial population on the root, resulting in a concomitant reduction in the elaboration of various substances, including amino-acids[8]. Rovira[5] has reported a reduction in excretion of certain amino-acids by the roots of plants grown aseptically under reduced light, but mentioned also that the presence of micro-organisms influenced the concentration of amino-acids in the solution surrounding tomato roots. However, the numbers of bacteria which do not require amino-acids and which may liberate them appear to be very similar on the roots of both sets of plants used in the present experiments (35 per cent of $7\cdot9 = 2\cdot76$ thousand million in the 'high light' series as compared with 70 per cent of $3\cdot9 = 2\cdot76$ thousand million in the 'low light' set). The plant, therefore, may be the major source of amino-acids for these organisms requiring them.

The significance of these observations with regard to plant nutrition, growth or susceptibility to disease is difficult to assess, especially since the role of the normal rhizosphere soil and root-surface microflora is still imperfectly understood. Eaton and Rigler[9] have reported decreased susceptibility of cotton plants to *Phymatotrichum omnivorum* as a result of defoliation or mutilation of the plants, which increased the carbohydrate content of the roots. This effect was associated also with a reduction in total bacterial numbers and an increase in numbers of fluorescent bacteria. Harley and Waid[10] observed an increase in the incidence of semi-pathogenic fungi on roots of beech seedlings grown in the shade. Whether these results are due to a concomitant reduction of the bacterial and possibly of the actinomycete population at the root surface, to an alteration of the types of organisms, as suggested above, or to changes in the plant and in the root which render them less able to withstand parasitic attack is not clear at present although the increased susceptibility of plants growing under reduced illumination to diseases produced by viruses, fungi and nematodes has been reasonably well established[11,12].

J. W. ROUATT
H. KATZNELSON

Microbiology Research Institute,
Research Branch,
Canada Department of Agriculture,
Ottawa.

[1] Katznelson, H., Lochhead, A. G., and Timonin, M. I., *Bot. Rev.*, **14**, 543 (1948).

[2] van Schreven, D. A., in "Nutrition of the Legumes", edit. by Hallsworth, E. G (Butterworths Scientific Publications, London, 1958).

[3] Björkman, E., *Svensk. Bot. Tidskr.*, **43**, 223 (1949).

[4] Foster, R. E., and Walker, J. C., *J. Agric. Res.*, **74**, 165 (1947).

[5] Rovira, A. D., *Plant and Soil*, **11**, 53 (1959).

[6] Lochhead, A. G., and Chase, F. E., *Soil Sci.*, **55**. 185 (1943).

[7] Katznelson, H., and Rouatt, J. W., *Canad. J. Microbiol.*, **3**, 265 (1957).

[8] Lochhead, A. G. and Thexton, R. H., *Canad. J. Res.*, C, **25**, 20 (1947).

[9] Eaton, F. M., and Rigler, N. E., *J. Agric. Res.*, **72**, 137 (1946).

[10] Harley, J. L., and Waid, J. S., *Plant and Soil*, **7**, 96 (1955).

[11] Stakman, E. C., and Harrar, J. G., "Principles of Plant Pathology" (Ronald Press Co., New York, 1957).

[12] Ellenby, C., *Ann. App. Biol.*, **32**, 67 (1945).

Iron Bacteria in Mine-waters

As van Beneden[1] has shown, iron bacteria may be obtained from fresh-water by reducing the iron in this water by percolation through a layer of soil. In the thin layer where the effluent oxidizes (presumably ferrous carbonate or bicarbonate to hydrated ferric oxide) the bacteria develop.

Baas Becking, Wood and Kaplan[2], using this method, obtained iron bacteria from sea-water. With the help of Mr. A. D. Haldane, senior chemist of the Bureau of Mineral Resources, a more efficient apparatus was constructed. Iron bacteria were grown on slides on which a reduced fresh-water effluent was dripping. Tap-water can be made free of oxygen by passing it through a column of steel-wool, previously washed in carbon tetrachloride. The effluent contains a slate-blue compound, possibly ferrous hydroxide, which oxidizes slowly to hydrated ferric oxide. Ferrous carbonate (and possibly the soluble bicarbonate) are formed and oxidized in culture flasks containing the infection material and a small amount of magnesium-ammonium phosphate.

As infection material, chalybeate waters from various localities in New South Wales were used (Matraville, Mittagong, Warrah, Palm Cave, Bungendore). Both a sheathed rod and a species of *Sphaerotilus* made their appearance. The method, however, is cumbersome and unsuitable for pure culture work.

The oxidation of pyrite proceeds in sterile suspensions, yielding ferrous sulphate and acid. In sterile suspensions, the oxidation of ferrous to ferric sulphate is very slow, only a few per cent being converted in four months at room temperature.

Iron bacteria isolated from chalybeate waters are capable of catalysing the oxidation of ferrous to ferric sulphate, the reaction running to completion in a few weeks at room temperature. It is possible to obtain pure cultures of these forms on 1 per cent ferrous sulphate agar containing 200 mgm./l. magnesium-ammonium phosphate. Pure cultures could also be obtained on powdered pyrite agar.

One of the final oxidation productions of pyrite is a mixture of ferric sulphates and oxysulphates, called 'yellowboy' by the miners. This ore, collected from various levels, Lake George Mine, Captains Flat, New South Wales, proved to contain *Sphaerotilus* and also *Gallionella*. The former could be isolated on 1 per cent ferrous-sulphate agar and on pyrite agar. Mine-water from the same mine contained *Sphaerotilus*.

A constant companion of both *Sphaerotilus* and the bacillary form is a small *Torulopsis*-like yeast, present in both mine-water and fresh-water, which also appeared from hydrated iron oxide collected near a hot spring at Talasea, New Britain.

Gallionella could not be isolated on sulphate media, but there are, apparently, iron organisms capable of developing on the ferrous (bi)carbonate as well as on the ferrous sulphate system.

In the latter system they give rise to electrode potentials of $+860$ mV.

The first stage in the oxidation of pyrite, where ferrous sulphate and acid are formed (pH $1\cdot5$–$3\cdot0$), is a purely chemical phase, as the oxidation proceeds with equal intensity in sterile and in infected materials. In the second phase the biological catalyst will create an environment with very high electrode potentials, the pH remaining almost the same.

In old plate cultures of *Sphaerotilus* sp. a crust was formed around the bacterial colonies. In certain instances material from these crusts showed, in concentrated solution, a negative pH and potentials of more than $+900$ mV. There are more than 40 ferrous and ferric sulphate minerals described in the literature, and almost invariably they seem to be formed by the oxidation of pyrite in a dry atmosphere.

We can say, therefore, that the desiccation of the bacterial end-products adds a third, final stage to the oxidation of pyrite—a physical phase.

This communication is published by permission of the Director, Bureau of Mineral Resources, Geology and Geophysics.

L. G. M. BAAS BECKING
D. MOORE

Bureau of Mineral Resources,
Department of National Development,
Turner, Canberra.

[1] Beneden, G. van, *Hydrologia*, **3**, 1 (1951).

[2] Baas Becking, L. G. M., Wood, E. J. F., and Kaplan, I. R., *Kon. Ned. Ak. van Wet.*, B, **59**, 399 (1956).

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, May 23

Laboratory Animals Centre (at the Royal Society of Medicine Wimpole Street, London, W.1), at 9.30 a.m.—Symposium on "The Provision of Animals for Cancer Research".

* Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. J. H. G. Lebon and Mr. V. C. Robertson: "Jebel Marra, Darfur, and Its Region".

University of London (at the Wright–Fleming Institute of Microbiology, St. Mary's Hospital Medical School, Norfolk Place, London, W.2), at 5 p.m.—Dr. P. L. Mollison: "The Role of Complement in Blood Group Reactions".

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. C. Robertson King: "The Retail Distribution of Electricity". (Last of three Cantor Lectures on "Energy".)

Monday, May 23—Saturday, May 28

Instruments, Electronics and Automation Exhibition (at Olympia, London).*

Tuesday, May 24

University of London (at the Imperial College of Science and Technology, London, S.W.7), at 5.30 p.m.—Prof. M. Blackman: "Some Applications of Electron Diffraction Techniques" (Inaugural Lecture).

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. B. Segre (Rome). "Continuous Variation and Homotopy in Algebraic Geometry".* (Further lectures on May 26 and 30).

University of London (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 5.45 p.m.—Mr. J. S. Wacher: "Recent Excavations at Catterick and Brough-on-Humber".* (Sixth of nine lectures on "Recent Archæological Discovery in Britain". Further lectures on May 31, June 7 and 14).

Society of Instrument Technology (at Manson House, 26 Portland Place, London, W.1), at 6 p.m.—Annual General Meeting. 7 p.m.—Mr. R. S. Medlock: Presidential Address.

Wednesday, May 25

Society of Chemical Industry, Nutrition Panel (at 14 Belgrave Square, London, S.W.1), at 4 p.m.—Dr. L. J. Teply: "Foods for the Under-developed Countries".

Institution of Electrical Engineers, Electronics and Communications Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "New Semiconductor Devices and their Possible Applications" opened by Dr. A. F. Gibson and Mr. G. King.

Polarographic Society (at the Royal College of Science, Imperial Institute Road, London, S.W.7), at 7 p.m.—Meeting on "Automatic Analysis by Electrochemical Methods".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. G. F. J. Garlick: "Luminescence—The Cold Light of Physics".

Wednesday, May 25—Friday, May 27

Society for the Study of Fertility (at the Royal Veterinary College; Guy's Hospital Medical School; and the Institute of Obstetrics and Gynæcology, Chelsea Hospital for Women)—Annual Conference.

Thursday, May 26

(In the Physiology Lecture Theatre, Guy's Hospital Medical School, London Bridge, S.E.1), at 5 p.m.—Dr. J. Parizek (Prague): "Sterilization of the Male by Cadmium Salts" (Third Oliver Bird Lecture).

Thursday, May 26

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. A. G. Gaydon, F.R.S., Mr. G. N. Spokes and Mr. J. van Suchtelen: "Absorption Spectra of Low-Pressure Flames"; Mr. R. Bralsford, Mr. P. V. Harris and Prof. W. C. Price, F.R.S.: "The Effect of Fluorine on the Spectra and Ionization Potentials of Molecules".

University of London (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. S. J. Bach: "The Metabolic Fate of Protein-Nitrogen in the Mammal"*. (Further lecture on June 2.)

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. P. Waser (Zurich): "The Cholinergic Receptor".*

Friday, May 27

Institution of Chemical Engineers (at the Imperial College of Science and Technology, Department of Chemical Engineering, Prince Consort Road, London, S.W.7), at 3.30 p.m.—Mr. J. W. Smith: "Heat Transfer to Liquid Fluidized Beds and to Coarse Suspensions Flowing in a Vertical Pipe".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer (with interests in physical chemistry, preferably in the field of theoretical chemistry) in the Department of Chemistry—The Secretary, The University, Edinburgh (May 28).

Principal Lecturer (with high academic qualifications, some industrial and research experience, and preferably teaching experience) in Industrial Statistics—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (May 28).

Assistant Lecturer or Lecturer (with an honours degree in zoology or a veterinary or medical qualification, and a special interest in experimental helminthology) in the Department of Agricultural and Forest Zoology—The Registrar, University of North Wales, Bangor, North Wales (May 30).

Scientific Officer (with a good class honours degree in zoology and some research experience, preferably in soil fauna) at Merlewood Research Station, Grange-over-Sands, Lancs, or Moor House Field Station, Alston, Cumberland, for work on the ecology of moorland invertebrates—The Nature Conservancy (E), 19 Belgrave Square, London, S.W.1 (May 30).

Lecturer in the Department of Mathematical Physics—The Secretary, The University, Edinburgh (May 31).

Lecturers in Experimental and Theoretical Physics—The Secretary of University Court, The University, Glasgow (May 31).

Mullard Research Fellow (preferably with a Ph.D. degree, or with equivalent research experience) in Physics, for research in various branches of solid-state physics with particular reference to defects, semiconductor or surface properties—The Registrar, University College of North Staffordshire, Keele, Staffs (May 31).

Lecturer, Grade II (with special interests in newer palæozoic stratigraphy and palæontology) in Geology—The Registrar, The University, Bristol 8 (June 1).

Assistant Lecturer in Genetics in the Department of Botany—The Registrar, The University, Leicester (June 4).

Demonstrator in Zoology—The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (June 4).

Fellow and Lecturer in Philosophy—The Rector, Exeter College, Oxford (June 4).

Lecturer or Assistant Lecturer in Pure Mathematics—The Registrar, The University, Leicester (June 4)

Assistant Lecturer (prepared to teach general invertebrate zoology, other than entomology) in Zoology—The Registrar, University College of North Wales, Bangor, North Wales (June 6).

Lecturer (with special qualifications in educational psychology) in Education—The Registrar, The University Sheffield (June 6).

Chemist, Assistant Experimental Officer or Experimental Officer grade (with a degree in chemistry or equivalent qualification and preferably experience in pesticide analysis) in the Plant Protective Chemistry Section, to assist in studies of pesticides in fruit culture—The Secretary, East Malling Research Station, near Maidstone, Kent (June 10).

Organic Chemist (Ph.D. standard) at the Medical Research Council's Carcinogenic Substances Research Unit, University of Exeter, to work with a team investigating the chemistry of tobacco and tobacco smoke—The Vice-Chancellor, The University, Exeter (June 10).

Research Assistant (with the degree of Ph.D. or about to submit a Ph.D. thesis) in the Department of Chemistry, for work, in collaboration with Dr. J. J. Kipling, involving carbonization of high-molecular weight compounds, graphitization of the resulting carbons, and examination of the physical properties of the product with particular emphasis on adsorption studies—The Professor of Chemistry, The University, Hull (June 11).

Senior Lecturer in Thermodynamics; a Senior Lecturer in Electricity (heavy and light current); and a Senior Lecturer or Lecturer in Fluid Dynamics (hydraulics or aerodynamics)—The Registrar, The University, Leicester (June 11).

Scientific or Technical Assistant (male, preferably with seagoing or diving experience), to assist in a research programme on the biology of the Western Australian commercial crayfish—The Director, Western Australian Museum, Beaufort Street, Perth, Western Australia (June 14).

Lecturer or Assistant Lecturer in Chemistry at the University of Malaya (Singapore Division)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 15).

Lecturer/Senior Lecturer in Pure Mathematics at the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 17).

Reader in Physiology at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 21).

Chair of Mathematics in Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

Lecturer (with research experience in the biochemical mechanisms of drug action) in Pharmacy at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

Research Students (2) (graduates or students graduating this year in chemistry, biochemistry or physiology) in the Cancer Research Department, for work on biochemical and immunological aspects of carcinogenesis—The Registrar, The University, Nottingham (June 30).

Reader in Applied Entomology at Imperial College—The Academic Registrar, University of London, Senate House, London, W.C.1 (July 1).

PROFESSOR (specialist in either applied mathematics or theoretical physics) OF APPLIED MATHEMATICS at Rhodes University, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, July 15).

LECTURER IN PHYSICAL METALLURGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 16).

LECTURER (with qualifications in either pure or applied mathematics) IN MATHEMATICS at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W C.1 (New Zealand and London, August 8).

BOTANIST (PLANT BREEDER) (with a good honours degree in botany and at least two years postgraduate experience, preferably with perennial crops) in Uganda, to breed locally adapted varieties of Arabica coffee resistant to rust; to investigate compatibility systems; and to conduct variety trials on Robusta and Arabica coffee—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/9/034/T.

EXPERIMENTAL STAFF (with a pass degree or H.N.C., and experience in one or more of the following fields: electronics, vacuum techniques, nuclear counting methods, or general experimental physics), to join a team studying experimental nuclear reactors and carrying out general neutron physics research—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 2632/34.

FISHERIES OFFICER (with a good honours degree in natural science (zoology), experience of the inshore fishing industry, and preferably a knowledge of East Africa) in Tanganyika, for the development of marine or inland native fisheries—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/012/T.

LECTURER (with high qualifications in electronics and communications) IN ELECTRICAL ENGINEERING—The Registrar, The University, Bristol.

MASTER (with an honours degree) TO TEACH PHYSICS up to "A" or "S" level—The Headmaster, Westminster School, 17 Dean's Yard, London, S.W.1.

PLANT PHYSIOLOGIST (with a good honours degree in botany or chemistry with specialization in plant physiology and not less than two years suitable postgraduate experience or training) in Tanganyika, for research work on coffee, with particular reference to over-bearing and plant nutrition, and to collaborate with other specialists—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/026/T.

POSTDOCTORAL RESEARCH FELLOWS IN INORGANIC CHEMISTRY, with special reference to transitional metal complexes and organometallic compounds—Prof. G. Wilkinson, Imperial College of Science and Technology, London, S.W.7.

READER (with the qualifications and experience to direct research and postgraduate work, and to take a leading part in advanced training) IN PHARMACOLOGY—The Registrar, Bradford Institute of Technology, Bradford 7.

RESEARCH FELLOW (with a good degree in electrical engineering, physics or chemistry, and some research or industrial experience) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1.

SCIENTIFIC OFFICER, Grade I (honours graduate in zoology, botany or agriculture, a practical knowledge of modern methods of pest and weed control, and preferably administrative ability) IN THE INFESTATION SECTION, British Railways Research Department, Manchester—Director of Research (British Railways), British Transport Commission, 222 Marylebone Road, London, N.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 123: Fowl Paralysis and Related Conditions in Poultry. Pp. 5. (Belfast: Ministry of Agriculture, 1960.) [292

Air Ministry: Meteorological Office. Meteorological Reports, No. 22: Aviation Meteorology of the West Indies. Pp. vi+85. (M.O. 621f.) (London: H.M. Stationery Office, 1959.) 5*s.* net. [292

British Coal Utilisation Research Association. Bibliography of Publications, 1938–1959. Pp. i+49. (Leatherhead: British Coal Utilisation Research Association, 1960.) [292

Department of Scientific and Industrial Research. Problems of Progress in Industry, No. 5: Human Problems of Innovation. Based on a study of some Scottish firms by Tom Burns and G. M. Stalker. Pp. 36. (London: H.M. Stationery Office, 1960.) 2*s.* 6*d.* [23

British Museum (Natural History). British Caenozoic Fossils (Tertiary and Quaternary). Pp. vi+130 (44 plates). (London: British Museum (Natural History), 1959.) 6*s.* [23

The Macaulay Institute for Soil Research. Annual Report, 1958–1959. Pp. 52. (Craigiebuckler, Aberdeen: The Macaulay Institute for Soil Research, 1960.) [23

Imperial College of Science and Technology (University of London). Postgraduate Courses, 1960–61. Pp. xii+113. (London: Imperial College of Science and Technology, 1960.) [23

Bulletin of the British Museum (Natural History). Botany. Vol. 2, No. 5. The Polypodiaceae and Grammitidaceae of Ceylon. By W. A. Sledge. Pp. 131–158. (London: British Museum (Natural History), 1960.) 10*s.* [23

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 84: Lime and Liming. Pp. 7. (Belfast: Ministry of Agriculture, 1960.) [73

Technical Possibilities of a Thames Flood Barrier. Pp. 29. (Cmnd. 956.) (London: H.M. Stationery Office, 1960.) 3*s.* 6*d.* net. [73

Other Countries

Research Bulletin of the Panjab University. No. 148 (Zoology): Histochemical and Morphological Studies of the Lipids in Oogenesis. 5: The Egg-follicle of *Culex fatigans*. By Vishwa Nath, Brij L. Gupta and G. S. Bains. Pp. 135–148+2 plates. Rs 3/55. No. 149 (Zoology): The External Morphology of *Chrotogonus trachypteris* Blanch (Orthoptera, Acrididae, Pyrgomorphinae). By G. L. Arora and Asket Singh. Pp. 149–174. Rs. 3/90 No. 150 (Zoology) On a New Trematode Belonging to the Genus *Cotylophoron* Stiles and Goldberger, 1910, from *Ovis aries* in Madras (South India). By N. K. Gupta. Pp. 175–178. Rs. 1/00. No. 151 (Zoology). Cytoplasmic Inclusions of the Spinal and Sympathetic Neurones of Mammals. By S. K. Malhotra. Pp. 179–209+1 plate. Rs 4/90. No. 152 (Zoology). Morphological and Histochemical Study of Oocytes of the Fish, *Barbus ticto* (Punctius), with particular reference to Lipids. By H. C. Chopra. Pp. 211–221. Rs. 1/85 No. 153 (Zoology): Histochemical and Morphological Studies of the Lipids in Oogenesis. 6: The Frog, *Rana tigrina*. By Vishwa Nath, Brij L. Gupta and Rajinder Kaur. Pp. 223–234. Rs. 2/15. (Hoshiarpur: Panjab University, 1958 and 1959.) [252

Research Bulletin of the Panjab University. No. 154 (Zoology): Histochemical and Morphological Studies of the Lipids in Oogenesis. 7: The Spider, *Crossopriza lyoni* (Blackwall). By Vishwa Nath, Brij L. Gupta and V. Rani. Pp. 235–243. Rs. 2/38. No. 155 (Zoology): Histochemical Studies of Lipids in Oocytes. 2: Lipids in the Oogenesis of *Hemidactylus flaviviridis* Ruppell. By S. S. Guraya. Pp. 245–253. Rs. 1/73. No. 156 (Zoology): Cytological Studies on the Indian Spiders. 2: Chromosome Complement and Meiosis in Seven Species of the Family Lycosidae. By G. P Sharma, S. S. Jande, M. G. Grewal and R. N. Chopra. Pp. 255–269. Rs. 2/56. (Hoshiarpur: Panjab University, 1958 and 1959.) [252

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Technique No. 59: Étude de Quelques bois Congolais. Par J. R. Istas, R. L. Raekelboom et R. Heremans. Pp. 188. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1959.) 100 francs. [262

Mitteilungen des Deutschen Wetterdienstes. Nr. 18 (Band 3): Veroffentlichte Extenso-Beobachtungen Deutscher Klimastationen. Von Karl Brose. Pp. 11. 1.30 D.M. Nr. 19 (Band 3): Bedeutung und Aufgaben des Phanologischen Dienstes. Von Franz Witterstein. Pp. 22. (Offenbach. a.M.: Deitschen Wetterdienstes, 1960.) [262

Canada: Department of Northern Affairs and National Resources. National Museum of Canada. Bulletin No. 161 (Biological Series No. 59): The Birds and Mammals of Adelaide Penninsula, N.W.T. By A. H. Macpherson and T. H. Manning. Pp. iii+63 (6 plates). (Ottawa Queen's Printer, 1959.) 1.50 dollars. [292

Union of South Africa: Department of Commerce and Industries. Division of Fisheries Investigational Report No. 38: The South African Pilchard (*Sardinops ocellata*). Trends in the Pilchard Fishery of the Union of South Africa, 1948–58. By C. G. du Plessis. Pp. 28. (Reprint from *Commerce and Industry*.) (Pretoria: Government Printer, 1959.) [292

Publications of the Kapteyn Astronomical Laboratory, University of Groningen. No. 61: The Ellipsoidal Velocity Distribution of the A Stars as a Function of the Distance from the Galactic Plane. By P. J. van Rhijn. Pp. iii+89. (Groningen: Kapteyn Astronomical Laboratory, University of Groningen, 1960.) [292

Annual Report of the Indian Council of Agricultural Research for 1955–56. Pp. vi+196. (Delhi: Manager of Publications, 1959.) Rs. 5.00. [23

Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31st December, 1958. Pp. 19. (Sydney: Museum of Applied Arts and Sciences, 1960.) [23

Institut Royal des Sciences Naturelles de Belgique. Exploration Hydrobiologique des Lacs Kivu, Édouard et Albert (1952–1954). Résultats Scientifiques. Vol. V, Fascicule 1: La Végétation des Rives des Lacs Kivu, Édouard et Albert. Par Dick Van Der Ben. Pp. 191+11 planches. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1959.) [23

Proceedings of the United States National Museum. Vol. 110, No. 3421: The Rodent-Infesting Anoplura (Sucking Lice) of Thailand, with remarks on some Related Species. By Phyllis T. Johnson. Pp. 569–598. Vol. III, No. 3422: A New American Genus of Cryptopid Centipedes, with an annotated Key to the Scolopendromorph Genera from America North of Mexico. By Ralph E. Crabill, Jr. Pp. 1–15. Vol. 111, No. 3423: A Fourth Contribution to the knowledge of Neotropical Platyrhacid Millipeds (Diplopoda: Polydesmida). By Richard L. Hoffman. Pp. 17–31. Vol. 111, No. 3424: Millipeds from Dominica, British West Indies. By Richard L. Hoffman. Pp. 33–41. Vol. 111, No. 3425: Notes on Larvae of Nine Genera of Aphodiinae in the United States (Coleoptera: Scarabaeidae). By Manohar Lal Jerath. Pp. 43–94. (Washington, D.C.: Government Printing Office, 1959 and 1960.) [23

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

CHEMICAL LABORATORY
Date 29.7.60.
SCIENCE COLLEGE

NATURE Library,
SCIENCE COLLEGE,
92, Upper Circular Road,
CALCUTTA.

SCIENCE IN SECONDARY SCHOOLS IN BRITAIN

UNDER the Government's five-year plan for 'Secondary Education for All', a phrase which seemed to be popular in official circles fifteen years ago, nearly £300 million will be spent on new and improved secondary schools. About 1,000 new science laboratories are being erected and equipped each year, and although most of these will be in new schools, special attention is being given to the needs of existing grammar schools. There has been a steady increase in the number of graduate teachers of science and mathematics in the past few years. But this number is still not satisfactory, and the general level of the qualifications of science and mathematics teachers is even worse. Although it is admitted that there is a position in the grammar school for the lower second-class, the third-class or the pass-graduate, successful science teaching demands a scientific ability and background, cultural in the fullest sense of the term, the incidence of which is not great. A pleasing feature of the present situation is the probability of better standards in some of the training colleges because of the extension of the course to three years.

A recent Ministry of Education pamphlet*, which modestly describes itself as such although it runs to 164 pages, is timely and stimulating although it does not say much that is new. It is written enthusiastically by a group of Her Majesty's Inspectors whose aim is to help to stimulate the better teaching of science. The authors do not make the mistake of trying to provide syllabuses for each type of secondary school, and, although a few matters are selected for detailed consideration and illustration, the treatment of the topics is general. The booklet commences, as does "The Teaching of Science in Secondary Schools" compiled by the Incorporated Association of Assistant Masters and the Science Masters' Association, published some months earlier, with a short history of science teaching in England and a short but very useful account of the English tradition of science teaching. These matters are worthy of serious study, because only by a reasonable assessment of past failures and successes can we hope to build satisfactorily in the future.

Of particular interest is a revealing chapter, which could only have been written adequately by H.M. Inspectors, on conditions under which science is taught in Britain. Then follows a chapter of three pages on the development of children and the teaching of science. This seems to be the core of the whole matter and it will be noticed later. There are useful chapters on the design of science courses and some hints on the approach to general science.

The book makes a plea for a more honest, stimulating and pedagogical approach to what is so often wrongly called experimental work in schools. There are objections to heuristic methods in their crudest forms, but the ideas of H. E. Armstrong, a remarkably fine teacher of chemistry, should be considered in relation to modern requirements and possibilities.

The investigation of some simple problems in dynamics and apparent solar diameter, chosen, no doubt, to escape for a while from the beaten track of elementary science teaching, have been given a detailed treatment and illustrated with excellent photographs and diagrams.

The teaching of biology, chemistry and physics are succinctly reviewed in order. Part 4 of the book deals briefly with practical considerations of immediate importance: the design of laboratories, laboratory assistance, apparatus-making and suitable tools for this task. Once again, the qualities of a good science teacher are set out. The interesting thing about this is that it has been said so often before and in the same terms, but with little effect. Perhaps it is pessimistic to suggest that few science teachers recruited since the end of the War will meet the desiderata so ably set forth.

It may be hypercritical to note such a sentence as: "It is simple to tow a trolley fitted with a speedometer by means of a spring balance" and to call a difference of 5 per cent in the results of simple astronomical observations a close agreement. With so many topics briefly considered in so short a space, it has been difficult to avoid occasional superficiality. Chapter 10, a short essay on scientific method and the place of mathematics in it, is brilliant. There is a great deal of useful matter in this little book, and much of its worth only reveals itself by a second careful reading. It is the product of the mature thought of many able minds and is warmly recommended not only to actual and potential teachers of science and educationists in general but also to all those who have any interest in science. With all this, however, there is still one important matter—in fact, the most important—on which a little has been said in Chapter 4 and, indeed, little is known. Under the Education Act of 1944, secondary education was divided into grammar, technical and modern. The grammar schools continued on the way which had been laid down for them by the syllabuses of the external examinations, with perhaps a slight tendency to more enlightenment in methods and content in science teaching, but with still too great a stress on the 'facts' of elementary science and the repetition of simple, well-tried demonstrations, usually with much dictation of notes. Some schools did and do make an earnest endeavour to get the best out of science teaching by considering the nature of the study, the planning and carrying out of experiments, the methods of dealing with observations, the problems of error and confidence, the applications of science, the scientific spirit and so on; but too often science teaching was measured by its efficiency in producing passes at Ordinary Level, and in the sixth form at Advanced Level, in the General Certificate of Education examination; and in many schools, particularly girls' schools, it was not efficient even there.

---

* Ministry of Education. Pamphlet No. 38: Science in Secondary Schools. Pp. vi+164+6 plates. (London: H.M. Stationery Office, 1960.) 6s. net.

The secondary technical school in Britain has suffered through lack of equipment and teachers, but in the former there is much improvement. Selection for secondary technical schools is largely unsatisfactory, since the more intelligent children among those who fail to secure places in grammar schools are sent to technical schools. A consideration of the selection problems for children suitable for technical education is long overdue. Finally, there are the secondary modern schools. It is not unfair to say that, even with a certain tradition inherited from the central schools, they have largely failed to find a philosophy or even a scheme of work for themselves. No doubt the problems of staffing such schools with men and women with adequate science and teaching qualifications have been insuperable. Nevertheless, in view of some of the recommendations of the recent Crowther Report, the future of the secondary modern schools is of paramount importance. There can be little doubt that their comparative failure to establish themselves educationally and socially has led to cries, with political overtones, for comprehensive, bilateral and other schools.

The science-teaching triangle is child, teacher, equipment. The best equipment in the world—and much of it in British schools is surprisingly good—does not make a good teacher; and even a good teacher will not improve the intelligence of a child, even if good teaching may awaken interests and may apply whatever natural intelligence is found in the pupil to the best advantage.

Much research is necessary concerning the child-mind in relation to science, and should be undertaken by institutes of education and postgraduate teachers. Various natural bents, intelligences and levels of maturation will have to be considered in relation to the scope and content of science syllabuses, the origins of interest, and the methods and techniques of teaching—and all this in relation to the various aims which educationists have in mind, in teaching science at all.

THE DILEMMA OF THE FAR EAST

Population and Progress in the Far East

By Warren S. Thompson. Pp. ix+443. (Chicago: University of Chicago Press; London: Cambridge University Press, 1959.) 56*s*. 6*d*. net.

THIS is an important book about an important subject—the struggle of half of the world's people to keep production ahead of population growth. Its merit lies essentially in the wealth of information and analysis it supplies about the basic resources, technologies, economic policies and social customs which governments of Asian countries are desperately attempting to manipulate to break through the Malthusian barriers of subsistence. Chapter by chapter, Prof. Thompson lays out the patterns in Japan, India, China, Pakistan, South-east Asia and Taiwan and Korea

The reader naturally hopes that out of the great knowledge which Prof. Thompson displays there will emerge a pattern of hope; but his conclusions are sober, if not gloomy. He warns that even Japan, now generally listed as Asia's most prosperous country and the one clear case of population control, is yet in a precarious position, with a cultivated area still less than in 1940 and a trading area reduced to "about what it was in 1872". Compared with the rest of Asia, Japan is well advanced along the roads of both economic growth and demographic transition. Not so India, where the author concludes that of the vast uncultivated areas of 124 million acres, probably only 25 million are cultivable, or only enough to take care of present rates of population growth for some 4 or 5 years. However, Prof. Thompson does admit some prospect of increased productivity and of raising investment to some 10 per cent of national product, or sufficient to cope with a population increase of about 1·7 per cent and to bring some slight rise in living standards. But short-run gains will become losses unless the rate of population growth can be slowed down.

As for China, Prof. Thompson also doubts some of the more optimistic claims about unused resources; and emphasizes that if the 1953 census and subsequent official pronouncements about the annual rate of population growth of some 2 per cent are correct, the Chinese problem may prove even more intractable than that of India, although China has almost certainly a much greater area of cultivable but unused land than India.

On the general issue of how to achieve a successful take-off in the process of economic growth, Prof. Thompson shows himself to be an ardent agricultural democrat and traditionalist. His warnings against undue expectations from innovations, over-capitalization in enterprises that could best be carried out by more intensive use of labour, and insufficient attention to the strength of traditionalism leading to false optimism about the speed with which controls over the rate of population growth can be introduced, are all timely. Nevertheless one feels that he may be a little too conservative here, considering the rate of change that has occurred, and is so clearly still occurring, throughout the whole Asian and African world.

The biggest issue is whether the processes of economic growth and population control can be accomplished within a democratic framework. Prof. Thompson looks with hope to the Indian pattern, although even here he fears there may be too much emphasis now upon industrialization and not enough upon production of food and fibres, which he considers "will almost certainly be the chief source of capital" in all Asian countries. I share his hope that these great issues will be resolved within democratic frameworks; yet there is no proof that they will be, and we have to face the issue that, however much we dislike their political system, the Chinese do seem to be making as much progress as the Indians in trying to resolve the Malthusian dilemma of keeping the tortoise of production ahead of the hare of population growth.

Prof. Thompson's informative and thoughtful book is warmly recommended to those who want to think on the world's other great explosion—population growth. W. D. BORRIE

MAN AMONG THE PRIMATES

The Antecedents of Man

An Introduction to the Evolution of the Primates. By Prof. Sir Wilfrid E. Le Gros Clark. (Edinburgh University Publications: Science and Mathematics Texts, No. 2.) Pp. vii+374. (Edinburgh: At the University Press, 1959. Distributed by Thomas Nelson and Sons, Ltd., 1959.) 21*s*. net.

LE GROS CLARK'S "Early Forerunners of Man" (1934) is one of the basic studies in primatology; but it has long been unavailable, the stock having been destroyed by enemy action during the War. It is also now seriously out of date because of the great increase in knowledge of fossil primates during the past quarter-century. The Munro Lectures at the University of Edinburgh in 1953 gave Le Gros Clark occasion to review the whole subject, and he has now published what is essentially a revision of the earlier book, incorporating the substance of these lectures and also discoveries made since 1953.

"The Antecedents of Man" covers the same field and has nearly the same organization as "Early Forerunners of Man". The bulk of the book, as before, comprises a series of chapters on the comparative anatomy of the dentition, skull, limbs, brain, special senses, digestive system, and reproductive system of the primates. All are treated from a taxonomic and phylogenetic point of view. Fossil evidence on the hard parts and endocranium is included. These chapters do not differ greatly from the earlier version but have been well brought up to date. A wholly new introductory chapter on modes and processes of evolution and the interpretation of pertinent evidence is a useful and welcome addition. An older chapter on the reference of the tree-shrews to the primates, a radical idea in 1934 but now widely accepted, has been eliminated, and the evidence has been given where appropriate in other chapters.

The revised final chapter on evolutionary radiations of the primates particularly reflects new palæontological discoveries. Among the earlier forms there is less insistence on a sharp tarsioid-lemuroid dichotomy and on derivation of anthropoids from definite tarsioids. Among the later forms, discovery of the australopithecines and recognition of their near-ancestral relationship to man has made the greatest difference. Le Gros Clark was among the first to recognize that relationship, and he has maintained it in the face of polemic criticism. He may be excused a measure of satisfaction, here only faintly expressed, that time and further discoveries have proved him right in the opinion of the great majority of his colleagues. Another extremely important body of discovery since 1934 is abundant Miocene primate material found by Leakey in central Africa and described in large part by Le Gros Clark himself.

The taxonomy of early (Palæocene to Oligocene) primates and their relationships to various primitive insectivore-like groups is now again in a fluid state. From that point of view, this is an unfortunate time to review the group, and this part of the discussion is already becoming out of date. However, one can scarcely wait for study to stop before summarizing past results.

The book is not written down to a popular audience, but it assumes only minimal knowledge of anatomy and zoology. It might, indeed, be considered somewhat elementary for use as a text-book as suggested by author and publisher. For that and also other purposes the absence of a formal reference classification is unfortunate.

There are numerous books, even good books, on fossil man and human origins. This is the only book that places man in true perspective within the whole order Primates and its seventy million years of history. It is an excellent synthesis and summary, and it is warmly recommended. G. G. SIMPSON

ASPECTS OF AERONAUTICAL SCIENCES

Advances in Aeronautical Sciences

Proceedings of the First International Congress on the Aeronautical Sciences, Madrid, 8–13 September, 1958. Edited by Th. von Kármán, A. M. Ballantyne, R. R. Dexter, H. Blenk, H. L. Dryden and M. Roy. Vol. 1: Pp. viii+1–562. Vol. 2: Pp. viii+563–1144. (International Series on Aeronautical Sciences and Space Flight. Division 9: Symposia.) (London and New York: Pergamon Press, 1959.) 200*s*. net the set of two volumes.

THE papers recorded in these two volumes were presented at the first international congress organized by the newly formed International Council on the Aeronautical Sciences, and it is hoped that similar meetings will be sponsored in different countries every two years or thereabouts.

It would be an impossible task for any one reviewer to comment with authority on more than a few of the papers presented, since they cover an immensely wide range of aeronautical science. Forty-six in number (eight in French, four in German, one in Spanish, the remainder in English) they embrace, *inter alia*, mathematics and materials, medicine and mechanics, mixed flows and magnetohydrodynamics. There are general surveys of fields of knowledge, and original contributions; the speed-range covered runs from the zero forward velocity of a vertical take-off aircraft to the escape velocity of a satellite. I can therefore do no more than skip through the volumes, noting here and there a paper of particular interest, and finally giving an overall impression.

In the formation of the International Council on the Aeronautical Sciences and the promotion of the congress, financial assistance was received from the Guggenheim Fund for Aeronautics; it is therefore appropriate that the Proceedings open with the first Daniel and Florence Guggenheim Memorial Lecture. It was delivered by Th. von Kármán, and entitled "Some Significant Developments in Aerodynamics since 1946". It gives a very readable survey of the subject, ranging through supersonic and hypersonic speeds to Newtonian flow, and then over boundary-layer theory and turbulence. One plea should be quoted: "I believe that a systematic nomenclature and classification of these new branches of combined fluid mechanics, electromagnetic theory, and thermodynamics is yet lacking". One may say 'amen' to that.

There follows a group of papers dealing with various problems of high-speed flight—design, navigation, propulsion, the theory of hypersonic flow; an informative little essay from the pen of Lighthill on the dynamics of a dissociating gas is followed by a substantial paper on American experimental work on hypersonics. Next, three papers concerned with thermal effects on structures and one on oscillatory transonic derivatives appear (the authors being respectively Dutch, Italian, French, and Swedish). The first volume is completed by a dozen papers in groups, dealing with heat transfer, noise (both physical and bio-acoustic), and automatic control.

The second volume opens with a series of substantial papers on boundary layers (particularly boundary-layer control). Next, two general papers survey respectively the subjects of aero-elasticity and of hypersonic flow; they are followed by two papers on ring aerofoils. An interesting Russian contribution from Dorodnicyn deals with the analytical difficulty of calculation in the transonic region, when the governing equations are changing from elliptic to hyperbolic type. Vertical take-off provides the subject for the next group; materials for heat resistance are then discussed in three papers. Two papers on telemetry, three on aviation medicine matters, and three on propulsion methods for astronautics (including ionic propulsion) conclude the volumes.

The general impression gained from browsing through these volumes is entirely favourable. To weld such a variety of papers from so many different sources into a coherent whole must have presented the editors with a major task; they are to be congratulated on the result. The volumes are admirably printed, and only one or two misprints were noticed. As regards the papers themselves, I do not feel competent to judge more than a few, which I found of high standard; in the many other fields I found much of interest and many papers which invite a second more careful reading. A. R. COLLAR

PROGRESS IN METAL PHYSICS

Progress in Metal Physics
Vol. 7 (1958). Pp. viii+408. 110*s*. net.
Vol. 8 (1959). Pp. viii+330. 90*s*. net. Edited by Dr. Bruce Chalmers and Dr. R. King. (London and New York: Pergamon Press.)

TO say that these two volumes maintain the standard, and the interest, of their predecessors in this series is in itself high praise which is fully deserved. To the authors of the articles—and to the editors it should not be forgotten—are due the thanks of all concerned with the ultimate structures of metals, their transformation by heat or mechanical deformation and their alloys.

Volume 7 contains an account of work on the equilibrium, diffusion and imperfections in semi-conductors, justified, as if this were necessary, by the fact that single crystals of silicon and germanium are now available of a purity and perfection which surpass those of metal crystals "by many orders of magnitude". The paper on the physical metallurgy of titanium alloys is a discussion in terms of the fundamental factors involved, of the question "What additions form useful alloys with titanium ?". It is obvious that the last words in the perennial problems of the thermodynamics and kinetics of martensitic transformations have not yet been said, as is abundantly evidenced by the noteworthy progress made in the past decade, which is excellently summarized here. That that part of the mechanical energy expended in deforming a metal and stored up in the deformed structure is the essential feature of the cold-worked state has, in general terms, been recognized for many years. That it is the cause of the instability of this structure is equally well known. The account, therefore, of the extent to which this qualitative treatment may be developed into a quantitative treatment is to be welcomed. The final article, a second one on the properties of metals at low temperatures, deals particularly with thermal conductivity, on which a large amount of work has been done, and on certain mechanical properties.

Volume 8 commences with still a third review in this series of the work-hardening of metals. Despite this, the account of new work extends to some hundred pages with getting on for two hundred references. Allied to this is an article on X-ray studies of deformed metals. The fact that metallic crystals are never perfect has long been known, and an account of the defects in pure metals discusses the subject from the point of view of modern knowledge. "Ten years of fairly intensive work has yielded a moderately complete experimental picture of copper and gold, and the theoretical estimates are apparently reasonably accurate", but "it would be unreasonable to expect to find any easy way of extending our knowledge to other metals".

Two articles remain to be mentioned, one a very welcome discussion on grain boundaries. After a period some thirty to forty years ago when these boundaries were the focus of metallographic thought, this, under the influence of the then new X-ray techniques, moved over to the structure of the crystals themselves. In view of the profound importance of the grain boundary on the properties, it is a healthy sign that their nature, still very far from being fully understood, should once again be a subject of investigation. Finally there is an account of the substructures in crystals grown from the melt, a matter of most obvious significance. The cellular structure on the solid-liquid interface of such a crystal of tin, Fig. 15, is so full of interest that one is led to wonder whether the old Quincke hypothesis might not repay renewed examination at the hands of a modern physical metallurgist.

An almost incredible amount of work is summarized in these volumes, and the need of men well-versed in such matters who can, and are willing to, apply this knowledge to modern industrial needs requires no emphasis. F. C. THOMPSON

FLAME AND EXPLOSION OF GASES AND VAPOURS

Explosions, Detonations, Flammability and Ignition
Part 1: Selected Analytical Studies on Explosions, Detonations, Flammability Limits, and Ignition of Gases, and on Heterogeneous Burning. By Prof. S. S. Penner. Part 2: Experimental and Theoretical Studies of Flammability, Ignitibility and Explosion Prevention. By B. P. Mullins. (AGARDograph No. 31.) Pp. xi+287. (London and New York: Pergamon Press, 1959. Published for and on behalf of Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization.) 70*s*. net.

THIS work is largely an account of recent advances in fundamental knowledge of initiation and propagation of flame in engines powered by gaseous and liquid fuels. Other subjects, such as the extinction of flame and the explosion of clouds of certain metallic powders and coal dust, have comparatively brief notices. Solid explosives are not included.

The work has two principal foci, one being the major interests of a professor of jet propulsion and the other of an officer of the National Gas Turbine Establishment. The two parts are written almost independently, and might well have been published separately. Indeed, the introduction to Part 2 claims that "it is often evident that a semi-empirical thermal approach can yield results which are much more accurate than a basic theoretical treatment which can usually only indicate orders of magnitude". A closer correlation of theory and experiment may be possible some day, but the authors, in their joint general introduction, say that "much more work must be done before we arrive at anything resembling a complete theory of, for example, flammability limits and ignitibility, particularly in heterogeneous systems", and hope that their monograph "will stimulate fresh ideas and indicate areas of combustion research in which future effort might be directed fruitfully".

Both parts of the book are based on a detailed knowledge of recent advances (up to about 1958) in the study of flame and explosion in gases, vapours and mists. The authors quote from their own contributions, some of which have not previously been published, and from available papers from many sources, including some important Russian work. The bibliographies seem to be thorough and carefully prepared; and the few errors that I have noticed (for example, the mis-spelling of the names of Blecher, Barth and Couriot) will not seriously inconvenience anyone.

The reference (p. 113) to "Semenov's original postulate that an ignition temperature is that temperature at which the initial loss of heat due to thermal conduction etc. is equal to the heat liberated at the same time by the chemical transformation" must have been written in ignorance of Van't Hoff's postulate ("Etudes de Dynamique Chimique", 1884), which reads "Le température d'inflammation est celle à laquelle la perte initiale de chaleur, dûe à la conductibilité etc., est égale à la chaleur que produit en même temps la transformation".

Although the chief value of the book is its review of the researches of the past ten years or so on gaseous combustion in relation to engines, it will be of much value to a wider circle concerned with the use or suppression of flame. The book is not for beginners, who have (as the authors repeatedly indicate) the works of Bone and Townend, Jost, and Lewis and von Elbe in which to find summaries of the older researches on this very intricate subject.

H. F. Coward

ARTIFICIAL INSEMINATION IN CATTLE

Lehrbuch der Rinderbesamung

Grundlagen, Technik, Organisation und züchterische Probleme der Samenubertragung beim Rind. Von Dr. Karl Eibl. Pp. xv+485. (Berlin und Hamburg: Verlag Paul Parey, 1959.) 74 D.M.

This book is a thorough and detailed compilation of facts from the literature about artificial insemination in cattle. While a list of the main books on the subject is given, no references to original papers are listed although names and dates are given in the text. It is arranged in six sections the scope of which are indicated by some of the examples quoted below. Section 1 deals with the anatomy and histology of the male organs. The structure of spermatozoa, the pathology of spermatogenesis and abnormal forms are well illustrated. Different forms of artificial vaginas and electro-ejaculation are described. Methods of semen examination such as the impedance test, staining for live and dead sperm and for fructolysis are outlined. In Section 2 the female organs are described. A good illustrated account is given of the development and timing of the fertilized egg from ovary to uterus. Conception rates are also dealt with. Section 3 outlines the history, development and present state of artificial insemination in different countries. Various methods for proving bulls for milk and type are also described. The practical problems of the organization of artificial insemination stations are given in Section 4: plans are given for the layout of centres. Methods of feeding and examining bulls for disease and impotency are included. The significance of testes volume is also discussed. Among the various things described in Section 5 are the different dilutors and the blood grouping of sires and their offspring. Details and illustrations of the apparatus used in the deep-freezing of semen are given and semen banks are discussed. Reference is also made to the carbon dioxide method of storage at room temperatures. In Section 6, and also elsewhere, the problems concerned with semen infected with *Vibrio* or *Trichomonas* are discussed.

This is a very useful book to consult on all questions of artificial insemination in cattle. J. Hammond

ADVANCES IN VETERINARY SURGERY

The Veterinary Annual, 1959

Edited by W. A. Pool. Pp. xxiv+363+36 plates. (Bristol: John Wright and Sons, Ltd., 1959.) 42*s*.

No veterinary periodical has as yet, as a matter of editorial policy, sought to provide a comprehensive selected abstract service. "The Veterinary Annual" aims to satisfy this need, and the first edition has made a very good start.

It must be judged mainly on the adequacy and topicality of its reviews of the current literature, which provide the main bulk of the text. The literature of 1958 and part of 1959 is covered in most of the sections as topically as any annual published in early 1960 can be. The reviews cover the diseases related to bacteria and fungi, to protozoa, viruses and parasites, nutritional and metabolic disorders, reproduction and reproductive disorders, neoplasms, radiation and radiology, pharmacology, toxicology, physiology, surgery, technique and apparatus and public health.

The editor, W. A. Pool, has contributed several sections himself, and these are a good indication of the high standard he is setting. He has also avoided, and restrained his contributors (one or two apparently with some difficulty) from, covering up a deficiency of research results by theoretical exercises which may only mislead the veterinary practitioner who is not so well informed on these matters. Indeed the mere fact that these deficiencies due to lack of progress in research are obvious is to the credit of the editor and his contributors.

One major deficiency is the lack of reports of clinical trials of new drugs. This is emphasized by the list of fifty new drugs and appliances together with manufacturers' descriptions—many of which may never be competently evaluated.

Besides the very adequate review of the current literature there are a number of special articles describing veterinary work in the United States of America, Denmark, Sweden, Canada, Australia, New Zealand, Central and South Africa. That by Smithcors about the United States of America is an excellent introductory article which sets a very high standard for those to follow. Various aspects of veterinary practice in Great Britain are also covered under the headings of country practice, horse practice and small-animal practice. Here the contributors are too vague and in none does the standard approach that of Smithcors or of the introduction to greyhound racing by Bateman. In the next edition the editor might pay attention to some of the subjects discussed in his own preface. Contributions relating new methods of husbandry and feeding to the wide range of standards of management existing in Great Britain would certainly become a most fruitful new venture. It should be noted that the small list of new publications included in the book cannot be considered by any means exhaustive.

This annual is strongly recommended to all those many veterinary surgeons and field research workers who lack adequate library facilities or a comprehensive abstract service. G. N. GOULD

STEROID CHEMISTRY

Steroids

By Prof. Louis F. Fieser and Mary Fieser. Pp. xvii+945. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1959.) 144*s*. net.

THIS book represents the fourth edition of one first published in 1936 under the title "Natural Products Related to Phenanthrene", the third edition of which was published in 1949. The present book deals entirely with the chemistry of the steroids, which have become by far the most important group of naturally occurring phenanthrene derivatives.

The reviewer's task is a pleasant one because this is a superb presentation, both for the specialist and for the general reader. Biological and commercial interest in the steroids over the past ten years has stimulated a vast amount of chemical research. This might have proved dull, but in fact it has been intimately connected with new applications of physical techniques (for example, infra-red spectra and rotatory dispersion), new theoretical ideas such as conformational analysis, and the development of new reagents. It might fairly be claimed that the steroids have set the pace for the development of alicyclic chemistry over the past decade.

This book can be read with pleasure and profit by workers in any field of organic chemistry, including the specialist on reaction mechanisms, the synthetic organic chemist, the worker who is concerned with the application of new instrumental methods, etc. Not only does this book review most admirably the literature of the subject; but also the authors in many places add their own interpretations and generalizations—and furthermore they pose new problems for research.

All aspects of steroid chemistry are covered, and although the book does not pretend to be a complete catalogue of all the facts, the wealth of detail is such that it may be feared that many research students will be tempted not to bother to look at the original literature.

The general chapters of the book cover the following topics: Chapters 1–2, introduction and structure of the steroid skeleton; 5, physical methods of characterization; 6, oxidation; 7, enes and ols; 8, ketones; 9, displacements and rearrangements; 10, stereochemical correlations and conventions.

The specialized chapters deal with all the main groups of steroids as follows: Chapter 4, vitamin D; 11, sterols; 12, methylsterols (including the tetracyclic triterpenoids); 13, biosynthesis of cholesterol; 14, bile acids and alcohols; 15, œstrogens; 16, androgens; 17, progestogens; 18, homo- and nor- steroids; 19, adrenocortical hormones; 20, cardiac-active principles; 21, sapogenins; 22, alkaloids.

The book is lavishly illustrated with structural formulæ, many of them three-dimensional. A pleasant feature is the inclusion of many personal notes about workers in the field; such insertions would be annoying if they took the place of good factual and theoretical information, but when they are added to a fine scientific presentation, they contribute greatly to the interest of the book.

One of the most important facts about this book is that it is so up to date. The date of publication in the United States was July 1959; there are many 1959 references, and others to work then unpublished. Many monographs to-day suffer so much from serious delays in editing, printing, revision, etc., that this book must provide authors and publishers with a model of what can be achieved; typographical accuracy and the clarity of the formulæ leave nothing to be desired.

The more one reads of the book the more one is amazed at the way in which the two authors have combined a broad view of the subject with a wonderful grasp of detail. It is significant that in a book of 900 pages they have not followed the common trend of making it a collaborative effort. They have, however, obtained the help of colleagues in the field in another way; the entire manuscript was read by six steroid chemists outside the authors' laboratory; individual chapters and sections were sent for comment to nearly every senior worker in each special branch of the field, and the authors generously acknowledge the very valuable help of these colleagues.

If I may offer one or two suggestions regarding further improvement of the book in its fifth edition, they are the following: the subject index, although very full, might be extended by the inclusion of an index of formulæ of the pattern used in *Chemical Abstracts*, and also an index of reactions; this might be of the type used in Theilheimer's "Synthetic Methods", or perhaps it would be more popular if it did not need a special technique for decoding. The authors have indexed some classes of reaction, including oxidation, reduction, hydrogenation, but not, for example, hydrolysis. Another useful addition to the index would be the names of 'classes' of compounds, such as glucuronides and sulphates.

All steroid chemists will be still further indebted to Prof. and Mrs. Fieser for this wonderful achievement, and it is hoped that many other chemists will take advantage of the mass of information and ideas which is laid before them in this book.

The minor criticisms of the index are rather like the comments of the traveller who directed attention to the ticking of the clock in a Rolls-Royce—for this is indeed a Rolls-Royce among monographs of organic chemistry. W. KLYNE

Applied Hydrodynamics

By H. R. Vallentine. Pp. viii+272. (London: Butterworths Scientific Publications, 1959.) 50*s*.

THIS is a text-book not so much of applied hydrodynamics as of classical theoretical hydrodynamics in an accessible form for application. It is meant for students of engineering and physics as well as applied mathematics.

The mathematics of the subject is expounded in some detail. A student with limited mathematical ability will probably find enlightenment here on subjects about which he would learn little from a more concise account, though occasionally he may have difficulty in seeing the wood as well as the trees.

In an introductory chapter, readers are forewarned of the important differences between inviscid and real fluid-flows. This is welcome. The matter might reasonably have been given more emphasis throughout the book, and in a future edition the apparent identification of near-irrotational flow outside boundary layers with turbulent flow ought to be corrected.

There is a chapter on the numerical and experimental-analogy methods for solving Laplace's equation. Here and elsewhere seepage problems are included among the illustrations; these help to justify treating solutions for boundaries at which separation would occur in ordinary fluid-flow at high Reynolds numbers. Aerofoil and wing theory get less attention than they deserve, apart from aerofoils obtained by conformal transformation of circles.

The book will probably be most useful as a hydrodynamics supplement to one of the better of the available engineering text-books of applied fluid mechanics, to be dipped into as required. Its readers should be well prepared with an understanding of real fluid flow, for while the reminders in it of the realities of applied hydrodynamics are useful, they are not complete enough to stand alone. E. P. SUTTON

British Caenozoic Fossils

(Tertiary and Quaternary). Pp. vi+130 (44 plates). (London: British Museum (Natural History), 1959.) 6*s*.

THERE has long been a need for some kind of comprehensive yet concise handbook illustrating the fossils most commonly found in the various strata of Great Britain. "British Caenozoic Fossils", prepared by the staff of the Natural History section of the British Museum, is the first of a series which will eventually embrace also the Mesozoic and Palæozoic fossils of Britain, and will be widely welcomed. The present volume contains line drawings of 354 Tertiary and Quaternary fossils, together with tables giving their geological distributions and a coloured map showing the principal fossiliferous localities.

The aim of the series is modestly described in the preface as being "to enable the young, or those without experience, to know what fossils they may expect to find, or, even more important from our point of view, to identify for themselves those they have collected"; but there can be few mature professional geologists in Britain who would not be glad to have this book on their shelves or, more to the point, in their pockets when in the field. For the latter purpose the book is ideal; it is compact (approximately 8½ in. × 5½ in.), and clearly printed on strong paper which is unlikely to be ruined by the occasional spot of rain. The drawings are a delight to the eye, and the typography and layout show a concern for clarity and style in every detail which is all too rare at the present day, and surely unequalled in a book of this price. The only criticism which might be levelled at it is that a work of such excellence deserves a more robust and attractive cover. The companion volumes will be eagerly awaited.

Organic Syntheses

Vol. 39. Edited by Max Tishler. (An Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals.) Pp. vii+114. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 32*s*. net.

OVER a long period a large number of the more familiar organic chemicals have been dealt with in this annual publication of satisfactory methods for their preparation. The later volumes have accordingly contained a larger proportion of more specialized structures, many of which were unknown at the inception of the series. The great diversity of organic types represented is well illustrated in the present selection of 31 synthetic preparations, including such items as benzeneboronic anhydride, di-*n*-butyldivinyltin, 9-methylfluorene, several derivatives of furan, and the heavily unsaturated alcohol, HC ⋮ C·CH(OH)·CH : CH·Ph, resulting from the interaction of ethynylmagnesium bromide and cinnamaldehyde. An interesting pair of stereoisomers is provided by the low-melting and high-melting forms of 9, 10-dihydroxystearic acid, prepared from oleic and elaidic acids respectively.

The subject index to Volume 39, occupying 34 pages, is a cumulative one, comprising material from volumes 30–39. All the entries in the preceding 29 issues are indexed in Collective Volumes 1, 2, and 3: details of any specific substance are therefore easy to trace. It is almost needless to add that this invaluable series continues to maintain its high reputation for accuracy and reliability. JOHN READ

Glutathione

Edited by E. M. Crook. (Biochemical Society Symposium No. 17, held at Senate House, University of London, February 15, 1958.) Pp. v+116. (Cambridge: At the University Press, 1959.) Cloth 22*s*. 6*d*.; Paper 15*s*.

THE ubiquity of glutathione in living organisms has prompted its widespread study and makes opportune the publication of this symposium, which includes much work carried out after the Ridgefield Symposium of 1953, also entitled "Glutathione". There is no overlap in the contributions to the two symposia, and the present symposium is characteristically different from its predecessor also in presenting a major part of its information in terms of the organisms or organs in which the behaviour of glutathione has been studied. There are considered successively the tissues of plants, of animals, neural tissues, and the lens of the eye. In each of these contributions the reviewers (L. W. Mapson, P. C. Jocelyn, H. McIlwain and S. G. Waley) place their own investigations in a wider setting of the biochemistry of the system concerned. Contributions on the chemistry and analysis of glutathione (F. A. Isherwood, C. G. Thomson and H. Martin) and on its role with other thiols in radiation damage (D. B. Hope) complete the Symposium. It is regretted that there is no index.

COMMUNICATIONS FROM SUPERIOR GALACTIC COMMUNITIES

By Prof. R. N. BRACEWELL

Radioscience Laboratory, Stanford University, California

SINCE Morrison and Cocconi[1] published the suggestion that there might be advanced societies elsewhere in the Galaxy, superior to ourselves in technological development, who are beaming transmissions at us on a frequency of 1,420 Mc./s., Drake[2] has described equipment under construction to look for such transmissions. The confidence necessary to commence actual observations is based on an opinion that planets are a common by-product of the formation of stars. One argument among others is that stars of spectral type later than $F5$ have low angular momenta, just as the Sun has; and in the case of the Sun we know that it is because the momentum (98 per cent of it) resides in planets[3]. Of the thousands of millions of planets in the Galaxy likely to be situated similarly to the Earth in relation to their star, it is hard to dismiss the possibility that some have more advanced civilizations than ours. In view of the acceleration with which technology develops, advanced societies could be incredibly more advanced.

Any simple test of this possibility would be well worth while. Drake plans to look at τ Ceti and ε Eridani. Of the list of likely neighbouring stars given by Morrison and Cocconi, these two, and ε Indi, are the only ones left when we eliminate double stars. Because of orbital perturbations, the planets of double stars are, with some exceptions, not expected to possess equable climates over the geological periods deemed necessary for evolution[4].

But do we really expect a superior community to be on the nearest of those stars which we cannot at the moment positively rule out? Unless superior communities are extremely abundant, is it not more likely that the nearest is situated at least ten times farther off, say, beyond 100 light years? Let us assume that there are one thousand likely stars within the same range as the nearest superior community. This makes it hard for us to select the right one. Furthermore, if this advanced society is looking for us, we can only expect to find them expending such effort as they could afford to expend on the thousand likely stars within the same range of them. It does not seem likely that they would maintain a thousand transmitters at powers well above the megawatt estimated by Drake as a minimum for spanning only 10 light years, and run them for many years, and we could scarcely count on them paying special attention to us. Remember that throughout most of the thousands of millions of years of the Earth's existence such attention would have been fruitless.

Would not this other more advanced society, on the contrary, be doing what we ourselves are now discussing and are on the point of doing, probably during this century, namely, sending probes to nearby stars. Their exploration and other activity would be intense in their immediately neighbouring planetary systems. Beyond their immediate neighbourhood, it might be feasible for them to spray some number of suitable stars, say, one thousand, with modest probes. Each probe would be sent into a circular orbit about one of the thousand stars, at a distance within the habitable zone of temperature. Armoured against meteorites and radiation damage, and stellar powered, the probes could contain durable radio transmitters for the purpose of attracting the attention of technologies such as ours.

Using this plan, our hypothetical advanced neighbours could lay down a stronger signal here than they could with a home-based transmitter handicapped by inverse-square attenuation over interstellar distances. They would also eliminate their dependence on our ingenuity in selecting the right star and the right wave-length.

For this reason we might better devote our efforts to scrutinizing our solar system for signs of probes sent here by our more advanced neighbours. In this way we would be effectively paying attention to all stars capable of reaching us. We need not expect, however, that any community other than the nearest is trying to reach us, because the superior communities throughout the galaxy are probably already linked together into an existing galaxy-wide chain of communication. They will act in concert and avoid duplication in searching. Our impending contact cannot be expected to be the first of its kind; rather it will be our induction into the chain of superior communities, who have had long experience in effecting contacts with emerging communities like ours.

For suggestions as to how the superior communities may detect us, consider what we might do to detect them. A very good first project for us, when we come to probe outside the solar system, would be to seek the presence of technological development on τ Ceti and ε Eridani by means of a probe that would listen for the existence of monochromatic radio-communication, and report back by star-to-star relay. We would see whether there is in those solar systems a radio-frequency line emission spectrum such as the Earth now emits. It is possible, in fact, that the hypothetical feelers sent out in large numbers by our nearest superior community did no more than listen for this radiation. If so, a positive answer could have been on the way back to the home star several decades ago, and we may look forward in due course to the arrival of a more sophisticated mission.

However, since interstellar transfer of material things is time-consuming, and transfer of information is in any event more important, it would be commensurate with the effort of delivering a material probe into our solar system if the very first probe sent here contained a quite elaborate store of information and a complex computer, so that it could not only detect our presence, but could also converse

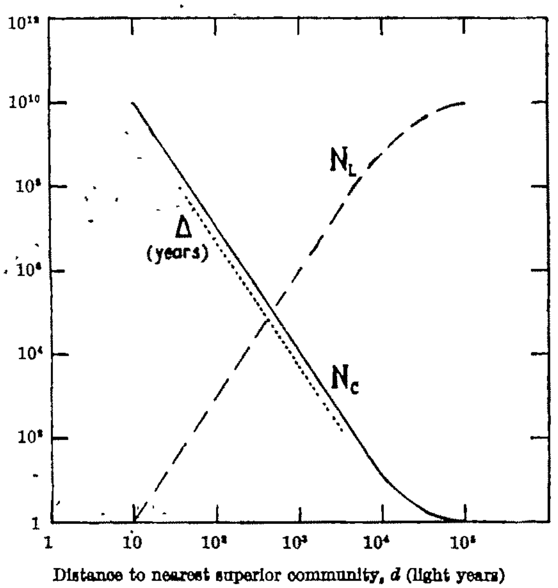


Fig. 1. N_C, total number of communities in the galaxy the technology of which is superior to ours; N_L, total number of likely stars out to a distance d; Δ, average life-time of a superior community

with us. Such a probe may be here now, in our solar system, trying to make its presence known to us. For this purpose a radio transmitter would seem essential. On what wave-length would it transmit, and how should we decode its signal? To ensure use of a wave-length that could both penetrate our ionosphere and be in a band certain to be in use, the probe could first listen for our signals and then repeat them back. To us, its signals would have the appearance of echoes having delays of seconds or minutes, such as were reported thirty years ago by Størmer and van der Pol[5] and never explained.

To notify the probe that we had heard it, we would repeat back to it once again. It would then know that it was in touch with us. After some routine tests to guard against accident, and to test our sensitivity and band-width, it would begin its message, with further occasional interrogation to ensure that it had not set below our horizon. Should we be surprised if the beginning of its message were a television image of a constellation?

These details, and the matter of teaching the probe our language (by transmitting a pictorial dictionary?), are fascinating but present no problems once contact has been made with the probe. The latter is the main problem. The important thing for us is to be alert to the possible interstellar origin of unexpected signals. We must avoid relegating them, if they are there, to the fate of the very strong emissions from Jupiter (of the order of 1,000 megawatts per Mc./s.) which were heard and ignored for decades[6].

If after a few years of careful attention we find no signs, radio or other, of such probe, we shall have to admit the possibility that our nearest superior community is beyond the range where attempts at contact with us would be assured of much certainty of success.

To survey the possibilities of there being a superior community within reaching distance of us, consider Fig. 1, which shows the number of superior communities in the Galaxy, N_C, plotted against the distance to the nearest superior community, d, in light years. This graph is obtained from the broken curve which shows a quantity N_L, the number of likely stars at a range less than d. By likely stars I mean those 5 per cent[4], here taken as 10^{10} in number, that cannot be ruled out at present as unsuitable to support life. The curve is based on a galactic mass distribution model and cannot be considered accurate to better than an order of magnitude.

Now consider the consequences if $N_C = 10^7$. Then $d = 100$ light years, and the number of likely stars within this range is 10^3. The frequency of occurrence, p, of superior communities among likely stars, is 10^{-3}. Although we have no evidence for intelligent life elsewhere, yet if we consider that on the average it takes 5×10^9 years for a likely star to produce one superior community, which then endures for an average life-time Δ measured in years, then $p = 10^{-3}$ implies a Δ of 5×10^6 years, assuming that we are in a state of secular equilibrium. This would seem to offer ample time to explore the 10^3 stars out to 100 light years and establish a chain of communication.

Consider the consequences, however, if technology in our galaxy is less abundant, for example, take $N_C = 10^3$. Then $p = 10^{-7}$, $N_L = 10^7$, $d = 2{,}000$ light years, and $\Delta = 500$ years. The duration of communities which can maintain a frequency of occurrence of only 10^{-7} is thus, on the average, too short to permit interstellar traffic.

If intelligent life does develop on other likely systems at the same tempo as ours has developed, and if some superior community has not made contact with us, it may simply be that the mortality-rate for advanced civilizations is too high for them to become abundant in the Galaxy. Even so, it is rather striking that there would be a thousand superior communities present in the Galaxy at any time even though it takes as long as five thousand million years to produce a technological community that is viable, on the average, for only 500 years beyond the point we have reached.

Even in the event of technology being rare, there is, however, the possibility of a chain existing. Thus, in a Galaxy supporting only 10^3 superior communities with brief expectation of life, there may be some communities that have achieved durability, even quasi-permanence, perhaps by gaining control of the circumstances that lead to short average life-times. Aided by accidental proximity due to random spacing, some of these could be in contact. Presumably such an ancient association would be very able indeed technically, and might seek us out by special means that we cannot guess. Whether they would be interested in rudimentary societies which, in their experience, would usually have burnt themselves out before they could be located and reached, is hard to say. Such communities would be collapsing at the rate of two a year (10^3 in 500 years), and they might already have satisfied their curiosity by archæological inspection made at leisure on sites nearer home. On the other hand, the prospect of catching a technology near its peak might be a strong incentive for them to reach us.

---

[1] Cocconi, G., and Morrison, P., *Nature*, **184**, 844 (1959).

[2] Drake, F. D., *Sky and Telescope*, **19**, 140 (1959).

[3] Struve, O., *Sky and Telescope*, **19**, 154 (1960).

[4] Huang, S. S., *American Scientist*, **47**, 397 (1959).

[5] Størmer, C., *Nature*, **122**, 681 (1928). van der Pol, B., *Nature*, **122**, 878 (1928). For later discussion, see Budden, K. G., and Yates, G. G., *J. Atmo. Terr. Phys.*, **2**, 272 (1951).

[6] Burke, B. F., and Franklin, K. L., *J. Geophys. Res.*, **60**, 213 (1955). Shain, C. A., *Aust. J. Phys.*, **9**, 61 (1956).

CO-ORDINATION OF LIGHT AND ELECTRON MICROSCOPY

BEING such a complicated and expensive instrument, the electron microscope until recently has remained largely in the hands of physicists. For developing operating techniques, and to a large extent special preparative methods also, this circumstance had distinct advantages, but inevitably it biased the use of the instrument in the direction of high resolving power, of investigating structures and particles (such as viruses) well beyond the limit of the optical microscope. A jump of one hundred times in useful magnification gave some excuse for this attitude, perhaps. There may also have been some tendency to regard electron microscopy as a field of research in its own right, both in biological and metallurgical applications, with the ill-result of detaching it from work done at lower magnifications. Properly seen, of course, it is just another tool of research, albeit a most powerful one, to be used in co-ordination with the established optical and other techniques for investigating microscopical structure. With the gradual realization that it is best situated in the laboratory of the scientist who wants to make use of it—even though it still requires a physicist to bring out all its potentialities—the electron microscope in the past few years has begun to find its way into departments of botany, zoology, metallurgy, and so on. As a result, increasing attention has been given to considering how to correlate its use with other techniques of observation, such as phase-contrast, polarizing and interference microscopy, in addition to X-ray and electron diffraction. It was this trend that prompted the Royal Microscopical Society to approach the Electron Microscope Group of the Institute of Physics, which until now has been responsible for the subject in Britain, to join in organizing a symposium on "The Co-ordination of Light and Electron Microscopy". The meeting was held in the University of Leeds during March 31–April 1. Its timeliness was reflected in an attendance of more than 150, including a number of visitors from Belgium, Holland, Germany and the United States. The proceedings, which will be published in full in the *Journal of the Royal Microscopical Society*, consisted of eight invited papers and a number of short contributions to the discussions on them.

The symposium opened with a detailed review by Dr. R. Barer (Department of Human Anatomy, University of Oxford) of the various methods of microscopy now available. He brought out the range of applicability and the degree to which quantitative information could be obtained with each technique. Prof. I. Manton (Department of Botany, University of Leeds) followed with a talk on the co-ordinated use of electron microscopy and a group of optical techniques in plant cytology, beginning with some remarks on the general difficulties of importing physical methods into a biological laboratory. It is not so much the first cost of an electron microscope as the running costs and the provision of specialist technicians which give trouble. The scale of staffing and expenditure is foreign to the experience of a biologist, and even to a university as a whole, as appeared from later discussion. The best use cannot be made of these new instruments, many of which are bought with grants from trusts and foundations, unless more adequate recurrent funds are made available by universities and the research councils, which ultimately means from government sources. Prof. Manton went on to describe the investigations made in her laboratory into the structure of micro-organisms, and particularly of their cilia. She emphasized the value of light microscopy of specimens dried in a controlled manner, as well as the use of the phase-contrast method for living material. The study of serial sections in the electron microscope may be complemented by through-focal observations in the ultra-violet microscope. Dr. A. D. Greenwood, of the same Department, showed a three-dimensional reproduction of a chloroplast which had been made with the aid of these techniques.

In the afternoon session the use of a selected battery of techniques was further illustrated by Dr. D. Lacy (Department of Zoology, St. Bartholomew's Hospital Medical College, London), on the basis of his own studies of the rat testis, and by Dr. K. M. Rudall (Department of Biomolecular Structure, University of Leeds) in a review of the work done in a number of laboratories on the cross-banding and fine structure of fibres and, in particular, of muscle, nerve, keratin and collagen. Mr. D. H. Page brought a different point of view, in describing the methods developed at the British Paper and Board Research Laboratory, Kenley, for studying the surface of paper and related materials. Ordinary optical techniques are inapplicable, except at low resolution, and transmission electron microscopy is of little help. Much information has been obtained by adapting the shadowcast replica method of electron microscopy to the conditions of optical microscopy. The final replica is embedded in a plastic block, so that the full aperture of the light microscope can be used and high resolution obtained. Much use has also been made of reflexion and scanning electron microscopy, which provide an image with considerable three-dimensional detail at a useful magnification just beyond that of optical methods.

On the following day, a paper by Dr. J. Nutting and Dr. P. Kelly (Department of Metallurgy, University of Cambridge) presented a wide survey of the microscopical techniques used in metallurgy, including X-ray as well as optical and electron methods. The overlapping of their ranges of applicability was displayed by means of a diagram (Fig. 1), in which resolving power is the abscissa and depth of focus the ordinate. Depth of focus is important in metallurgical work, since the relative height of surface features often comes in question. The complementarity of the available methods is well brought out by the diagram. Particular attention was paid to the new techniques developed for observing thin films of metals directly in the electron microscope and to new optical methods for observing slip lines and dislocations. Dr. A. Keller and Mr. D. C. Bassett (H. H. Wills Physics Laboratory, University of

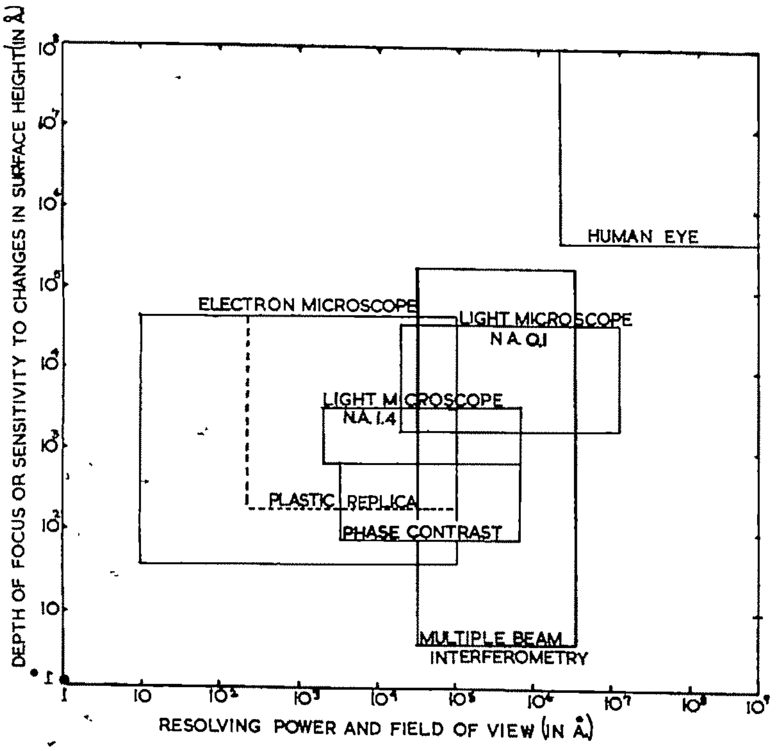


Fig. 1. Range of applicability of a number of microscopic techniques, in terms of resolving power and depth of focus (after Nutting and Kelly)

Bristol) gave a similar review, though on a narrower front, of light and electron microscope investigations of the habit and structure of crystals, particularly of long-chain polymers. Those of polyethylene are so sensitive to the electron beam that progress has only been possible by careful correlation of optical observations with those made by specially developed electron microscopical techniques at low and intermediate magnifications. The final paper, by Dr. Anna Cosslett (Cavendish Laboratory, University of Cambridge), dealt with the use of some of the optical techniques in association with electron microscopy in a few selected problems, and so far as possible quantitatively, rather than with a broad survey of a branch of science. The ultra-violet microscope at its highest resolving power provides semi-quantitative evidence of the distribution of nucleic acid in chromosomes and micro-organisms, for example, for comparison with the various light and dark regions seen in electron micrographs. The interference microscope can be used to measure the changes in thickness and refractive index of thin sections caused by exposure in the electron beam. In this way the competing effects of loss of material by irradiation and deposition of 'contamination' have been followed in a variety of plastics used for embedding purposes. As much as 50 per cent is lost from some, and 20 per cent from the most resistant, even with an electron dose very small relative to that incurred in normal operation of the microscope.

The main features of the contributions and discussions were summed up by Dr. V. E. Cosslett (Cavendish Laboratory, University of Cambridge). The fruitfulness of a combined attack with all the relevant optical and electron microscopical techniques had been demonstrated in every paper. X-ray methods, which had had little mention, could provide a further dimension in so far as they give information about the nature and amount of the different elements locally present in a specimen. For the most part, light and electron techniques give only the distribution of dry mass, although optical microspectrometry of stained specimens can now explore the localization of particular biological compounds. Optical microscopy will continue to be indispensable in electron microscopy for charting a course through the specimen at the higher available magnification and, even more important, for checking the incidence of artefacts in the various stages in its preparation. At the same time, electron microscopy is beginning to feed back ideas to optical microscopy, in new preparative methods and also in demanding that optical techniques be used to the very best advantage. The standards set by the great light microscopists of the end of the past century are now being re-discovered, and more attention is being paid to teaching the use of the light microscope at high resolution.

Great progress has been made with the electron microscope, since it was invented thirty years ago, but a comparison with the range of optical methods now available brings out how much remains to be done. An electron interference microscope, of limited applicability, has been constructed, but a practicable electron phase-contrast system is not yet in sight. Our electron lenses are still extremely primitive, and, although methods of correction are known in principle, there is a long way to go before a lens corrected for operation at even moderate aperture can be built. The wave-length range available for electron microscopy is barely 1·5 as compared with an optical range of 5 or more. Experimental work at accelerating voltages down to 10 kV. and up to 350 kV. has shown the value of variable wave-length, for image contrast on one hand and specimen penetration on the other; but commercial instruments for the upper and lower ranges are only now being projected. The biggest problem remaining to be solved is that of examining living matter in the electron microscope. Some recent work in Germany and the U.S.S.R. has suggested that this may not be absolutely impossible, as had been thought from the few attempts made in the early days of the subject. It may be that a combination of high-voltage operation with indirect observation at low beam current, using an image intensifier, will allow electron images to be obtained of a limited class of organism and at moderate magnification. Even if we can do no more than follow the effect of radiation damage, this would be of great interest if it is at a resolution appreciably better than that of the light microscope. Such an advance is still many years away, even if it be possible at all. If it is made, then the co-ordinated use of optical and electron microscopical methods will be even more vital than it is in present fields of research.

V. E. Cosslett

SCIENTIFIC TECHNIQUES IN ART AND ARCHÆOLOGY*

By DR. A. E. WERNER

Department of Research Laboratory, British Museum, London, W.C.1

IT was in France during the last quarter of the eighteenth century that certain chemists began to apply their specialized knowledge in the field of the fine arts. Their efforts were first directed to the discovery of new artists' pigments. Thus, in 1781, Guyton de Morveau discovered zinc white which he recommended as a new white pigment that would resist the action of sulphurous fumes in urban atmospheres which tended to darken white lead. In his plea to artists to use this pigment, despite the fact that it was more expensive than white lead, he ended his paper to the Academy of Dijon with the phrase: *"On ne marchande pas l'immortalité"*[1]. In 1804 the chemist Chaptal was anxious to find a blue pigment which could be used by the Sèvres porcelain factory in place of the expensive imported ultramarine. He commissioned Thenard to undertake the necessary research, and in a few months he discovered the pigment cobalt blue which now bears his name.

Certain distinguished scientists in Great Britain soon began to follow the example of their colleagues in France. In 1815, Sir Humphry Davy published his classical paper entitled "Some Experiments and Observations on the Colours used in Painting by the Ancients"[2] in which he analysed and identified pigments found at Pompeii, and in 1818 he was commissioned by the Prince Regent to examine manuscripts that had been recovered from Herculaneum in order to find a way of unrolling them without damage[3]. In 1843, Michael Faraday, when lecturing at the Royal Institution, exhibited leather-bound books from the Athenæum Club which were in a very bad state of decay. He correctly attributed this condition to the products of combustion of coal gas and demonstrated that the moisture from a gas flame, condensed on cold metal, contained sulphuric acid. This was the earliest observation concerning the decay of leather by sulphuric acid. In 1853, Faraday served as an expert witness before the Select Committee of the House of Commons which was appointed to inquire into the methods of cleaning paintings being used at the National Gallery at that time.

These examples represent, however, isolated occasions when scientists were called upon to use their specialized knowledge. The intensive application of scientific methods in art and archæology is, on the other hand, of comparatively recent origin.

The work that is carried out in museum laboratories may be considered under three aspects. One is the application of scientific methods to the conservation of works of art and antiquities, the second is the extension of our knowledge about the materials and techniques of painters and craftsmen so as to acquire general information of value to the scholar and art historian, and, thirdly, there is the question of providing objective criteria relating to the authenticity of works of art and antiquities.

Let us consider first of all the use of scientific techniques in the examination of paintings. Normally, one regards a painting from the purely artistic point of view; but, in order to appreciate how scientific methods are employed in the examination of paintings, it is necessary to realize that, from a physical point of view, a painting is a stratified object consisting of four essential layers. These are (starting from the back) the support, the ground, the paint film and the varnish film. In the case of early paintings, the support was usually of wood but, from about the fifteenth century onwards, canvas was used. The ground-layer consisted of a white inert material in a glue medium; in Italy and southern Europe calcined gypsum (hence the word *gesso* often used in describing this layer) was used as the white inert, but in northern Europe it was normally chalk.

Great care was taken by the Old Masters to produce a ground which would have a finished surface that would be as perfect as possible for painting upon; in the words of Cennino Cennini —the famous fifteenth-century writer—it should be "as white as milk (*biancho chome lacte*)" and "smoothed as if it were an ivory (*pulendo si chome fusse uno avorio*)"[4].

The paint film consisted of an aggregate of pigment particles in a binding medium. In so-called tempera painting the medium was egg-yolk, but this was later replaced by various drying oils—the commonest being linseed oil.

The varnish layer was not really an integral part of the painting. It was usually applied after a period of time and served a two-fold purpose; it protected the paint film against atmospheric contamination and restored the original brilliance to those oil paintings which tended to become rather dull in the course of time.

Among the physical techniques used in the investigation of paintings, X-rays are of paramount importance. The degree of absorption of X-rays passing through a painting will depend primarily upon the chemical nature of the pigments present. This can be conveniently expressed in terms of the mass-absorption co-efficient (μ/c), the value of which will be greater for pigments containing elements of high atomic weight. Thus, the value for white lead is about ten times greater than that for calcium pigments such as chalk or gypsum. It is fortunate that calcium pigments were used for the ground-layer whereas white lead was extensively used in the actual paint layers. This means that the ground is relatively transparent to X-rays, whereas the paint layers—particularly those areas containing white lead—will be registered in radiographs. The radiographic examination of paintings is not new; in fact, shortly after Röntgen discovered X-rays in 1895, radiographs were being made of paintings. However, improvements in X-ray equipment and a true understanding of the physical factors involved in the X-ray photography of pictures were necessary before the technique could be used to its full advantage[5].

---

* Substance of a Friday Evening Discourse delivered at the Royal Institution on March 11.

Radiography can often yield information about the technique of an artist. Thus, an X-ray photograph of the painting of "S. Catherine of Alexandria" (National Gallery 168) by Raphael shows that the background (a blue sky) is relatively opaque to X-rays whereas the figure of S. Catherine is more or less transparent to X-rays. This means that the luminosity of the background has been achieved by using a paint containing a large amount of white lead, whereas the luminosity of the figure has been created by allowing the ground to serve as a white reflecting layer which shines through the thinly superimposed layers of flesh paint.

Information can also be obtained which may assist the art-historian in determining the attribution of a painting. Thus in the case of a large altar-piece in the National Gallery originally ascribed to Ercole Grandi (National Gallery 1119) doubts were raised about the attribution. When the Madonna's head was examined, the radiograph showed that the superficial image was very thinly painted and was barely visible, whereas underneath, and posed at a different angle, the original version of the Madonna's head showed up clearly and was obviously painted in a different style. This showed that two artists had been engaged on this altar-piece, and documentary evidence confirmed that this painting was started by the artist Maineri, and finished by Lorenzo Costa. What we see to-day is Costa's version of the Madonna's head which was repainted over Maineri's version, which is visible in the radiograph.

Another physical technique used in the examination of paintings is infra-red photography. Infra-red radiation has a greater penetrating power than visible light so that it can pass through the varnish and uppermost paint layers, and, if the underpaint or ground has a high reflectance coefficient around 8000 Å., it is often possible to reveal *pentimenti* (that is, alterations in composition made by the artist himself) not visible to the naked eye. One rather dramatic example of the success which can be achieved occurred in connexion with van Eyck's well-known painting, "The Marriage of Arnolfini" (National Gallery 186). The artist's first sketch of Arnolfini's right hand as drawn in charcoal on the white chalk ground was clearly revealed beside the final painted version of the hand now visually apparent in the picture. The reason why the initial drawing shows up in the infra-red photograph is that carbon absorbs infra-red radiation whereas chalk reflects it.

Differences in the infra-red reflectance of pigments can often yield information about over-painting. Thus, in a picture by a follower of van der Weyden, "The Exhumation of S. Hubert" (National Gallery 783), the bishop's cope appeared to be painted in a uniform dark blue colour. However, an infra-red photograph revealed an overpainting, which appeared almost black. Subsequent chemical examination showed that the paint in this dark area was a mixture of Prussian blue and chrome yellow. These pigments absorb infra-red radiation to a greater extent than the pigment used in the original paint and hence appear dark against the rest of the cope. This overpainting had been carried out to conceal a hand belonging to the figure standing beside the bishop. When an X-ray examination showed that this hand was, in fact, not badly damaged but was in a good state of preservation, this overpainting was removed and the hand once again revealed as it had been originally painted.

Ultra-violet radiation also can be used for the examination of works of art. Retouchings on paintings and repairs in ceramic or bronze objects are revealed because they show a different fluorescence from that of the background, and in the case of drawings which have faded, fluorescence under ultra-violet may render them visible. Thus, in a collection of drawings by Leonardo da Vinci in the Royal Library at Windsor Castle, there were two sheets upon which very little was visible; but under ultra-violet light they became alive with drawings of hands which were identified as sketches for the "Virgin of the Rocks"[6]. These sketches had been done on a pale pink paper using a soft metal (probably silver) pencil as the drawing instrument. In the course of time the traces of metal were either rubbed off or, possibly, converted into a colourless compound so that the drawing disappeared. However, there still remained enough of the metal to give the characteristic fluorescence under ultra-violet light and bring these sketches miraculously back to life.

Physical techniques give information about the structure of a painting, but chemical—or rather micro-chemical—techniques are concerned with the actual nature of the pigments and binding media used. Precise micro-chemical tests for the identification of pigments have been developed using modern organic reagents for metals in conjunction with Feigl's 'spot test' techniques. Details of the method and typical examples of the reagents used in the National Gallery laboratory have been given by Miss R. J. Plesters[7]. As a natural extension of pigment identification the technique of preparing paint cross-sections has been developed. Minute fragments of paint are embedded in a suitable synthetic resin (for example, polymethyl methacrylate or a cold-setting poly-ester) which is ground down on emery papers until the paint fragment is exposed; the layers of paint can then be examined under the microscope, and information be derived about over-painting and about artists' methods[8].

Recently this technique has been advanced a stage further by Dr. P. Coremans[9], who has succeeded in preparing paint cross-sections which are sufficiently thin (20–30μ) to be viewed under the microscope in transmitted light at a high magnification. Such cross-sections permit a much more precise examination of the structure and composition of the various layers of a painting. Thus, in a fragment of blue paint from van Eyck's "The Mystic Lamb", it was possible to recognize no less than eleven layers; of these, six were authentic van Eyck and consisted of a chalk ground, an isolating layer of oil, three layers of opaque paint containing azurite and lead white in an oil medium and a translucent glaze consisting of natural ultramarine in an aqueous medium, whereas the other five consisted of three layers of varnish between which were sandwiched two layers of repaint containing the modern pigments synthetic ultramarine and Prussian blue.

When compared with the precise tests for the detection of pigments, the methods available for the identification of media were less satisfactory, and were largely based on the comparative behaviour of media towards different solvents. However, the technique of partition chromatography has been successfully applied to this problem and methods have now been developed in the National Gallery Laboratory[10] for the precise detection of the presence of resins, oil, egg-yolk and glue in paint media.

When one passes from paintings to a study of archæological material, the problems of scientific examination and conservation are quite different. One has to deal with a wide range of objects which differ in their material make-up and are liable to have undergone profound changes while buried in the ground. Methods for the treatment of waterlogged wood, porous ceramic objects saturated with soluble salts, and corroded bronze objects have been recently discussed in *Nature*[11]. Attention will therefore be focused on a few examples selected to illustrate some general principles involved in the examination and treatment of metallic antiquities.

The first example relates to a silver cup which was excavated at Enkomi in Cyprus and was dated about 1400 B.C. This was covered with green corrosion products derived from the copper present in the alloy which had been leached out while the cup was buried. Preliminary examination showed the presence of gold and a black powdery substance which spectrographic analysis showed to be probably a material called *niello* (a mixture of the sulphides of silver and copper). The detection of gold and *niello* suggested the presence of a decorative inlay, and radiography confirmed that this original decoration still survived under the corrosion products. The problem, therefore, was to remove the incrustation and reveal the ornamentation without losing either the gold or the *niello* in the process. Experiments with *niello* prepared in the laboratory showed that this material was unaffected by hot formic acid. This reagent, therefore, was used to remove the unsightly incrustation and the original decoration was revealed in a surprisingly fresh condition[12].

The next example is instructive because it shows that, in the case of iron objects, material which at first appears most unpromising may yield interesting results. A small fragment of a Roman sword of the second century A.D. appeared to have been reduced to a mass of rust. However, radiography revealed evidence of inlays, and, with the X-ray photograph as a guide, the rust was carefully removed to reveal the inlays which had been done in a yellow alloy of copper and zinc (so-called orichalcum). On one side of the fragment there emerged a figure which was identified as the god Mars, and on the other side the Roman eagle with standards.

The conservation of archæological material often presents problems which necessitate the development of a novel technique. Thus, about two years ago an important archæological find was made on the site of a mediæval church in St. Ninian's Island in the Shetlands. This consisted of twenty-eight metal objects thought to be early Christian in origin and to date from about A.D. 800. These objects were regarded by the excavators as bronze, but examination showed that the metal was, in fact, a base silver alloy containing much copper which had mineralized during the years of burial to form a thick coating of copper corrosion products. The most interesting item in this hoard was a composite object thought to be a hanging bowl with an internal liner. This supposed liner was soon found to be a separate decorated bowl, which had been pushed into the hanging bowl, and it was easily removed and cleaned. The hanging bowl itself was of particular archæological significance, because it is the only known surviving example of a *silver* hanging bowl to have been found in Britain. Its conservation presented a problem of peculiar interest[13]. The strength of the bowl was due almost entirely to the layers of corrosion products, between which egg-shell thin silver was sandwiched; but at the same time it was considered necessary to remove this incrustation because it was unsightly and gave a false impression of the original appearance of the bowl. When cleaned, the hanging bowl was therefore extremely fragile, so that it was necessary to devise some form of internal support to act as a permanent reinforcement. After a series of trial experiments, a cold-setting epoxy resin ('Araldite' casting resin *F*) was chosen because it adheres well to metal, is transparent, and sets without appreciable shrinkage. A viscous mixture of resin and hardener (together with dibutyl phthalate as plasticiser) was brushed uniformly over the inside of the bowl, which was rotated on a small turntable so as to keep the resin mixture uniformly distributed while it set. In this way it was thus possible to reinforce the bowl with a thin transparent film which gave sufficient mechanical strength so that the bowl could be handled with perfect safety.

When scientific methods are used in connexion with the authenticity of antiquities, the evidence obtained may be either positive or negative. In the former case, the evidence will indicate the approximate age or the definite antiquity of the material of which the object is made, thus establishing probable authenticity. In the latter case, one seeks evidence of anachronisms in the use of materials or techniques which prove that the object could not belong to the period assigned to it.

In order to appreciate how varied are the scientific methods that can be used in this field, it is of interest to mention a new technique which was developed at the Leather Industries Department of the University of Leeds to confirm the alleged age of the Dead Sea parchment scrolls. The first step was to take photographs with the electron microscope to show how the actual collagen fibres had undergone a characteristic degradation due to the long sojourn of the scrolls in the dry atmosphere of the caves in which they had been discovered. Then, the decrease in the shrinkage temperature of small fibres teased out from the scrolls was measured, and, by comparing the value found with that of parchments of known date, it was possible to arrive at an approximate age of about two thousand years for the Dead Sea scrolls[14].

In the case of metal objects, a metallographic examination, both of the corrosion products and of the metal remaining beneath the corrosion layers, may provide manifestations of antiquity. It will, however, be impossible to give even an approximate age, because the rate at which a metal corrodes will be greatly influenced by its environment.

Genuine patinas are minerals that have slowly grown on the surface of the metal, and under high magnification they will usually show a complex banded structure and inter-crystalline penetration into the metal leading to replacement of metal crystals by mineral, that is, pseudomorphism. On the other hand, false patinas which are induced by accelerated corrosion can be distinguished by the fact that they tend to be on a much smaller scale, do not usually show the banded structure or penetrate into the metal. A metallographic study of cross-sections of patinas, particularly in the case of bronze objects, may, therefore, yield conclusive evidence either for or against antiquity.

In the case of silver objects, a study of the metal itself may be very informative. Ancient silver acquires a crystalline quality—the characteristic property that accounts for its brittleness. Fractures in the surface of the metal may look lined and decayed like old leather, and granular crystals are often visible.

In contrast to this a technical examination of a silver plate in Bactrian style (second to first century B.C.) revealed features which cast serious doubt on its authenticity. A photomicrograph of dents in the edge of the plate and scratches on the surface showed the silver to be in a ductile condition, and there was no evidence of crystallization. Moreover, when struck, the silver rang like a bell quite unlike the dead response given by highly crystallized silver. Also, the foot rim was in an almost virgin condition and showed no signs of wear; in an object of the presumed age of this plate, which weighed 1,128·5 gm., one would normally expect to find signs of wear visible to the naked eye. In this case none was visible even under the microscope. Another odd feature was the absence of silver chloride—the typical corrosion product of silver to be expected from the presumed environment. These findings were confirmed when the models which served for the design on the plate were traced to a manuscript of the "Fables of Bidpai" in the Yildiz Library at Istanbul[15].

In the scientific examination of paintings of doubtful authenticity one is concerned either with the possible discovery of anachronisms in the use of pigments and media or with abnormalities in technique. Three examples will show how this kind of evidence can be used to detect forgeries. In the case of a painting of a "Laughing Cavalier" attributed to Franz Hals, microchemical examination of fragments of *original* paint revealed the presence of no less than three pigments—synthetic ultramarine, zinc white, and cobalt blue—which were unknown in Franz Hals's time. The presence of these pigments constitutes undoubted proof that this painting could not be by the hand of Franz Hals.

The next example is the famous forgery case which shook the art world on July 12, 1945, when the Dutch artist, van Meegeren, claimed he had painted certain pictures which had been attributed to Vermeer—the most famous of which was the "Christ with the Disciples at Emmaus"[16]. Microchemical tests revealed many facts which clearly showed that these paintings were indeed fakes. Thus, the medium proved to be a modern synthetic phenol–formaldehyde resin, traces of the pigment cobalt blue were found in samples of blue paint, and the dirt in the craquelure—that network of fine cracks which is to be seen on all old paintings—proved to be ordinary indian ink which, moreover, had in places seeped into the porous medium, thus blurring the sharp outline of the cracks, and giving them a very suspicious appearance.

It is also possible to use radiography to unearth further scientific evidence. Since potential buyers of Old Master paintings are always impressed by signs of age in the support, it is a common practice among fakers to use authentic old supports upon which to perpetrate their forgeries. In this particular case, van Meegeren bought seventeenth-century paintings by minor Dutch artists and scraped off as much as he could of the paint so that he had a suitable canvas upon which he could proceed to paint his pseudo-Vermeer pictures.

It is, however, very difficult to remove completely all traces of the original painting, and therefore, when X-ray photographs of these suspected paintings were taken, it was possible in all cases to detect traces of some different painting lying beneath the superficial image. In the case of one of these pseudo-Vermeers representing "The Last Supper", the radiograph showed the distinct outline of dogs and birds. A Dutch art dealer had fortunately kept a photograph of a painting of "A Hunting Scene" by Hondius which van Meegeren had bought from him in 1938. When this photograph was compared with the above radiograph, there could be no doubt whatever that the pseudo-Vermeer "The Last Supper" had been painted over what had once been the Hondius "Hunting Scene".

The techniques mentioned so far can only be applied to detecting forgeries of Old Master paintings. When the question arises of detecting a forgery by a modern artist, anachronisms in the actual materials will obviously not apply. It is necessary instead to obtain evidence about the actual technique of the artist so that it may be compared with the technique of the suspected painting. This can often be achieved by radiography. It was successfully used to unmask a number of van Gogh forgeries which came to light in 1928. When X-ray photographs were taken of these paintings, a striking difference was found between the radiographs of the suspected paintings and the radiographs of genuine van Gogh paintings. The latter showed the powerful brush strokes which give van Gogh paintings their rhythm and true meaning. On the other hand, the radiographs of the forgeries showed the restless nervous brush strokes of the faker, who had merely succeeded in imitating the characteristic superficial appearance of van Gogh paintings.

This account of the kind of work carried out in a scientific department attached to a museum or art gallery will show that the work is very varied, both as regards the type of problems—whether of conservation or scientific examination—and the methods which are brought into play to solve them. The scientist is often accused of indulging his idle curiosity, and at first his intrusion into the museum and art gallery may perhaps have been viewed by the scholar with a certain amount of alarm. However, the position has now happily arisen in which there is active and intimate co-operation between the scientist and the scholar in the study of problems of mutual interest. In this field it can be justly claimed that a successful attempt has been made to bridge the gap which has sometimes been presumed to separate science and art.

[1] *Nouveaux Mémoires de l'Academie de Dijon*, 1, 1 (1782).

[2] *Phil. Trans. Roy. Soc.*, **105**, 97 (1815).

[3] *Phil. Trans. Roy. Soc*, **111**, 191 (1821).

[4] Cennino Cennini, "Il Libro dell' Arte", ed. D. V. Thompson, jun., Caps. CXX and CXXXK (New Haven, 1932).

[5] Rawlins, F. I. G., *Technical Studies*, 7, 74 (1938).

[6] Popham, A. E., *Burlington Mag.*, **94**, 127 (1952).

[7] *Museums J.*, **54**, 97 (1954).

[8] Plesters, R. J., *Studies in Conservation*, **2**, 110 (1956).

[9] Coremans, P., and Thissen, J., *Bull. de l'Institut Royal du Patrimoine Artistique*, **2**, 41 (1959).

[10] Mills, J. S., and Werner, A. E. A., *Nature*, **169**, 1064 (1952); *J. Oil and Colour Chemists' Assoc.*, 37, 131 (1954); *J. Chem. Soc.*, 3132 (1955). Hey, Margaret, *Studies in Conservation*, 3, 183 (1958).

[11] Werner, A. E. A., *Nature*, **184**, 585 (1959).

[12] Plenderleith, H. J., Technical Report in C. F. A. Schaeffer's *Enkomi-Alasia* (Paris, 1952).

[13] Organ, R. M., *Studies in Conservation*, **4**, 41 (1959).

[14] Burton, D., Reed, R., and Poole, J., *Nature*, **184**, 533 (1959).

[15] Pope, A. Upham, *Burlington Mag.*, **66**, 288 (1935).

[16] Bredius, A., *Burlington Mag.*, **71**, 211 (1937).

OBITUARIES

Prof. E. G. Richardson

EDWARD GICK RICHARDSON, who died on March 31 at the age of sixty-three, was well known, not only in Great Britain, but also internationally, for his work in acoustics and ultrasonics.

He took the degree course in physics at East London (now Queen Mary) College, graduating during the First World War. He then served in the Royal Air Force (Balloon Section), which no doubt initiated his life-long interest in aerodynamics and meteorology. After a short period as a grammar school master, he undertook research at East London College under Prof. C. H. Lees. About two years later he was appointed a lecturer at University College, London, and during the next seven years his research work in acoustics, recognized by the award of a D.Sc., firmly laid the foundation of his subsequent reputation. In 1931 he moved to King's College, Newcastle upon Tyne, where he spent the rest of his life; he was made a reader in 1943, and in 1956 a chair in acoustics was created for him.

Richardson's research achievement was so extensive and diverse that no brief summary is possible. It must suffice to say that he published some ninety papers on a wide variety of topics, including, besides acoustics and ultrasonics, liquid jets and suspensions, viscosity, hot-wire anemometry and viscometry, atmospheric turbulence, relaxation processes and fish locomotion. In acoustics he made notable contributions to many branches; among these the best-known are probably the absorption of sound in vapours and narrow tubes, phonetics and speech analysis, and æolian, edge and transient tones. In later years he turned his attention to ultrasonics, with special reference to absorption and dispersion. In these researches he was often assisted by students, many of them from overseas, who owe much to his help and encouragement. His experimental work was characterized by directness of attack and economy of means, and he was particularly interested in new lines of investigation. He opened up many of these, leaving others to explore the territory which his work had made accessible.

In addition to his research work, Richardson found time to write upwards of a dozen books, including several compilations which he edited or to which he contributed sections. The most widely known are probably "Sound" (a very popular textbook), "The Acoustics of Orchestral Instruments", "Acoustics for Architects" and "Physical Science in Art and Industry". He wrote fluently and well, with an admirable clarity of expression and an easy mastery of his subject. He was English editor of the international journal *Acustica*, in the founding of which he played a prominent part.

He received numerous invitations to lecture abroad, and did so in the United States (several times), Canada, India and most countries of Europe. He was visiting professor of physics at the University of Cairo for a term in 1947, and a Leverhulme Fellow during 1955–57. During the Second World War he served as scientific adviser from early 1940, first in the Admiralty (Mine Design Department) and later in the Air Ministry (Royal Aircraft Establishment and Helensburgh). After returning to King's College he carried out various research contracts for these Ministries.

Although Richardson's primary interest was research it was by no means his only one, for he was an accomplished musician, a dedicated cyclist, and an indefatigable member of the College Country Dancing Club. He played both piano and organ well, and for many years travelled between Durham and Newcastle twice daily on Sundays (some sixty miles in all) in order to sing in the Cathedral choir. He was a deeply religious man, although none but his closest friends would be aware of this, for he was somewhat shy and reticent by nature. Nevertheless, his sterling qualities of modesty, sincerity and kindliness were apparent to all who knew him, and endeared him the more the better one knew him. His sudden death was a great shock to all his friends; they will long bear him in affectionate memory.

W. E. CURTIS

Dr. John Duckworth

THE sudden death on April 11 of Dr. John Duckworth, head of the Applied Biochemistry Department of the Rowett Research Institute, Aberdeen, has robbed the science of food and agriculture of an outstanding investigator.

Born in Manchester but educated in Canada, and in the course of his life conducting research in Canada, Trinidad and Guatemala, he spent about a quarter of a century in the service of the Rowett Institute at Aberdeen. He obtained his original training at the Ontario Agricultural College, Guelph, and took the degree of B.S.A. at the University of Toronto. He next spent a year with Lever Brothers, Ltd., in Toronto, as analytical chemist, and another year with the same firm's economics section studying production efficiency. In 1931 he became assistant to the professor of chemistry at Macdonald College, McGill University, where he carried out research on the blood chemistry of cattle afflicted with genital disease, and on contagious abortion in cattle.

In 1933, Dr. Duckworth came to the Rowett Institute, where he investigated the relationship of nutrition to pathological conditions in farm animals. He also worked on the partition of serum calcium and the factors affecting it. The object was to establish a closer relationship between the blood picture and the evidence of certain types of disease, such as milk fever and rickets, in farm stock. The latter work was incorporated into a thesis, for which the University of Aberdeen awarded him the degree of D.Sc.

Later he investigated magnesium metabolism in animals, and the influence of fibre in the diet on the utilization of protein and calcium. He collaborated in work on problems connected with both human and animal nutrition, for example, the utilization of phytic acid phosphorus in oatmeal by men and farm animals.

In April 1944 he was appointed senior lecturer in the Agricultural Department of the Imperial College of Tropical Agriculture, Trinidad. There he developed courses of instruction in animal husbandry, and created a nutrition laboratory for investigation of the value of various feeding stuffs under tropical conditions.

In September 1946 he returned to the Rowett Institute, and three years later became head of the Department of Applied Biochemistry. His work concerned protein and vitamin requirements, energy needs and metabolism, and mineral metabolism and requirements. He also developed chemical tests which might be correlated with the biological value of proteins. With Mr. N. W. Pirie, of Rothamsted Experimental Station, biological tests had been made on leaf protein for non-ruminants.

Duckworth was responsible, with the Institute's X-ray Section, for developing a mobile X-ray unit for the outdoor study of hill sheep in relation to calcium and phosphorus requirements. In his Department the role of copper in the ruminant was also under investigation, and much progress was being made in the elucidation of this problem.

In 1954, Dr. Duckworth was elected a Fellow of the Royal Society of Edinburgh, and in 1955 was one of four British scientists who attended a symposium of Europe's leading agricultural research experts in Rome, sponsored by the Pfizer Agricultural Research Institute of America, for discussion of research into the use of antibiotics and other new growth factors in animal nutrition. Later in the same year, he was one of three British experts invited to an international conference in Washington on the same subject.

From August 1956 until August 1957, he was seconded to the Food and Agriculture Organization of the United Nations and the United Nations Children's Fund, to assist the Governments of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama on food and nutrition policy. With Señorita E. Musmanno of Argentina, he collected statistics of the countries' food production, which showed that between 6 and 10 per cent of their population were dependent on outside sources of food supply. If one took into account the rate of growth of the population, it appeared to be necessary to double food production in the next twenty-five years, and to alter the balance between cereal and livestock production in favour of the latter. Due account was taken of the actual situation in the area: for example, cattle and sheep raising was to be based on native stock feeding on grass, rather than on imported stock eating concentrate feeding stuffs, at least in the early stages. The need was stressed for modern factories for milk and meat products. Almost his last task was to check the Spanish edition of their second report on the area.

Dr. Duckworth was an enterprising yet meticulous experimenter, a skilled statistician and planner, an arresting and clear expositor of his researches, and one who knew the agricultural industry as few others. He was a lively conversationalist and good pianist. He is survived by his wife, and a son and daughter.

D. P. Cuthbertson

Prof. K. W. Szarski

The death of Prof. Kasmierz Witalis Szarski on January 18 prematurely severed a life of great service to zoology and Polish universities. He was born in Vienna in 1904 and on the family's removal to Lwów attended school and the University there. He took his doctorate, and seven years later (1939) became *docent* in comparative anatomy. Soon afterwards the Russians occupied the University and demoted the staff. Later, under Nazism, academic work ceased, but by acting as hosts for lice used in preparing Prof. Weigl's anti-typhus vaccine, Szarski and colleagues slightly eased impoverishment and received certification as persons usefully employed. Afterwards he and his wife were arrested in Warsaw, but by mere chance escaped transportation to Nazi concentration camps and secured release, he being directed to vitamin investigations.

When war ended, Szarski became professor of comparative anatomy at Wrocław, the new setting for the University of Lwów—Polish no longer. Amid the devastation of Wrocław half the zoological institute lay ruined and in its and the University's rehabilitation Szarski played a leading part, particularly as pro-rector and rector (1954–59).

Szarski was a born naturalist. His early researches related principally to developmental anatomy: three long papers on the urogenital systems of mice being authoritative. His post-war work mainly comprised ornithology and translation. His account of the birds adopting residential niches in the mountainous ruins of Wrocław is fascinating. Freed from rectorial labours, he turned eagerly to study the avian brain—promising work cut short by his death. His comprehensive learning in zoology and his command of Slav and European languages—especially English, French and German, fitted him perfectly as counsellor, editor and translator in many professional capacities. His notable translations, with scholarly commentaries, comprise Darwin's "Voyage of the Beagle" (two editions) and Darwin's and Wallace's historic essays on natural selection (Linnaean Society of London). He was deservedly honoured when chosen to deliver the Darwin Centenary Lecture to the 1959 Polish Zoological Congress in Cracow—practically his last service to science.

Szarski was small and delicate-looking; of great culture, wit, sensitivity and charm; unpretentious; of highest integrity, with an over-riding sense of duty that over-taxed his strength. He had courage: during the Warsaw rising a young insurgent refugee to Szarski's lodging owed his life to Szarski's bluffing of a *Luftwaffe* search-party. He won friendship everywhere: his students and colleagues speak of him as truly 'nieodzalowany' (never to be sufficiently mourned).

Two recent working visits to England gave Szarski renewed inspiration; in Poland British zoologists have profited by his collaboration and enjoyed the bright hospitality of Pani Szarski, himself, and their young daughter, in their modest flat high above the Oder.

In preparing this notice I am indebted to Mr. W. Rybotychi of London, Prof. Sembrat of Wrocław and Prof. Henryk Szarski, rector of the University of Torun.

A. D. Peacock

Prof. Ramesh Chandra Ray

Ramesh Chandra Ray was born in 1890 and took the degree of M.Sc. from the Presidency College, Calcutta, in 1911. He was one of the first students of the Indian Institute of Science, Bangalore, where he worked with Travers on boron compounds formed by the decomposition of magnesium boride. In 1915 he was appointed professor of chemistry at Patna College and, after the War, joined Donnan's laboratory at University College, London, where he continued his work on boron compounds. He succeeded in preparing borohydrates and in establishing the existence of hitherto unknown oxides of boron. For his work on this complicated system he was awarded the D.Sc. of the University of London. He also obtained the fellowship of the Royal Institute of Chemistry.

Returning to Patna, he was responsible for creating a school of research which produced a steady output of papers on inorganic chemistry. The majority of these dealt with boron compounds and formed a valuable contribution to the chemistry of that element. In 1940 he was appointed head of the Department of Chemistry, and in all he worked for thirty-five years at the College. His outside interests were extensive, even after retirement; he was chemical adviser to the Government of Bihar, chairman of the examination board of Bihar University, founder-rector of the Ram Mohun Roy Institute and president of the Manorma Vidyapith. In 1944 he was elected president of the Chemistry Section of the Indian Science Congress.

He died on December 3 and leaves a widow, four sons and three daughters.

NEWS and VIEWS

Electrical Engineering at Cambridge: Prof. E. B. Moullin

PROF. E. B. MOULLIN retires from the chair of electrical engineering at Cambridge on September 30. Thus will end his official connexion with the Engineering Laboratory, which he first entered in 1913. In that year he began to read for the Mechanical Sciences Tripos, having previously taken Part I of the Mathematical Tripos. After a short period in industry, Moullin returned to a lectureship in engineering at Cambridge which he held until 1929. It was during this period that he developed the valve voltmeter associated with his name, and carried out numerous researches in collaboration with L. B. Turner. In 1930 he migrated to Oxford where he held the Donald Pollock readership in engineering science until 1945. Here, his scientific approach to electrical engineering problems attracted numerous research students, several of whom have since achieved world-wide recognition. Moullin was elected to a fellowship at Magdalen in 1932. During the Second World War he worked first at the Admiralty Signals Establishment and later in the research laboratories of Metropolitan-Vickers. In 1945 he returned to Cambridge as the first occupant of the newly created chair of electrical engineering and was elected to a fellowship at King's College. For many years Moullin has taken an active part in the affairs of the Institution of Electrical Engineers. He was chairman of the Radio Section in 1939 and president of the Institution in 1949. He is the author of a number of successful text-books which are distinguished by a freshness and individuality of outlook. His scientific writings cover a wide range of subjects but are largely concerned with problems in electromagnetic theory. The honorary degree of LL.D. was conferred on him by the University of Glasgow in 1958.

Prof. C. W. Oatley

C. W. OATLEY, who succeeds Prof. Moullin in the chair of Electrical Engineering at Cambridge on October 1, was educated at Bedford Modern School and St. John's College, Cambridge. He read both parts of the Natural Sciences Tripos, specializing in physics, and graduated in 1925. After a short spell in the radio-valve industry he was appointed to a demonstratorship in the Physics Department of King's College, London, where he worked under Sir Edward Appleton and later under Sir Charles Ellis, until the outbreak of war. During this period his interests were centred on various problems of electron physics, particularly those concerned with the measurement and interpretation of the contact potential difference between metals. In 1939, Oatley joined the Air Defence Experimental Establishment of the Ministry of Supply, then situated at Christchurch. There he took charge of a group working on radar receivers and became especially interested in ultra-high frequency and microwave measurements. In 1942, when the Establishment moved to Malvern and became the Radar Research and Development Establishment, Oatley was responsible for all basic research work. A year later he became deputy to the Chief Superintendent and, during 1944–45, was in charge of all technical work in the Establishment. In 1945 he returned to Cambridge with a lectureship in the Department of Engineering and a fellowship at Trinity College. During the past fifteen years he has been active in building up research work in electronics and has become interested in problems of electron microscopy. He was appointed to a readership in 1954. Since the War he has had close connexion with the work of the Institution of Electrical Engineers. He served on the Radio Section Committee for a number of years and was chairman of the Section in 1954.

Chemistry at Aberystwyth: Prof. C. W. Davies

PROF. C. W. DAVIES, who is retiring from the chair of chemistry in the University College of Wales, Aberystwyth, is well known for his many contributions to electrochemistry extending over an active research career of more than thirty years. Prof. Davies early became interested in the conductivity of electrolytes, and at the appearance of the Debye–Hückel theory he was among the first to suggest the combination of the law of mass action with the ionic interaction theory to account for the conductivity of strong electrolytes. He showed that the dependence on concentration of the conductivity of many electrolytes could be accounted for if they were incompletely dissociated in solution. This conclusion was not at first readily accepted, because to many chemists the Debye–Huckel theory implied complete dissociation of all electrolytes. The idea that salts are completely dissociated in solution, and that variations in conductivity are due to variations in mobility, was too simple and attractive to be readily abandoned. This difficulty of acceptance was increased by the fact that the physical interpretation of incomplete dissociation was rather obscure. However, Prof. Davies and his collaborators showed that measurements of conductivity and of solubility led to results for dissociation constants of salts in good agreement with one another. Kinetic studies, too, have given results which can only be explained by incomplete dissociation. Apart from the important idea of incomplete dissociation and its careful experimental support, Prof. Davies's other main contribution to electrochemistry was his book, "The Conductivity of Solutions", published in 1929 and in 1933. His more recent work in the field includes studies of the polyphosphate ions in solution, as examples of ions with high negative charges, and the use of ion-exchange resins in electrochemistry. In addition to his personal researches, he has played a major part in building up the Chemistry Department at Aberystwyth to achieve its present reputation as an active centre in physical chemistry.

Prof. A. F. Trotman-Dickenson

Dr. A. F. Trotman-Dickenson, who has been appointed to succeed Prof. Davies, is at present lecturer in chemistry in the University of Edinburgh. In the course of a research career of more than ten years, he has made several important contributions to chemical kinetics, chiefly to the study of elementary reactions in gases. His work with Dr. E. W. R. Steacie at the National Research Council in Canada on the reactions of methyl radicals gave information about the rates with which these radicals abstract hydrogen from a wide range of compounds. Dr. Trotman-Dickenson has studied the abstraction, decomposition and disproportionation reactions of many alkyl radicals and has obtained an important body of new information. In collaboration with Dr. J. H. Knox, he has developed competitive methods for obtaining relative rates of reaction of halogen atoms with various alkanes and has extended such methods to the study of oxidation. He has made contributions to the study of the reactions of the methylene radical. In yet another recent series of experiments, Dr. Trotman-Dickenson has determined several carbon–metal bond-strengths by kinetic methods. In addition to his main work on elementary reactions, Dr. Trotman-Dickenson, along with Drs. H. O. Pritchard and R. G. Sowden at Manchester, has made a most important detailed investigation of the effect of added gases on the rate of isomerization of *cyclo*propane; this gave valuable information about energy transfer to reacting molecules. His book, "Gas Kinetics", published in 1954, is a useful survey of this branch of chemistry, and his recent monograph, "Free Radicals", is a valuable introductory text.

Agricultural Sciences in the Rockefeller Foundation: Dr. A. H. Moseman

Dr. Albert H. Moseman has been appointed director for the agricultural sciences in the Rockefeller Foundation. Dr. Moseman went to the Rockefeller Foundation in 1956 as associate director for the agricultural sciences. Previously he was director of crops research of the Agricultural Research Service of the U.S. Department of Agriculture. He was born in Oakland, Nebraska, received the B.S. and M.S. degrees from the University of Nebraska and the Ph.D. degree in plant breeding and genetics from the University of Minnesota. He served on the mission which helped plan the Point IV programme in agriculture, and was a member of the joint Indo-American team which developed recommendations to the Government of India for improvements in agricultural research and education. The University of Minnesota conferred its Outstanding Achievement Award on Dr. Moseman in 1958.

Biology at Oregon: Prof. G. Streisinger

Dr. George Streisinger has been appointed associate professor of biology in the Institute of Molecular Biology at the University of Oregon as from September 1. Prof. Streisinger is at present at the Carnegie Institution of Washington, Department of Genetics, Cold Spring Harbor, New York. He took his Ph.D. degree in bacteriology at the University of Illinois, and was a post-doctoral fellow of the National Foundation for Infantile Paralysis at the California Institute of Technology. He spent the year 1957–58 working with Dr. Francis Crick in the Cavendish Laboratory, Cambridge. Dr. Streisinger's principal research interest at present is in the relationship between the structure of a protein (bacteriophage lysozyme) and the structure of the gene which controls its formation.

Experimental Biology at Rehovoth, Israel: Prof. J. Berenblum

The establishment of the Jack Cotton research professorship of experimental biology at the Weizmann Institute of Science, Rehovoth, Israel, will help to consolidate and further the work carried out in the Department of Experimental Biology at the Institute. The first holder of the chair will be Prof. I. Berenblum, who has been in charge of the Department since its inception in 1950. This Department comprises a number of sections in different branches of biology and experimental medicine, several of them connected with cancer research—the field of Prof. Berenblum's own specialization. Prof. Berenblum is a graduate of the University of Leeds, a former Beit Memorial Research Fellow (at the Dunn School of Pathology, University of Oxford), and at one time in charge of the Oxford University Research Centre of the British Empire Cancer Campaign. His field of research has been mainly concerned with the 'two-stage mechanism' of carcinogenesis. The proposed expanded programme of research, aided by the munificent gift of Mr. Jack Cotton, will entail the expansion of the work on the two-stage mechanism of carcinogenesis, with particular emphasis on the biological and biochemical role of urethane in the two-stage process, and the extension of the principle to systems other than the skin, including its recently discovered role in leukæmogenesis. The recent addition of further animal buildings, X-ray equipment, and the intended expansion of its biochemical facilities, will further the projected expansion of the research programme.

Amalgamation of the Institute of Physics and the Physical Society

The Institute of Physics and the Physical Society have amalgamated and the new body will be known as "The Institute of Physics and the Physical Society". The first president of the amalgamated body is Sir John Cockcroft, and the four vice-presidents are Dr. J. Topping, Dr. W. H. Taylor, Prof. R. W. Ditchburn and Mr. A. J. Philpot, each responsible to the Council for a defined area of the many activities to be taken over by the new organization from its predecessors. The presidents of the original bodies, Sir George Thomson and Mr. J. A. Ratcliffe, are also members of the new Council. The other officers are Dr. J. Taylor (honorary treasurer) and Dr. C. G. Wynne (honorary secretary).

The Physical Society of London, as it was then called, was founded in 1874, and on the initiative of that Society's Council, the Institute of Physics was founded forty-five years later. The original scheme envisaged a kind of federation of societies interested in physics, to provide, among other objects, rooms for meetings, a library, and a common secretariat. In fact, the Institute's offices were in the Society's present rooms in South Kensington during 1927–49, and the Institute provided the secretariat for the Physical Society and the Optical Society, which themselves amalgamated in 1931. Broadly speaking, before the War the scientific meetings and publications of the Institute were confined to applied physics, while those of the Society were concerned more with pure physics. As, however, the boundary between these two aspects became less definite there has been increasing overlap in the activities of the two bodies and in their membership. It is not, therefore, surprising that during the past twenty years proposals for the amalgamation of the two bodies have been made repeatedly, and from time to time detailed proposals examined, until eventually a satisfactory solution was worked out. The executive officers of the new body are: *Secretary*, Dr. H. R. Lang; *Editor and Deputy Secretary*, Dr. A. C. Stickland; *Deputy Secretary*, Mr. N. Clarke. The registered offices and headquarters are at 47 Belgrave Square, London, S.W.1, and for the present, offices will also be retained at 1 Lowther Gardens, South Kensington, London, S.W.7.

University of Toronto Computation Centre

The Board of Governors of the University of Toronto has approved the proposal to construct, install and operate a copy of *Illiac II* as the major computing facility in the Computation Centre at the University of Toronto. This project is financed in part by a grant of 600,000 dollars from the National Research Council of Canada and the Sir Frederick Banting Fund. *Illiac II* is the high-speed computing machine now being constructed at the Digital Computing Laboratory of the University of Illinois. In it, solid-state devices are used as the main electronic parts. It is designed to be a very reliable and easily serviced machine. Its logical design is elaborate, novel and very efficient in large calculations. The construction at Toronto will be under the supervision of Profs. R. W. McKay and C. C. Gotlieb, who have been associated with the work at Illinois for the past four years. The University of Toronto plans provide special accommodation for the Centre in the new Physics Building to be occupied, it is hoped, in 1962.

Appointments in Industry and Commerce

The annual report for 1959 of the Committee for Appointments, published in a supplement to the *Oxford University Gazette* of March 14, records that of 8,792 vacancies, 5,545 called for men with scientific qualifications, an increase of 2 per cent on the previous year, compared with 11·6 per cent increase in the demand for arts men for industry and commerce. Discussing the effect on graduate employment of the bulge in school population and of the trend to stay on in sixth forms of grammar and public schools, the report stresses the need to convince industrial firms that universities really are creaming off the best of the sixth-form leavers even when university places cannot keep pace with the rise in numbers of sixth formers who are up to normal entrance standards and when sandwich courses are very attractive to parents. Meanwhile, it is apparent that there are far too many mediocre graduates on the market, and three-quarters of the engineering graduates entering the engineering industry make competent specialized technical men but are not up to leading teams in difficult times. The emphasis in recruitment must be on good engineers who can handle people, practical men who can get results from engineering ideas, and the Committee suggests that if the universities cannot prove that such are their products, industry could lose much of its interest in graduates. It is also suggested that there may be a tendency in some firms to concentrate, up to 1965, on school-leavers to the exclusion or partial exclusion of graduates. The school-leaver is refreshingly attractive, being eager to get going in a job, lively, enthusiastic, not choosy, and in contrast with graduates who have been generally cosseted in choosiness and superficial indifference and an attitude suspiciously near that of "the world owes me a living". Pointing out that if the effect of the bulge and trend ultimately is to compel graduates to try harder to secure an appropriate job, graduates will benefit, and commenting on "the dreary procession of would-be B.Sc.'s" seen each year by industrial recruiters, the report suggests that sixth formers may constitute formidable competition in that they will have had two or three years experience.

Choosing a Career

To help young people in their choice of a career, some twelve years ago the Central Youth Employment Executive of the Ministry of Labour and National Service began a series of publications designed to give information about various occupations and the opportunities they provide entitled "Choice of Careers". The series has been remarkably successful and, altogether, 163 editions, many of them revisions of earlier issues, have been published. Total sales of all editions have been well over a million. To mark the issue of the 100th booklet, which is called "The Scientist", the Central Youth Employment Executive has reprinted the first booklet, "Choosing your Career", which deals with the fundamental questions which young people need to pose before selecting a particular occupation in which they intend to pursue a career (Choice of Careers Series No. 1. Pp. 32. 1*s*. 6*d*. net). Another booklet, "Laboratory Technicians and Assistants", is even more profusely illustrated and contains much information about an assistant's job in the laboratory (Choice of Careers Series No. 94. Pp. 56. 2*s*. 6*d*. net). It is surprising, therefore, that "The Scientist" should be produced with such little imagination and launched at half the cost of "Laboratory Technicians and Assistants" (Choice of Careers Series No. 100. Pp. 48. 1*s*. 3*d*. net). The text seems designed to show that the scientist's highest ambition should be to become a 'backroom boy' while, if he turns to industry, he may find jobs in plant management provided he is prepared to give 'technical guidance' in running the plant and not wish to accept "direct responsibility for production management". Little reference is made to the scientific training which our future administrators will need. The tone of the booklet appears to indicate that Whitehall is still controlled by men who believe that men of science can perform useful supporting roles as technical experts, but that direction should rest with men trained in the liberal arts. Forthcoming booklets in the series are to be "Mathematics" and "Applied Science and Technology". The booklets are obtainable from H.M. Stationery Office.

British Water Research Association

THE fourth annual report of the Water Research Association covers the year ended June 30, 1959, and includes the reports of the Council and of the director of research, Dr. R. G. Allen, together with lists of staff and of members (pp. 31+4 plates. Redhill: Water Research Association, 1959). The Association's application for a grant from the Department of Scientific and Industrial Research was approved in February for the five years commencing 1959, at £15,000 a year, conditional on a minimum of £30,000 being raised by the industry, with up to a further £12,000 a year on the basis of £80 for every further £100 of membership income. In his report, the director again refers to the studies of the effect of pH on the coagulation of dilute colloidal dispersions of clay minerals, which have indicated that except for the bentonites, which can be coagulated with low doses of aluminium sulphate at all pH values below 7·5, the amount of aluminium sulphate required to effect coagulation is at a minimum about pH 6·8–7·5. Work on the isolation of suspended colloidal matter in rivers using a continuously operated centrifuge is virtually complete, and a comprehensive investigation has been commenced on the effect of various factors in the preparation of activated silica. Other work has included the effect of physical variants on coagulation, the absorptiometric determination of aluminium, the leaching of lead stabilizers from polyvinyl chloride pipes and the determination of the permeability of plastic pipes to coal gas.

Museum of Applied Arts and Sciences, Sydney

IN common with most museums and art galleries the institution at Sydney is greatly in need of additional buildings to enable the Trustees to fulfil their obligations to the public. Lack of amenities for both visitors and staff, as well as inadequate facilities for exhibition, storage and preparatory work, was causing concern, and disappointment was expressed at the delay in implementing plans for improvement. Recently, however, some progress has been made and plans have been prepared for an extension to the present building and negotiations have started to take over an existing building on a neighbouring site for the storage and display of heavy machinery and transport exhibits. It is the aim of this Museum to show the latest trends in technology and thus provide inspiration and ideals for local manufacturers and others interested. To do so the staff must study developments in science at world research centres and by continuous contact endeavour to obtain specimens and relevant information regarding examples of applied science (Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31st December, 1958. Pp. 19. Sydney: Museum of Applied Arts and Sciences, 1960).

New Mineralogical Periodicals

THE formation last year of the Mineralogical Society of India has been quickly followed by the publication of *The Indian Mineralogist*, to be issued by the Society half-yearly as a medium for articles on crystallography, mineralogy, petrology, and allied subjects (Editorial Office: Department of Geology, A.C. College, Madras 25; price 10 R. per annum). The first number (Part 1, 1960) comprises twelve articles in 107 pages, most by Indian workers but a few contributed by Scandinavian and Australian mineralogists. If the initial standard is maintained, the journal will become one of international reputation and the Society should readily enlarge its present membership of 160, mainly resident in Southern India. Simultaneously, a new Russian journal has been issued by the East Siberian Division of the All-Union Mineralogical Society (*Zapiski Vostochno-Sibirskogo Otdeleniya Vsesoyuznogo Mineralogicheskogo Obshchestva*, Academy of Sciences, Moscow: Vol. 1, No. 1, 1959. Pp. 130. price 7r. 30k.), concerned principally with the topographical mineralogy of the territories east of the Urals. The eastward drift of Soviet geological–mineralogical interests is reflected also in the establishment this year of a new Geochemical Institute and Laboratory for Isotope Geology in the town of Irkutsk, administered by the Siberian Division of the Academy of Sciences, and one can expect that there will be no shortage of important contributions to the new periodical.

Compilation of Russian Journals

UNDER the title "Russian Journals", a union list of titles of 54 such periodicals held by four libraries in Manchester and Salford has been compiled for the benefit of scientists, research workers, students and librarians (pp. 14. Library Association: North Western Group. Reference, Special and Information Section. Manchester: Central Library, 1960). In an introduction, Mr. L. L. Ardern, under whose direction the list has been compiled, indicates that the Secretary of the Group will be glad to have details of other Russian titles held by other libraries in the area and to add these to a union list on cards held by the Regional Library Bureau. The entries are listed in alphabetical order of the Russian title, under the society's name if the periodical is published by a society. There is a full index under transliterated and translated titles. The participating libraries are those of the Manchester College of Science and Technology, University of Manchester, Royal Technical College, Salford, and Manchester Public Libraries.

Chromosome Abnormalities in Man

IN a recent issue of *Science Progress* (48, No. 190, April 1960) Dr. C. O. Carter points out that the year 1959 will be remembered for an important breakthrough in the science of human genetics. This was the discovery that certain congenital abnormalities in man are due not to 'point mutations', that is mutations involving only a tiny fragment of a chromosome, but to the addition or loss of whole chromosomes. Most mutations in animals and plants are 'point' mutations, and no change is apparent on examining chromosomes. Some mutations, however, are accompanied by visible changes in the chromosome. These vary from the addition or loss of whole chromosomes to the addition or loss of a small fraction of a chromosome. Investigation has shown that loss of an appreciable fragment, say, a fifth, of an average-sized chromosome is not compatible with life. The presence of extra fragments of chromosome, however, is better tolerated, though resulting in some degree of abnormal development, and in plants a number of examples of individuals with one extra chromosome have been studied. These 'trisomics' have the chromosome number $2n + 1$, and one chromosome is present in triplicate, not paired.

Resistance to Root-knot Nematodes

THE immunity or resistance which some plants possess to attack by root-knot eelworms (*Meloidogyne* spp.) has led to the suggestion that the use of such plants in the rotation, or as trap crops, would effect a measure of control in root-knot infected land. A list of published records of plants showing complete or partial resistance to identified *Meloidogyne* species has recently been compiled and catalogued by Mary T. Franklin and D. J. Hooper on behalf of the Commonwealth Agricultural Bureaux (Plants Recorded as Resistant to Root-Knot Nematodes (*Meloidogyne* spp.). Pp. iii+33. Farnham Royal: Commonwealth Agricultural Bureaux, 1959. 7*s.* 6*d.*). In the first section the resistant plants are listed alphabetically, with the authorities for their scientific names as given in *Index Kewensis* and the breeding line, strain or varietal name if stated, followed by the species of *Meloidogyne* to which they are resistant, with the author and date of record. In the second section the plant species are arranged in their families and listed under each nematode to which they have been recorded as resistant. The third section gives the literature from which the records have been taken. It is emphasized that the plants listed are not necessarily representative of the whole plant kingdom. They are either crop plants in which resistance has been noticed by chance, plants that have been tested for resistance because they would be suitable rotation or cover-crops in root-knot infested areas, weeds growing among infested crops or plants bred for root-knot resistance. For the purpose of the compilation resistance is taken to be any relationship between plant and nematode in which the nematode fails to produce viable eggs. Records of partial resistance (defined as the condition in which the rate of reproduction of the nematode is extremely low in relation to the degree of soil infestation) have been included.

Cleaning Fossils by Ultrasonic Waves

AN important article by Mr. J. N. M. Firth in the *Museums Journal* of April describes the cleaning of fossils in various types of matrix by ultrasonic waves. The instrument used was a 500-W. 'Soniclean' generator, type 1150, manufactured by Dawe Instruments, Ltd., and the cleaning tank of 1½ gallons was made of welded stainless steel. The specimen was either placed in a glass beaker containing cleaning fluid and floating in the tank or was suspended directly. A temperature of 65° C. was found to give the best results, and a few drops of liquid soap added to the fluid decreased the surface tension. It was also found advisable to replace the cleaning fluid when it became dirty, as such particles tended to damp out the waves. From a series of experiments, it would appear that there is a short interval of time at the start of treatment during which most of the dirt adhering to the specimen is removed. This is followed by a period of no further appreciable cleaning and finally by gradual degradation, the time for which depends on the lithological properties of the specimen.

Royal Geographical Society Research Fellowship

DR. P. SALWAY, Research Fellow of Sidney Sussex College, Cambridge, has been awarded a Royal Geographical Society research fellowship for work on the geography and topography of the Roman Fenland. During past years the progressive desiccation of the Fenland has revealed an extensive system of Romano-British farms and settlements, with associated field-systems, droveways and water-courses, both artificial and natural. Continued desiccation will obliterate most of these before the end of the century. There is no part of the surface of Great Britain where the details of an ancient landscape can be so completely recovered as in the Fenland, and one product of Dr. Salway's research and field-work will be a detailed map of the region as it was in Roman times. The fellowship has been established by the Society with the aid of a grant from the Marc Fitch Fund.

Ciba Fellowships

THE Ciba Fellowship Trust, which was founded for the purpose of furthering the exchange of ideas between scientists in the United Kingdom and on the Continent, has awarded the following fellowships for the academic year 1960–61: Dr. V. P. Arya (Banaras Hindu University, University of London and the Polytechnic, Zurich), to study in Stockholm (natural products chemistry); Dr. K. Jones (University of Sheffield), to study at the University of Heidelberg (organic chemistry); Dr. B. L. Mordike (University of Birmingham and University of Cambridge), to study at Gottingen (physical metallurgy); Mr. C. N. Banwell (University of Cambridge), to study at Zurich (spectroscopy); Miss P. M. Bryant (University of Oxford), to study at Basle (organic chemistry); Mr. R. Grinter (University of Exeter), to study at Zurich (physical organic chemistry); Mr. W. D. Hamilton (Queen's University of Belfast and University of Birmingham), to study in Yugoslavia (nuclear physics); and Mr. J. R. Miller (University of Cambridge), to study at Munich (inorganic chemistry).

National Science Foundation Awards

THE National Science Foundation has announced the award of 1,200 graduate fellowships in the sciences, mathematics, and engineering for the academic year 1960–61. Successful candidates were selected from 4,696 applicants from all parts of the United States and its territories. Of the awards, 233 were made in the biological sciences, 946 in the physical sciences, including a number in interdisciplinary fields, and 21 awards were made in certain areas of the social sciences. The fellowships enable the holders to attend any appropriate non-profit-making institution in the United States or in a foreign country. The graduate fellowships provide basic stipends (for 12 months) of 1,800 dollars for the first-year level of graduate study, 2,000 dollars for intermediate years, and 2,200 dollars for the terminal year. These fellowships include additional allowances for dependants and tuition, as well as a limited travel allowance.

Royal Society of Arts: Industrial Arts Bursaries Competitions

THE Royal Society of Arts has issued a report on the Society's annual Industrial Arts Bursaries Competition for 1959, in which 653 candidates from 81 schools and industrial establishments entered the 17 sections (pp. 56. London: Royal Society of Arts, 1960). A total of 34 bursaries amounting to £4,425 was awarded and the report includes the reports of the individual juries. Two inquiries were conducted by the Industrial Arts Bursaries Board in connexion with these competitions during the year. The replies to the first inquiry, which covered those directly concerned with the competition, including the principals of some twenty of the larger schools, indicated that the overwhelming majority considered the competition was doing useful work and that the Society should continue to organize similar competitions. Many suggestions for the extension of the competition to cover a wider range of industrial and commercial needs were also received. The second inquiry was into the subsequent careers of winners of bursaries since 1946. Most of these young designers attribute their present employment, at least in part, to their success in these competitions, and all pay tribute to the opportunity which the bursaries provided, at the outset of their careers, to broaden their outlook and experience.

Nato Meeting on Ionospheric Research

Greek national authorities have invited the Ionospheric Research Committee of the Nato Advisory Group for Aeronautical Research and Development to hold its next meeting in Athens during June 20–23. The four-day meeting will be devoted to discussions on radio-wave absorption. Among those who will be presenting papers are Mr. J. Ratcliffe (University of Cambridge); Mr. Finn Lied, director of the Norwegian Defence Research Establishment; M. Nicolet, director of the Centre National de Recherches de l'Espace (Belgium); and Prof. Vassy (Université de Paris). Further information can be obtained from the Advisory Group for Aeronautical Research and Development, Organization du Traité de l'Atlantique, Palais de Chaillot, Paris, 16.

Summer Courses in Western Europe

Two publications have recently become available concerning summer courses in Western Europe. "Residential Short Courses" is a six-monthly calendar issued by the National Institute of Adult Education and covers short courses to be held, during the summer, in Britain. "European Calendar of Short Summer Courses" covers a similar field of courses to be held in Western Europe as a whole, and is issued by the Bureau Européen de l'Education Populaire (Notes et Etudes, No. 15). Both publications are available from the National Institute of Adult Education, 35 Queen Anne Street, London, W.1, price 1*s*. each (postage 6*d*.).

Announcements

Prof. R. L. Wain, professor of physical sciences in Wye College (University of London), has been awarded the Research Medal of the Royal Agricultural Society of England.

Dr. C. J. T. Cronshaw has been awarded the Hinchley Medal of the British Association of Chemists for his great services to the chemical industry while head of the Dyestuffs Division of Imperial Chemical Industries, Ltd.

Mr. Leslie T. Morton, librarian of the National Institute of Medical Research, Mill Hill, London, N.W.7, has been given the Marcia C. Noyes Award of the Medical Library Association of America for his outstanding services to medical bibliography and librarianship. This Award has hitherto only been made to medical librarians in the United States.

Honorary fellowships of the Royal Aeronautical Society have been conferred on Prof. W. J. Duncan, professor of aeronautics and fluid mechanics at the University of Glasgow and chairman of the Aeronautical Research Council; and Sir George Edwards, managing director of Vickers-Armstrongs (Aircraft) Ltd., and a past president of the Society.

Dr. W. J. Kroll of Corvallis, Oregon, has been appointed the sixth Castner Memorial lecturer and will deliver his lecture, entitled "The Fusion Electrolysis of Titanium", in Glasgow on October 7. Further information can be obtained from the Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

The German Academies and the Austrian Academy of Science have announced that an edition of the letters of Alexander von Humboldt (1769–1859), the German naturalist and traveller, is in the course of preparation. Owners of any letters by Humboldt or addressed to him are invited to communicate direct with Prof. Dr. H. Ertel, chairman of the Alexander von Humboldt-Commission, Deutsche Akademie der Wissenschaften zu Berlin, Berlin 6, Germany.

The fourth volume of the *Journal of Electronics and Control* contains interesting papers on plasma physics and on recent developments in the theory of transistors. A particularly interesting research note describes a switching diode, using gallium arsenide, in which hole storage effects have been so reduced that transition is less than two milli-micro-seconds.

A symposium on recent developments in the applications of nuclear science for peaceful purposes will be held in Hauradan, Iran, during July 6–19. Further information can be obtained from Dr. M. L. Smith, CENTO Institute of Nuclear Science, P.O. Box 1828, Tehran, Iran.

The annual Electronics and Instruments Exhibition and Convention of the Institution of Electronics is to be held, at the Manchester College of Science and Technology, during July 7–13. Further information can be obtained from W. Birtwistle, general secretary of the Institution of Electronics, 78 Shaw Road, Rochdale, Lancs.

A joint meeting of the Challenger Society and representatives from the Marine Laboratories (Development Commissioners Scheme) will be held in the Department of Zoology, University of Cambridge, during June 23–24. Further information can be obtained from Dr. R. Bainbridge, Department of Zoology, Downing Street, Cambridge.

The Nutrition Society is holding a symposium at Rothamsted Experimental Station, Harpenden, on "Food Losses in Field and Store", on July 2. Further information can be obtained from the honorary programmes secretary of the Nutrition Society, Miss D. F. Hollingsworth, at the Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W.1.

An international conference, the first of its kind, is to be held on "Congenital Malformations" by the International Medical Congress, Ltd., at Church House, Dean's Yard, Westminster, London, S.W.1, during July 18–22. Further information can be obtained from the Secretariat of the First International Conference on Congenital Malformations, 67 New Bond Street, London, W.1.

Erratum. In the note entitled *Instrument Abstracts* in *Nature* of April 30, p. 359, it is stated that the issue dated January 1960 is No. 1, Vol. 1; this is incorrect. It should read: No. 1, Vol. 15.

U.S. NATIONAL ACADEMY OF SCIENCES

MEDALS AND AWARDS

THE following awards by the U.S. National Academy of Sciences have been announced: The James Craig Watson Medal, to Prof. Yusuke Hagihara, formerly professor of astronomy in the University of Tokyo and director of the Tokyo Astronomical Observatory and later professor in Tohoku University, a post from which he has just retired. Prof. Hagihara is best known for his original contributions to the field of celestial mechanics, the study of celestial bodies in motion. Perhaps his most significant work has been his paradigms for the general problem of the stability of motion—a basic question in celestial mechanics. Prof. Hagihara's mathematical talents have also been turned to one of astronomy's most vexing puzzles—the restricted problem of three bodies. Astronomers have long sought, without complete success, to calculate the relative motions of three bodies when given the positions and motions of the bodies at a point in time. Celestial mechanics is not the only astronomical field of interest in which Prof. Hagihara has gained distinction. He has also made original contributions to theoretical astrophysics, the theory of relativity, and solar eclipses. A prodigious scientific author, he has published more than twenty-five papers and monographs on celestial mechanics alone, and is the author of ten books on various astronomical subjects.

The Agassiz Medal, in recognition of original contributions to the field of oceanography, to Dr. Anton Frederick Bruun, of the University of Copenhagen. Dr. Bruun is a leading authority on life in the deep sea, and has won similar distinction as an effective leader of oceanographic expeditions. In addition to the many expeditions in which he has participated, Dr. Bruun led an expedition during 1945–46 to tropical West African waters, and, during 1950–52, headed the *Galathea* expedition that circled the globe in a study of the ocean deeps. At present, he is directing an expedition to the South China Sea, sponsored jointly by the Scripps Institution of Oceanography and the International Co-operation Administration. It was the *Galathea* expedition that earned Dr. Bruun especial acclaim for his ability to enlist scientists from many nations in a co-operative research programme. Although a voluminous series of reports has already resulted from the *Galathea* findings, it is anticipated that additional reports will be published for many years to come. One of the expedition's most significant achievements was its trawling of the approximately 34,500-ft. deep Philippine Trench, just east of the Islands. Most dramatic finding of the *Galathea* expedition was the discovery of a 'living fossil', the mollusc *Neopilina*, the nearest relatives of which were thought to have become extinct some three hundred million years ago (*Nature*, 179, 413; 1957). During 1926–33, Dr. Bruun was engaged in oceanographical research as a member of the Danish Fisheries Commission. In 1933 he was appointed curator of molluscs in the Zoological Museum of the University of Copenhagen. He has also held appointments at the Carlsberg Laboratory, the Marine Biological Laboratory, and the Danish Aquarium.

The Kimber Genetics Award, to Prof. George Wells Beadle, professor of biology and chairman of the division of biology at the California Institute of Technology. Prof. Beadle's specific research interests have been, successively, the genetics and cytology of maize; the genetics of *Drosophila melanogaster*; the chemistry and the biology of eye pigment in *Drosophila*; and the chemical genetics of *Neurospora crassa*, or red bread mould. Perhaps the most significant result of his work has been the finding of new ways to trace the action of genes. The best-known of these techniques is the use of *Neurospora* to follow the steps by which genes influence the synthesis of vitamins, amino-acids, and other basic ingredients of life. This simple and ingenious tool was developed by Dr. Beadle in collaboration with Dr. Edward L. Tatum and others. Prof. Beadle has occupied his present chair at the California Institute of Technology since 1946. Previously, he was professor of biology at Stanford University during 1937–46, and assistant professor of genetics at Harvard University during 1936–37. Prof. Beadle has been elected a foreign member of the Royal Society of London this year.

The J. Lawrence Smith Medal, for outstanding investigations of meteoric bodies, has been awarded to Dr. E. J. Öpik (*Nature*, April 23, p. 280).

The Public Welfare Medal of the National Academy of Sciences has been awarded for "eminence in the application of science to the public welfare" to Dr. Alan T. Waterman, director of the National Science Foundation. Established in 1913 by Mrs. Helen Hartley Jenkins in honour of her father, Marcellus Hartley, the Public Welfare Medal is considered to be the most distinguished of the Academy's medals. It is unique among them in that it is awarded for outstanding public service in the uses of science, rather than for achievements within a particular scientific discipline.

SIXTH-FORM SCIENCE AS A PREPARATION FOR UNIVERSITY WORK

IN March 1958 the Senate and Council of the University of Birmingham approved a proposal for an inquiry to be held into the suitability of the General Certificate of Education (Advanced Level) syllabuses in science as a preparation for direct entry into first-degree courses in the Faculty of Science. This useful report, now published, was financed by the Gulbenkian Trustees. The subjects under consideration were biology, chemistry, geography and geology, mathematics and physics. The Panel began its work by considering what sixth-form training would be most valuable to a pupil who proposed to enter a first-degree course in a biological subject[*].

It was felt to be essential, in view of the increasing emphasis on the experimental aspects of biology, that such pupils should acquire an understanding of the basic sciences—chemistry, mathematics and physics. They should preferably study biology, but the Panel would not exclude from a university course those whose only background was a sixth-form knowledge of the three other subjects. "Intending biology students should be taught to practise the scientific discipline of observation and deduction, and to despise that pointless accumulation of facts and terms which sometimes passes for scientific education and they should be given training in clear, purposeful and accurate descriptive writing in their own language". The Panel was impelled by two main considerations to pronounce against botany and zoology and the current biology, and in favour of a single, revised course in biology, which should stress the underlying principles of the subject and show the fundamental similarities of living things as well as the fundamental differences between plant and animal.

The present chaotic system of examinations at Ordinary, Advanced and Scholarship levels, with different requirements from each Board, is critically considered, and so useful proposals are made towards a more rational system. The approach of the teacher to the syllabus is largely determined by the type of examination paper which is set. Although the marking of a large number of scripts by many examiners is not easy, and this has led to the use of questions which can be marked quickly and precisely, these questions may not be of the type best suited to selecting the best candidates.

At present, selection for entry to university is made on the basis of Advanced-level performance, supplemented by an interview. The latter occasionally reveals that a student with good marks depends on a particularly good memory and that this kind of entrant usually fails to maintain his performance in the university. It was felt that the introduction of Scholarship-type questions would enable a distinction to be made between the fundamentally sound pupil and the 'memory-man'. In general, there is a remarkable parallelism between the weaknesses, difficulties and suggested remedies in all the subjects. Very useful suggestions are made towards the teaching of fundamental principles, and the eschewing of the unintelligent learning of masses of factual snippets. The report of the Panel is so detailed and yet succinct that further summary is not possible.

This report throws into relief the need for other investigations. Each university can have its own pre-requisites for entry to its courses, and, in this matter, there are differences in standard and scope between science subjects. This makes difficulties for the sixth-former who, in the hope of securing entrance to a university, applies to a number of them. While it is impossible, and if it were possible it would be undesirable, to secure uniformity in this matter, much wastage of effort (even clerical effort), confusion and disappointment result.

It is hoped that other universities will issue similar reports, for the matter is both socially important and urgent. Although it is outside the terms of reference of the present report, there is a more general problem of a parallel nature which is receiving some attention in an inquiry of which the results are awaited. Too many sixth-form students, who seem to promise much, fail to do well at the university. This is a source of disillusion, a wastage of brain-power and money, and a failure to meet social needs, which needs careful investigation and, if possible, a remedy.

There are other matters which should be considered, though these are outside the scope of the present report. For example, there is the failure of the less-than-brilliant sixth-form student to adjust himself quickly enough when he comes to the university with its short terms and social temptations presented by the Students' Union, the failures to use the vacations adequately and the early dates of the examinations in the last undergraduate year. The shortages of good sixth-form teachers, particularly of science and mathematics, and even of good examiners are other, but nevertheless important, matters.

W. L. SUMNER

---

[*] University of Birmingham. Report of an Enquiry into the Suitability of the General Certificate of Education Advanced Level Syllabuses in Science as a Preparation for Direct Entry into First Degree Courses in the Faculty of Science. Pp. v+212. (Birmingham: The University, 1959.)

THE NEEDS OF UNIVERSITY STUDENTS

IN a memorandum submitted to the University Grants Committee, the National Union of Students describes its attitudes to the problems involved in university expansion. Because of their direct experience, the views of the National Union of Students are likely to be of greatest significance where it discusses the needs of students. It has recently suggested, for example, that if adequate and suitable accommodation, which may be of many different kinds, cannot be provided near at hand for the whole student population, then neither the expansion of an existing university nor the establishment of a new one should be allowed (Memorandum to the University Grants Committee on the Expansion of University Education, 1960–1970. Pp. 12. London: National Union of Students of England, Wales, and Northern Ire'and, 1960). Insufficient attention has been paid to this problem in the past, with consequent harmful effects on the undergraduate, as a person and as a student, and upon the community of which he is a member.

While there is a variety of different types of accommodation which fulfil the needs of students, great benefit is derived from time spent in residence. Ideally, halls of residence should be composed of comparatively small units of ten to fifteen rooms, each providing a small kitchen and a discussion room. The units are often well arranged on staircases with small groups of rooms on each floor. There might be three such units on each of three or four sides of a small court, so that each block provided accommodation for some 150 students. There is, however, a considerable range of ways in which good residential accommodation can be provided; the student flats at King's College, Newcastle, and the Studentenhaus at West Berlin University are examples of such variations. There is considerable scope for experiment in this field.

When planning residential accommodation, the architect should consult fully with the university authorities and with student representatives to ensure that the most economic as well as the most effective lay-out is obtained, encouraging the corporate spirit of the university as well as facilities for private study and relaxation of the individual student.

Since the provision of enough residential places is economically unattainable in the near future, the Union emphasizes that not all forms of lodging are necessarily suitable for students, who need a quiet room for study, flexible hours and a sympathetic atmosphere. Lodgings that may suit some purposes can be quite unfitted for study. In a small town such as Aberystwyth, where the university dominates the life of the community, students often find that landladies come to understand their needs and take a real interest in providing the right environment for study. If the university atmosphere and community is to develop, all accommodation should be in close proximity to the university centre.

Another important factor is the academic and administrative structure of the university. Apart from the fact that this can determine the success or failure of its development as a community, it will have repercussions on the breaking down of faculty or departmental inter-relationships, which is already taking place through increased specialization; it will also affect the balance of Faculties and of undergraduate/postgraduate ratios. The structure most conducive to a fully integrated university education is the collegiate structure as will be developed at Bristol. In the expansion of existing universities it may well be desirable to avoid the piecemeal addition of extra sections to the present structure, but rather to change to the collegiate pattern.

All the major buildings of the university—halls, union building, laboratories, libraries, lecture theatres and refectories should be grouped together on one site. It would be valuable if a few small buildings in the various towns selected as new university sites could be leased to the university for use as, say, libraries for the smaller Faculties, and as staff houses where some tutorials could be given; arrangements might also be made for the designation of a university church within the town. Such facilities should not be allowed to detract from the creation of a single university unit.

There should be some degree of specialization in each university in selected areas of study. Such specialization could build up a reputation, encourage research, simplify application problems, attract interested staff, and might also prevent duplication of capital costs on research equipment. Development should be considered in relation to the paramount need to operate a proper tutorial system.

The major need of students is adequate provision for the development of an active student community. There should be a Students' Union building, providing a meeting place and a centre of student life, which should, where possible, be a separate building.

Where new laboratories are being erected, these should be designed in conformity with good safety regulations. It is also hoped that the need for an adequate and well-equipped clinic is generally recognized. These are already provided in many universities, and will be essential in new universities where the treatment of physical or mental illness should not be left to the care of local doctors who might not be readily accessible.

SENSORY SPECIALIZATION IN RESPONSE TO ENVIRONMENTAL DEMANDS

THE third of a series of Zoological Society of London symposia was held on March 4 under the title "Sensory Specialization in Response to Environmental Demands". It was organized by Prof. O. Lowenstein, and the meeting was held under the chairmanship of Prof. R. J. Pumphrey.

In his introductory remarks, Prof. Lowenstein directed attention to the somewhat Lamarckian ring of the title; but he envisaged that none of the topics under discussion would make it necessary or desirable to infringe neo-Darwinian orthodoxy. Outlining the rationale of the programme, he went on to point out that two different types of adaptive specialization could usefully be surveyed in this context. The first may affect the whole range of sensory modalities as a means of adapting an animal to a successful integration into a sub-social or social organization. This type is found, for example, in locusts and to a more extreme degree in the social Hymenoptera. The second type of sensory specialization may be confined to one sense organ only, the eye in nocturnal, deep sea, or cave animals, or the ear in animals like bats and cetaceans which find their way about by means of sonar.

A comparative analysis of sensitivity limits may also reveal instances of adaptation to special environmental circumstances. The sensitivity limits of photo-receptors may serve to illustrate this point.

In a paper on the sensory equipment of the migratory locust, Dr. P. T. Haskell (Anti-Locust Research Centre, London) showed that special sensory adaptations are related to the control of steady and stable flight of the swarming insect and to the maintenance of cohesion between locusts in the swarm. 'Dorsal-light' reaction of the compound eye and proprioceptive feed-back from receptors on the cervical hair plates control anti-roll stabilization, whereas anti-yawing responses are elicited by cephalic hair sensilla. Preferred inter-locust distance in the swarm is maintained by an equilibrium between visual attraction and repulsion in response to auditory and other mechanical stimuli.

Fully social organization as shown by the social Hymenoptera involves a number of instances of extreme sensory specialization in the various castes of ants and bees. Dr. H. Kalmus (Galton Laboratory, University College, London) described some new results concerning colour vision and odour discrimination in the honey bee. Whereas scent is an important item of information in bee-to-bee communication, symbols for colour are very likely missing from the 'vocabulary' of the social insects. A discussion of the mechanism of analysis of the plane of polarized light was illustrated by an electron-micrograph of an insect ommatidium. Dr. Kalmus suggested that the chief sensory adaptation in the social Hymenoptera consists of a co-adaptation of pre-existing sensory mechanisms with patterns of motor activity into systems of communication.

In a paper on the sensitivity limits of photoreceptors, Dr. F. H. C. Marriott (Department of Physiology, Oxford) stressed the necessity of presenting measurements of spectral and absolute threshold sensitivity in such a form that they can be compared throughout the animal kingdom. Such measurements made on five species, namely, man, cat, owl, the amphibian *Xenopus*, and the flatworm *Dendrocoelum*, were discussed and compared with special reference to the differences in the visual sensory structures.

Dealing with the problems of the sensory aspects of adaptation in cave animals, Dr. G. Thines (Laboratory of Experimental Psychology, University of Louvain) gave a paper on sensory degeneration and survival in cave fishes. After a critical discussion of the general idea of evolutionary 'progress', Dr. Thines defined regressive changes as a gradual reduction of independence leading to the 'abnormal' character of regressive faunas such as cave fishes. The survival value of regressive changes in photoreceptors in cave fishes was then assessed and this led to the introduction of the hypotheses of 'remanence' and 'vicariance' with regard to the significance of the continuation in eyeless cave fishes of the pre-existing epigean photokinetic functions and of the supplanting of the functionally insufficient eye by the pineal organ. Dr. Thines then showed a short film on the blind fishes of Somaliland.

The design of fish and cephalopod eyes in relation to their environment was discussed by Dr. E. J. Denton (Marine Biological Laboratory, Plymouth). The density, the refractive medium, absorption and scattering of light by the medium all have their effect on the morphology and functional characteristics of the eyes of marine animals. At greater depth and at night the light emitted by luminescent animals may be more important than the light coming from the sky. Light will only be 'useful' for vision if it can be absorbed by photosensitive pigments. Pigments then play an important part in the adaptive specialization of eyes. The elongation of the rods of the deep-sea fish retina, although raising sensitivity, could have an adverse effect on visual acuity were it not for the existence in these elongated rods of marked channelling of light along the rod. Pigment migration between rods also diminishes the blurring effect of lateral spread of light.

The symposium ended with an account by Prof. F. P. Mohres (Department of Comparative Physiology, University of Tubingen) on sonic orientation of bats and other animals. Prof. Mohres recounted how, during the Second World War, Spallanzani's classical observation of orientation of bats in the dark found its explanation in the simultaneous discovery of ultrasonic echo-location in the vespertilionid bats by Griffin, Pierce and Galambos in the United States, by Dijkgraaf in Holland and by himself in Germany, all of them confirming a hypothesis advanced by Hartridge in 1922. In vespertilionid bats short volleys of ultrasonic pulses of a broad and irregular frequency spectrum are utilized in a system of time difference estimation in which the time difference between the emitted signal and its returning echo is a measure of the distance of the reflecting object, and the time difference between the arrival of the echo at the two ears serves as a measure of direction. A completely different sonar mechanism of orientation was, however, discovered by Prof. Mohres to exist in the horse-shoe bats (Rhinolophids). While flying, the horse-shoe bats keep their mouths closed and the horse-shoe points in the direction of flight, or in stationary animals into the direction of 'interest'. Ultrasonic sound, consisting of prolonged cries without frequency or amplitude modulation, is emitted through the nostrils and cast about in a beam 'focused' by the horse-shoe. In Rhinolophids the essential feature of ultrasonic orientation is thus, according to Prof. Möhres, not a time difference but an intensity-difference estimation. The animals are thus believed to assess the sound intensity of their orientation cries reflected by objects in their environment in turning their ears point to point through the range of space under scrutiny. Rendering the ears immobile abolishes successful orientation. It must be mentioned here, however, that certain aspects of the *modus operandi* of sonar as summarized by Prof. Mohres are meeting with adverse criticism from a number of quarters.

Finally, Prof. Möhres described how a search for mechanisms intermediate between the vespertilionid and the rhinolophid extremes led to the discovery of intermediate situations in the Hipposideridae and the Megachiroptera (fruit bats). However, no conclusive phylogenetic picture emerged, and the origin and ways of the evolutionary lines remain hidden in the darkness of the past.

O. LOWENSTEIN

ASPECTS OF OROGENS

THE Geologische Vereinigung held its fiftieth anniversary meeting under the presidency of Prof. G. Fischer in Würzburg during March 12–14. The theme for discussion was the Orogen, the mobile belts or those parts of the Earth's crust in which mountain chains are formed. The process of orogeny can best be considered in respect of time; a time when the materials accumulate and become compacted to form the building materials for the mountains; a time when these rocks are disturbed by forces usually regarded as being produced by shrinking of the Earth's surface; and a time when magmas from deeper horizons within or below the crust break through and pierce the strata whether quiet or crumpled and broken. Part of the magmatic activity consists of the release and movement of reagents which metamorphose the sediments. Then comes a final act in which vertical movements are considerable, helping to account for the present stature of the mountains and their wild or orderly scenery by exposing the various structures to erosion.

There is also a space relationship. The orogens are restricted to comparatively narrow belts in which mountain building takes place. The arrangement of the mountains within these belts is not simple or regular. One reason for this is that earlier chains may have stood along or across the line followed later by younger mountains, and their presence, or that of broken fragments of these old ranges, interferes with the growth and orientation of the later ones. The structures themselves may be divided into those formed under comparatively little cover and therefore at low pressure, and others which have formed deep in the crust under high pressure. The former are more often well exposed in present-day mountains, but the latter are seen only where erosion has been unusually deep. The former have often escaped intrusion, but the latter have suffered magmatic injections and are in part complicated by metamorphism.

The forces at work within the orogen also vary. Opinions diverge as to what initiates the commencement of growth, and it is probable that tension played a part. Lateral compression undoubtedly was important during much of its life and resulted in the formation of the folds and associated thrust-faulted structures. At a late stage, however, tension again developed and allowed normal faults to form accompanied by floods of lava or the great sheets of tuff or volcanic ashes.

Most of the papers delivered during the meeting by some 35 speakers were orthodox enough, but one by Dr. L. Egyed (Budapest) seemed more than a little heretical to some in the audience. He suggested that below the layers of ultrabasic rocks reputed to underlie the sima, there exists less-basic material; magma containing water and other light fugitive constituents which are absent from peridotites. Such ideas appear to be in accord with Dr. Egyed's published views that the Earth is an expanding body, not the contracting one, described, for example, by the late G. M. Lees, which is how many other geologists would have it.

In the opening paper Dr. R. Trumpy (Zurich) remarked that no scheme of mountain building as yet worked out can be applied generally. Each orogen has to be treated as an individual. As well as the disturbing influence exerted by fragments of earlier mountain-chains the type of sediments involved played an important part in determining the shape of the resulting structures. For example, the thick column made up of alternating thin beds of muds and sands, characteristic of eugeosynclines, fold in a totally different style from that found where the strata are mainly thick bodies of limestone and sandstone such as accumulate in miogeosynclines. Examples to illustrate his opinions were chosen from the western Alps which, although well known, are complicated and are by no means typical of structures in some other orogens. Dr. E. K. Walton (Edinburgh) described the eugeosynclinal region of the Scottish Southern Uplands where the Ordovician and Silurian strata are now regarded as being thicker than was previously estimated and as including higher stages in the Silurian than those hitherto recognized there. Broader asymmetrical folds with steep thick flanks and disturbed by large strike faults are commoner structures than the groups of innumerable isoclinal folds depicted in the classical sections by Peach and Horne.

The spilites of the Lahn–Dill region discussed by Dr. H. Hentschel (Wiesbaden) contain albite, chlorite, quartz and calcite instead of the normal minerals of a basaltic suite, plagioclase, pyroxene and olivine. The possibility that sea water entangled among the geosynclinal sediments reacted with basaltic intrusions is considered as probable.

The veteran Dr. P. Eskola (Helsinki) referred to juvenile granites produced by intrusive magmas formed from components from within the Earth which have diffused outwards. These he contrasted with secondary granites derived from re-working of metasomatized sediments or migmatites. These may appear as disharmonic stocks even in epeirogenic regions. The presence of an aureole of contact metamorphism serves to demonstrate cases in which a hotter intrusion pierced a colder environment.

Because the bodies of sial and sima extend laterally as sheets which are nearly horizontal it is easier to imagine the movement of material along rather than across them, but where they are in an unusual relationship, such as occurs near the edge of an orogen where it touches the margin of an ocean basin, transverse movement of magma should be easier. Dr. P. Michot (Liège) directed attention to the importance of such marginal intrusions and suggested that they may originate at depth in the katazone. Now that methods have been devised enabling rapid analyses to be made, Dr. K. R. Mehnert (Berlin) considered that a new and important research tool is available which may be applied to the study of the distribution of alkalis throughout the body of an orogen. Dr. H. Borchert (Clausthal) also spoke of geochemistry, referring to the association of the copper, zinc, lead and barium ores on one hand and chromium, nickel and titanium ores on the other.

The complicated structures of the Central Pyrenees, involving the interpretation of areas with slaty cleavage and of orientation patterns assumed by newly formed metamorphic minerals, were described by Dr. H. J. Zwart (Leyden). Dr. E. Bederke (Gottingen) considered the relationship between stress and regional metamorphic effects. He cited examples from the Sudeten hills and western Alps in which active phases of disturbance were separated by long intervals of quiet. The late history of the orogen was the theme of Dr. A. J. Pannekoek's (Leyden) discourse. Folding, faulting and differential vertical movements contribute to the present morphology. Theories of mountain building should be capable of explaining the late movements as well as other early ones. The association between late movements and post-orogenic vulcanism suggests the intervention of a magmatic process. The breaking down of a basin like the Mediterranean with excess gravity may be connected with the uplift of neighbouring hills and be independent of the structure of the orogen.

Dr. A. Winkler von Hermaden (Graz) described examples of structures from the western Alps and Croatia, while others chose examples from central Asia, central Africa, the Carpathians, the Balkans, the east Alpine zone and the Ligurian Alps with part of the neighbouring northern Apennines. The object of four other papers was to make use of features seen in Central and South America to show that structures there run nearly parallel to the present coast; that there has been deposition and folding along an old mass lying to the east; that breaking down accompanied by intense vulcanism and intrusion has produced a graben-like feature a little inland from the coast; and that large uplifts have taken place rather recently. The frequent earthquakes both out at sea and up to 100 miles inland are taken to indicate that the region is still tectonically active.

During the session the Steinmann Medal was awarded to Prof. H. H. Read. The text of the contributions made by the several speakers is expected to appear in the next volume of the *Geologische Rundshau.*

J. V. HARRISON

INDIAN INSTITUTE OF SCIENCE, BANGALORE

GOLDEN JUBILEE SYMPOSIA

As a part of scientific activities during the Golden Jubilee Year (1959–60) of the Indian Institute of Science, Bangalore, which was inaugurated in February 1959, the Department of Chemical Technology and Chemical Engineering arranged symposia on "Hydrocarbon Synthesis and Hydrocarbon Conversion" and on "Mass Transfer" during January 11–13, 1960. The technical session commenced with an address by Prof. W. Groth, director of the Physical Chemistry Research Institute, University of Bonn, who discussed new developments in the field of emission mass spectroscopy. A number of original papers covering different aspects of the two subjects of the symposia were also read and discussed. Papers were presented by scientists from the United States, the United Kingdom, Germany and Italy, as well as from many Indian universities and institutions.

In the session on hydrocarbon synthesis a paper on the "Performance of Iron Catalysts and the Promoter Action of Alumina and Platinized Asbestos at Atmospheric Pressure" was presented in which the authors indicated that alumina behaved as a structural promoter and increased the polymerization activity and hydrocracking, whereas platinized asbestos improved the overall activity and hydrogen consumption, keeping the formation of gaseous hydrocarbons low. Papers on "Fischer–Tropsch Synthesis in Fluidized Bed" using an Fe–Cu–MgO–K_2O catalyst and the "Rheinpreussen–Koppers Liquid-phase Process" were also read. In the former method the performance compared favourably with the already established units. In the latter process the authors reported considerable selectivity for C_3 hydrocarbons and versatility to suit the market requirements. A probable mechanism of Fischer–Tropsch synthesis based on intermediate reactions of the carbonyl and oxo-complex types was reported and discussed. The possibility of producing gas from methane-rich low-temperature carbonization gas using a nickel catalyst with a high conversion (92 per cent) at a temperature of 900° C. was reported. The paper on "Rectisol Process for Gas Ultra-purification under Elevated Pressure" indicated the advantage of simplicity of operation in a single unit.

Concerning hydrocarbon conversion, reformation by hydrogenation, cracking, etc., a number of interesting papers were presented. The medium pressure hydrogenation of coal-tar distillate with a desulphurization catalyst was reported to have resulted in the formation of a refined product which could be used as a starting material for the chemical industry or as motor fuel. The results of cracking of high boiling fractions from Nahorkatiya crude oil over a silica–alumina catalyst showed yields of high percentage of middle distillates. The use of the same catalyst promoted by calcium oxide for the production of lubricating and diesel oils from paraffin wax from Assam crude oil was also reported. The gasification of hydrocarbon oils for conversion into gases of high B.T.U. by cracking over various contact beds, including activated coke and in an atmosphere of carbon dioxide, indicated the possibility of developing a single-stage continuous process for preparing gas of uniform composition and for meeting standard requirements. One paper dealt with the structural features of reactants on the basis of which predictions could be made regarding the reactivity and nature of products obtainable in the alkylation of olefins with paraffins and alkylbenzenes under pressure. There were three papers dealing with oxo-reactions. In one paper, the author reported the synthesis of propionaldehyde, propionic acid and methyl and ethyl propionate by the oxonation of ethylene. The other two papers dealt with the thermodynamics of oxonation of butenes, preferential oxonation, etc.

In the session on mass transfer a number of interesting papers were presented, some of them dealing with isotope separation. The separation processes based on ion-exchange methods with special reference to band displacement and elution principles, including elution chromatography, were reviewed and their application to separation of low- and high-mass numbers up to calcium was discussed. The processes for production of carbon-13, nitrogen-15 and oxygen-18 were also surveyed. The derivation of a relationship for the calculation of transfer columns for heavy-water enrichment plants, and the comparison of the theoretical and experimental values obtained in case of Bitterns water were discussed. A simplified and experimental modification of the temperature-float method, as developed recently, was described and discussed with reference to such factors as float design, horizontal and vertical temperature gradients in the float chamber, etc., for isotopic analysis of heavy water. Based on experimental data, the possibility of co-current distillation in a gas stream for the enrichment of heavy water was indicated. The theory of separation potential of thermally controlled gas centrifuges, and some experimental results obtained from centrifuge models *ZG*3 and *ZG*5 for separation of argon, xenon and krypton isotopes were presented.

A method of determining the mass transfer rates by means of a single particle placed in a bed of similar-sized inert particles by radioactive tracer technique and the application of the same in the case of ion-exchange processes was described. The results obtained in the steam-stripping of carbon dioxide from sodium carbonate–bicarbonate solution in perforated plate columns indicated that the liquid hold-up in the column is chiefly a function of the rate of flow of the liquid, which itself is dependent on the decomposition of the sodium bicarbonate during the process. The studies on the mechanism of mass transfer in naphthalene-packed beds indicated that the values of diffusivity coefficients differed from those obtained by other investigators. This was attributed to some other mechanism such as surface resistance, the diffusion of solute molecules, etc., besides the molecular diffusion in the surrounding gaseous film. A generalized correlation of operating hold-up in packed columns, which gave a value within 5 per cent of the observed values in most cases, was discussed. A method has been proposed for the design of a fixed-bed catalytic reactor for vapour-phase reactions based on the reaction-rate constant and the overall heat-transfer coefficient, and on the assumption that there is no radial temperature variation. Dixon-ring packings prepared locally were reported to be highly efficient in laboratory fractionating columns. An empirical equation based on experimental results obtained with a Northrup and Anson diaphragm cell for calculating diffusivity coefficients of organic acids in ethanol–water mixtures was proposed.

A re-cycling pressure-equilibrium still was described in one paper, and the results obtained for benzene–toluene and ethanol–benzene systems up to 200 p.s.i.g. were discussed.

In one paper attempts were made to explain the heat-transfer characteristics of stirred and gas-fluidized beds of particles on the basis of a theoretical model in which the rate of heat transfer from a heated surface in contact with a stirred bed is dependent on the rate of replacement of particles at the surface by particles of 'average' temperature from the bulk of the bed. The experimental results obtained in an apparatus in which circulation of particles was caused by stirring were found to agree with the model proposed.

Some review papers dealing with the theory of air-drying of solids and its application for the design of industrial dryers, separation of hydrocarbons by chromatographic methods, the application of urea and thio-urea complex formation for separation in petroleum industry, the various petroleum-refining processes with special reference to coking, thermal cracking and catalytic cracking, and the recovery of catalytically cracked feed stocks from petroleum residue by propane-decarbonizing were also read.

R. L. DATTA

PSYCHOLOGY OF GIFTED CHILDREN

HIGH intelligence is probably the most valuable of a community's social and economic assets. From gifted individuals come the sources of creativity, of leadership and of progress at all levels—moral, artistic, scientific and political. On the other hand, the highly intelligent maladjusted or anti-social individual can be a greater threat to his fellows and to his society than his less able contemporaries. Thus, the best all-round education and training of the most able group of children and adolescents are essential aspects of the conservation and exploitation of our natural resources. To some extent, the Education Act of 1944 recognized this, crowning nearly half a century of attempts to give able children the right to a fitting education in school, and later in university, irrespective of their social background.

Dr. W. D. Wall, director of the National Foundation for Educational Research in England and Wales, has now examined the knowledge available as a basis for reviewing that part of our educational system and methods which deal with the pool of high ability (*Educational Research*, 2, No. 2; February 1960).

Genius in its fullest sense is of immense importance to any society. As, however, it is very rare, and in any event so little is known about the conditions which produce it, attention must be concentrated on the general pool of high intellectual ability from which will be recruited scientists, teachers, leaders in political and business life and the professions generally. At present in the English educational system it is assumed that this pool is defined by the ability to profit from a grammar school type of curriculum in adolescence. Few of the outstandingly able children now fail to qualify for entry to grammar school.

Our present allocation procedures, however, although generally more efficient than any other form of examination, can take no account of a number of factors which determine potential performance. Virtually a child's education during adolescence and consequently his chances of higher education are determined by the result of five years in the primary school.

Ability, however, as shown in school learning and afterwards by vocational success or social contribution, is only in part determined by strictly genetic factors. 'Operational intelligence' is an innate product of ability and the educational effects of the environment. The ability which psychologists see and attempt to measure in children and adolescents is the sum of inheritance, motivation and nurture. Marked lack of affectionate mothering will result in a lowering of ability, and emotional deprivation in infancy particularly affects the development of verbal concepts and abilities. If this continues beyond a certain point, its effects are irreversible. From the work of the Population Investigation Committee, which is following the growth of some 5,000 children born in 1946, it seems to be indicated that the quality and level of parents' interest in their children markedly affects not merely academic attainment but also the complex general ability measured by intelligence tests. There is, therefore, a proportion of children whose talents never show themselves to the full because the environment starves them in important ways.

General ability and talent well above the average may never declare themselves if nurture is lacking, or if emotional deprivation is marked.

It is difficult to over-estimate the importance of a constructive education at home, and in the school, for able children if they are to realize their intelligence capabilities to the full. However, socially and personally something more than a merely reasonable state of emotional equilibrium is necessary. It is of fundamental importance that highly intelligent children and adolescents should see their high endowment, not as a source of egocentric and purely personal advancement, but as a trust which increases their responsibilities towards others. It is doubtful whether the present stress on inter-personal competition which marks some facets of our educational system is fully desirable; and whether sufficient demands are made upon our ablest ten per cent of pupils.

The notion is still current that genius is maladjusted emotionally, often feeble physically, and that poets, in particular, tend to die young. Similarly, the popular picture of the highly intelligent child presents him as puny and bespectacled, as precocious in language interests as he is retarded in his emotional development, liable to over-fatigue and difficult to get on with. There is little truth in these stereotypes. The able child tends to be superior to the average in every way: there is no law of compensation which offsets high intelligence by inferiorities in non-intellectual fields. The degree of superiority to the average is not the same in all fields and is greatest in those most closely related to intelligence, that is, originality, intellectual interests and achievement test results. Terman's extensive investigations showed that "contrary to the theory that great achievement is usually associated with emotional tensions which border on the abnormal, in our gifted group superior success is associated with stability rather than instability, with absence rather than presence of disturbing conflicts—in short, with well-balanced temperament and freedom from excessive frustrations".

The majority of intelligent children, and particularly the highly intelligent, tend to have interests well in advance of their physical age. Precociously concerned with such things as matters of origin, destiny and evil in the abstract, immature in experience but mature in logic, they rouse the anxiety, antagonism and jealousy of adults. They easily become negatively suggestible, and the illogical conduct of adults may lead to rebellion or to a gathering cynicism.

The difficulties of very able children are most likely to be marked within the middle years during the junior school period, and lessen as age increases the range of social movement, allowing them to seek companions of their own kind and as mastery of educational skills allows them to seek and find the intellectual challenge they need. Our system of progressive selection by academic attainment, though it has many defects, makes it more likely that the able child, even in the primary school, and certainly at the secondary and subsequent stages, will meet his equal and find stimulation. This does not mean that the problem of how the most able one, five or ten per cent of children, should be educated has been solved. This is a matter which is occupying the attention of educators in the United States as well as in Great Britain and Europe.

THERMODYNAMICS AND KINETICS OF SPONTANEOUS GENERATION

IN the current enthusiasm to put forward theories that provide a milieu rich in organic compounds for the spontaneous generation of life, little attention has been given to the quantitative aspect of the problem. One might estimate the rates of reactions producing such compounds, on one hand, from pertinent kinetic data; or one might use thermodynamics as a guide to the quantities of compounds expected, particularly in view of the long times available for approach to equilibrium. In a recent paper[1], however, Miller and Urey apply thermodynamic formulæ only to the equilibrium concentrations of inorganic raw materials in the primitive atmosphere; but they do not apply thermodynamics to the synthesis of organic compounds.

It seemed interesting to me to calculate the equilibrium concentrations of some amino-acids under the conditions postulated by Miller and Urey. For example, the first compound listed in their Table 2, glycine, is formed from the starting compounds by a reaction that may be written:

$$2\,CH_4 + NH_3 + 2\,H_2O = NH_2CH_2COOH + 5\,H_2$$

with an equilibrium constant of 2×10^{-40}. Substituting the partial pressures assumed by Miller and Urey (and taking p_{NH_3} as 0·04 atm.), the aqueous concentration of glycine is 10^{-27} mole/l. Similar calculations for more complex amino-acids yield smaller concentrations.

Now, of course, it is possible that, in an energy-rich medium, steady-rate concentrations can be maintained far from equilibrium. In such case the expected concentrations depend on the available mechanisms for synthesis and decomposition. Ultra-violet light is the most important source of energy to consider, being hundreds to thousands of times more abundant than electrical discharges or ionizing radiation. The atmosphere postulated is transparent to ultra-violet down to 2250 Å.

A glycine molecule formed in such an atmosphere is immediately vulnerable to radiation up to 3000 Å., absorbing in a part of the solar spectrum far more intense than that which produced it. Decarboxylation of activated glycine would presumably occur with a quantum efficiency of the order of unity. Thus, any glycine formed would be rapidly decomposed. Its absorption coefficient, about 0·15 cm.$^{-1}$-(moles/l.)$^{-1}$ at 2500 Å., and the intensity of ultra-violet below 3000 Å., about 0·01 cal./cm.^{2}/min., or 10^{15} quanta/cm.^{2}/sec., give it a half-life of about 30 days. This is much shorter than the half-time of transport from the stratosphere to the surface, now estimated from fall-out data as three years. Thus, 97 per cent of the glycine would be decomposed before it could reach the surface.

Miller and Urey hope to save the synthesized products by removing them from the reaction zone in the atmosphere to the ocean. But even after the glycine reaches the ocean, the victory is not won. Abelson[2] has discussed the possible stability of simple amino-acids throughout geological time; the important effect, however, is not thermal, but decomposition by ultra-violet radiation. The ultra-violet reaching the surface would penetrate to a considerable depth. To-day's sea water transmits 10 per cent of light of wave-length 2600 Å. to a depth of 6 in., and fresh water, which may be more nearly comparable to the primitive ocean, to as much as 3 ft. (ref. 3). In the mixed layer above the pycnocline, about 100 metres deep, glycine would have a half-life to ultra-violet destruction of about twenty years. Even assuming it to be mixed to the bottom of the ocean, with an average depth of 4 km., the half-life is only 1,000 years. These short lives for decomposition in the atmosphere or ocean clearly preclude the possibility of accumulating useful concentrations of organic compounds over eons of time.

The limiting concentrations to be hoped for can be estimated from the steady state between production and decomposition. The rate of formation of glycine by ultra-violet irradiation (1165–1470 Å.) from a mixture of methane, ammonia and water vapour may be estimated from the reported work of Groth and von Weyssenhoff[4]. They were barely able to identify glycine and alanine in the product after exposure to 10^{21} quanta. On the assumption that they could detect $0 \cdot 1$ μgm. of glycine, this gives a quantum yield of 10^{-6}. The flux of solar ultra-violet radiation below 1500 Å. is given as $3 \cdot 5$ cal./cm.^{2}/yr., which corresponds to 3×10^{11} quanta/cm.^{2}/sec. Thus, glycine would be formed at a rate of 3×10^5 molecules/cm.^{2}/sec. During the average life-time in the atmosphere this could build up to 10^{12} molecules/cm.^{2}, or a partial pressure of about 10^{-14} atm. Allowing for 3 per cent to reach the ocean and the 1,000-year life there, the maximum concentration in the sea would be 10^{-12} molar.

This concentration is far from equilibrium. The actual concentrations realized would probably lie between the thermodynamic and the kinetic estimates, that is, between 10^{-27} and 10^{-12} molar; but even the highest admissible value seems hopelessly low as starting material for the spontaneous generation of life.

Consideration of other sources of energy, although they are very much weaker than the ultra-violet radiation, leads to similar conclusions. Thus, ionizing radiation may form complex products from simple reactants, but the more complex and highly organized compounds are more vulnerable to the same agent than their simple precursors. *G*-values of the order of unity are found for the decomposition of proteins by radiation[5]; whereas the formation of protein by radiation has not been observed.

The conclusion from these arguments presents the most serious obstacle, if indeed it is not fatal, to the theory of spontaneous generation. First, thermodynamic calculations predict vanishingly small concentrations of even the simplest organic compounds. Secondly, the reactions that are invoked to synthesize such compounds are seen to be much more effective in decomposing them.

Further, it must be remembered that both lines of argument become quantitatively of an overwhelmingly greater magnitude when organic compounds other than the very simplest are considered. From thermodynamics, the equilibrium concentration of glucose is 10^{-134} at unit activities of the component reactants. The values for the simplest proteins must be unimaginably small. Also, in agreement with the thermodynamic prediction, the kinetic steady-state concentration falls rapidly with increasing complexity of organic compounds, because (1) the quantum yield for their formation decreases; (2) at the same time their stability against thermal decomposition decreases; and (3) their opacity to ultra-violet radiation and decomposition by this means increases. The physical chemist, guided by the proved principles of chemical thermodynamics and kinetics, cannot offer any encouragement to the biochemist, who needs an ocean full of organic compounds to form even lifeless coacervates.

These estimates are not in conflict with the experimental results of Miller and others who have synthesized organic compounds with electrical discharges or ultra-violet light in the laboratory. They have merely used the well-known principle of increasing the yield of a reaction by selectively removing the product from the reacting mixture. But the fact that a chemist can carry out an organic synthesis in the laboratory does not prove that the same synthesis will occur in the atmosphere or open sea without the chemist. The second law of thermodynamics applies not only to inorganic gases in the atmosphere, but also to organic compounds in the ocean. Living cells may reverse the process, but in the absence of life, "die Entropie der Welt strebt einem Maximum zu".

D. E. Hull

California Research Corporation,
Richmond,
Cal.

---

[1] Miller, S. L., and Urey, H. C., *Science*, **130**, 245 (1959).
[2] Abelson, P. H., *Ann. N.Y. Acad. Sci.*, **69**, 276 (1957).
[3] Koller, L. R., "Ultra-violet Radiation" (Wiley, New York, 1952).
[4] Groth, W., and Weyssenhoff, H. von, *Naturwiss.*, **44**, 510 (1957).
[5] Bennett, W., and Garrison, W. M., *Nature*, **183**, 889 (1959).

Dr. Hull's analysis of the production and stability of simple organic molecules in a lifeless Earth is a valuable contribution to the discussion on biopoesis. By introducing a quantitative discussion he has effectively narrowed down the range of possibilities and thus presented a much more definite problem to be solved. Others are far more competent to discuss the thermodynamic aspects of this communication, and I would rather question the conclusions that Dr. Hull draws from his arguments.

Even if we accept that small organic molecules, *a fortiori* larger organic molecules, are likely to exist in an atmosphere and open ocean only in very small equilibrium concentrations, it does not necessarily follow that the way of photosynthesis for the origin of even more complex compounds, or of life itself, is effectively barred. The fact that Miller and others have produced such compounds by radiation is, as Dr. Hull quite rightly points out, because these products are selectively removed from their zone of formation. It would seem to follow that if complex organic molecules were ever produced on a lifeless Earth, something similar must have occurred there. There must have been a process which removed a certain proportion of these molecules from their zone of reaction. Further, the same or another process must have concentrated them to the extent where they could enter into still more complex reactions. Such reactions did not necessarily require further energy sources to promote them. In other words, the original concept of the primitive soup must be rejected only in so far as it applies to oceans or large volumes of water, and interest must be transferred to reactions in more limited zones.

Even in the inorganic world, minerals are produced which involve very large degrees of concentration of rare elements, in fact, unless two atoms resemble each other in nearly every particular, as rare earths do, then somewhere in the world a mineral will be found containing mainly that element, however rare. The processes for the concentration of organic molecules may well be similar and equally effective. I have at various times proposed such a mechanism of just such concentration and shielding organic molecules originally formed in an ocean. My first was that of the concentration of molecules directly from sea water in estuarine clays[1]. More recently I have realized[2] that there exists a much more powerful method of concentration of all molecules which have either surface activity or which tend to concentrate in the neighbourhood of water surfaces, that is, effectively all molecules containing alkyl groups. A. T. Wilson[3] has directed attention to the processes of the concentration of organic material derived from dead organisms, first on the surface of the ocean and then, through the action of the wind in foam or spray, along the coasts, thus providing nutriment for benthic organisms. The same processes would certainly have occurred in an abiotic sea in which any mineral hydrocarbons or their oxidized derivatives were to be found. The effectiveness of this process for concentrating tar will not be doubted by anyone visiting a beach in Britain to-day. The probability of the original presence of such hydrocarbons would be much strengthened if the ideas recently put forward by Mason[4] on the formation of meteorites containing hydrocarbons were accepted and extended to the outer layers of a primitive Earth.

By such a two-stage process, a relatively very small bulk concentration of synthetic molecules can be turned into a large concentration in specified areas. Further, once involved in clay, which absorbs such molecules readily, they will be completely shielded from ultra-violet radiation. A further mechanism of concentration of the smaller groups, particularly those containing nitrogen, will be provided by the presence of transition metal ions, notably those of iron, which may also play a part in primitive photosynthesis, as N. W. Pirie has pointed out[5]. One way of verifying or negating these hypotheses would be by extensive experimentation using large volumes of very dilute organic solutions and absorbing them on clay under controlled conditions. Until this is done, it is premature to accept any arguments, quantitative or qualitative, against the spontaneous formation of organisms, indirectly if not directly, from the primitive ocean.

J. D. Bernal

Birkbeck College,
Malet Street,
London, W.C.1.

[1] Bernal, J. D., *Proc. Phys. Soc.*, 62, 537 (1949); "The Origin of Life on the Earth", 38–53 (Pergamon Press, London, 1959).

[2] Bernal, J. D., Proceedings of the First International Congress on Oceanography, New York, 1959 (in the press)

[3] Wilson, A. T., *Nature*, 183, 318 (1959); 184, 99 (1959).

[4] Mason, B., *Nature*, 186, 230 (1960).

[5] Pirie, N. W., "The Origin of Life on the Earth", 76–83 (Pergamon Press, London, 1959).

AN ASSOCIATION BETWEEN DENTAL CARIES AND CERTAIN SOIL CONDITIONS IN NEW ZEALAND

By T. G. LUDWIG
Medical Research Council, New Zealand

W. B. HEALY
Soil Bureau, Department of Scientific and Industrial Research, New Zealand

AND

Captain F. L. LOSEE
(Naval Medical Research Institute, Bethesda, Maryland)
Medical Research Council, New Zealand

In 1955 Hewat and Eastcott[1] reported that a relationship exists between prevalence of caries and certain soil conditions in New Zealand, and a general investigation is at present being conducted to determine the causal mechanisms responsible for this relationship.

One phase of this investigation involves the study of the effect on prevalence of caries of recent saline soils at Napier, Hawke's Bay. In 1931 the major Hawke's Bay earthquake resulted in the uplifting of a land mass some 60 miles long and at least 10 miles wide to heights ranging up to 9 ft. The epicentre of the disturbance was situated in the vicinity of Napier, where the shore-line was elevated from 6 to 8 ft., this resulting in the draining of more than 5 square miles of the extensive lagoon adjacent to the city. The saline soils[2] thereby exposed have since been brought into production and in comparatively recent years used for residential development. The preliminary results of our investigation in this area are presented in this report.

During 1954–55, dental examinations were undertaken of children resident throughout life in the adjacent cities of Hastings and Napier to establish a base-line whereby the effectiveness of the fluoridation of the Hastings water supply in reducing the prevalence of caries could be evaluated[3]. The results of these examinations showed that Napier children aged 5–8 years had a considerably lower caries experience than children of an equivalent age in Hastings, this difference being manifested in both permanent and deciduous dentitions. Napier children aged 6, 7 and 8 years had, respectively 57, 46 and 21 per cent fewer permanent teeth with caries experience than Hastings children of the same age (Table 1); and Napier children aged 5, 6 and 7 years had, respectively, 20, 14 and 6 per cent fewer deciduous teeth with caries experience. These differences in prevalence of caries were statistically significant at the 0·1 per cent level.

This finding was unexpected in view of the apparent similarity of conditions in the two cities. Both have populations of approximately 20,000 and are situated in the eastern part of Hawke's Bay, Napier being the

Table 1. Comparison of Caries Prevalence Rates in Permanent Teeth of Hastings, Napier and Palmerston North Children in 1954–55 and in 1957

	Mean No. permanent teeth D.M.F.* per child			
	Hastings 1954–55	Napier 1954–55	Napier 1957	Palmerston North 1957
No. children examined	1,204	1,114	1,186	1,009
6 years	1·41	0·61	0·70	1·21
7 years	2·75	1·49	1·49	2·50
8 years	3·73	2·93	2·95	3·69
9 years	4·45	4·06	3·83	4·49
10 years	5·48	5·25	4·91	5·46

* D.M.F. = decayed, missing (extracted due to caries) or filled.

Table 2. TRACE ELEMENT LEVELS (P.P.M.)* IN EDIBLE PARTS OF VEGETABLES GROWN ON HASTINGS AND NAPIER SOILS

Vegetable	Area	Mo	Al	Cu	Ti	Mn	Ba	Sr
Beans	Hastings	0	8–11	7·4–11	0	26–68	1·2	20–23
,,	Napier	1·1–9·5	34–95	4·5–6·0	1·0–4·0	7·6–11	0·3–11	7·6–13
Cabbage	Hastings	0	1·2–7·4	1·8–2·8	0	9·1–9·7	0·6–1·1	14–24
,,	Napier	0–3·7	3·0–15	1·9–3·6	0	5·3–10	0–1·1	15–26
Potatoes	Hastings	0	4·4–5·2	3·6–4·5	0·1–0·2	3·7–4·7	0·2–0·3	1·7–2·1
,,	Napier	0·2–0·4	4·0–5·0	2·4	0·1–0·9	2·8–3·3	0·1–0·4	1·4–3·8

* Results on oven dry basis. Zero levels mean that the element could not be detected by the method used.

chief port of the province and Hastings lying 8 miles from the sea and about 12 miles from Napier. Rainfall, hours of sunshine, socio-economic conditions, and racial composition of the populations are closely comparable. The reticulated water-supplies (normal fluoride content 0·15 p.p.m.) are drawn from the same artesian strata, and analyses have indicated that the normal mineral composition of the two supplies is similar (Healy, W. B., unpublished results). The cities have a common milk supply. Analyses of urine samples from Napier children have indicated that their lower caries experience is unlikely to be related to the ingestion of fluoride from fish or some unsuspected source, since the mean fluoride content of these samples was 0·15 p.p.m. (Malthus, R. S., unpublished results).

Dental examinations of Hastings and Napier children were repeated in 1957, and it was found that fluoridation at Hastings over a period of about 2½ years had reduced caries prevalence among children to approximately the same level as at Napier. To provide an additional check on the low caries experience of Napier children, dental examinations were made of children resident in the city of Palmerston North, which lies 110 miles south-west of Napier on a similar soil to that of Hastings. The results showed that, in 1957, Napier children up to the age of 10 years had a considerably lower caries experience than Palmerston North children of an equivalent age (Table 1), and that the relationship between caries prevalence in Napier and Palmerston North in 1957 was closely comparable to that between Napier and Hastings in 1954.

Both Hastings and Napier are situated on soils which are derived from similar alluvial materials. However, as a considerable area of soils in the vicinity of Napier has a recent marine history, this appears to be the most likely variable which may have influenced conditions between Napier and Hastings. To test this hypothesis, soil and vegetable samples were collected from five market gardens in the Napier area and from four in the Hastings area.

Analysis of the soils from the two areas shows little difference in total content of some twenty elements as determined by the spectrograph. Differences in soil properties such as exchangeable cations including magnesium and sodium, cation exchange capacity, carbon/nitrogen ratios, and available phosphorus, were comparatively minor in nature and probably reflect management practices of individual market gardens. Very definite differences in *p*H and per cent calcium carbonate were found. Hastings soils had *p*H's of 5·7, 6·0, 6·3, 6·7, while Napier soils had *p*H's of 6·4, 7·5, 7·7, 7·8, 8·1. The three soils with *p*H's above 7·5 contained shell fragments, and gave figures of 2–3 per cent for calcium carbonate.

The vegetables selected were potatoes, carrots, silver beet, French beans, green peas, cauliflower, cabbage, lettuce and tomatoes, since there is evidence to show that these include those most commonly used in the New Zealand diet (Cadell, P., unpublished results). The edible portions showed no marked differences in major elements, but spectrographic analysis of the ash showed some notable differences in trace elements. In general, Napier vegetables were higher than Hastings vegetables in molybdenum, aluminium and titanium, and lower in copper, manganese, barium and strontium. Typical results are shown in Table 2.

Trace elements other than fluoride have been suggested as possible factors in human caries. A high urinary selenium content, which reflects intake, has been associated with a high caries prevalence in humans by Hadjimarkos[4]. On the other hand, Ter Meulen[5], Adler and Straub[6], and Nagy and Polyik[7] have associated high molybdenum-levels in soils or in drinking water with low prevalence of caries in humans, while Adler[8] and Kruger[9] have developed a greater degree of caries resistance in rats by the administration of molybdenum during the period of mineralization of the rat molar. Stookey and Muhler[10] have reported that molybdenum increased fluoride retention in rats. Consequently, it is of considerable interest that our results showed that while molybdenum was detected in the ash of only one Hastings vegetable, it was present in that of the majority of Napier vegetables in amounts up to 9·5 p.p.m. The higher molybdenum content of Napier vegetables is attributed to its greater availability in Napier soils due in the main to higher *p*H.

At present it seems possible that a higher intake of molybdenum may be the prime factor responsible for the lower prevalence of dental caries among Napier children. However, additional studies involving these children, and extension of the investigation to animal experimentation and analysis of vegetables from home gardens, will be necessary before definite findings can be established.

A full report of this work will be published elsewhere.

The opinions expressed here are those of the authors themselves and are not necessarily those of the organizations represented.

[1] Hewat, R. E. T., and Eastcott, D. F., "Dental Caries in New Zealand", Medical Research Council of N.Z. Publication (1955).

[2] Land Utilization Report of the Heretaunga Plains. Bull. No 70, Dept. of Sci. and Indust. Research.

[3] Ludwig, T. G., *N.Z. Dent. J.*, **54**, 165 (1958).

[4] Hadjimarkos, D. M., and Bonhorst, C. W., *J. Pediatrics*, **52**, 274 (1958).

[5] Ter Meulen, H., Hand. XXVe Ned. Natuurk. Geneesk. Congr., 228 (1935).

[6] Adler, P., and Straub, J., *Acta Med. Acad. Sci. Hung.*, **4**, 221 (1953).

[7] Nagy, Z., and Polyik, E., *Fogow. Syle*, **48**, 154 (1955).

[8] Adler, P., *Odontologiai Rev.*, **8**, 202 (1957).

[9] Kruger, B. J., "The Effect of 'Trace Elements' on Experimental Dental Caries in the Albino Rat", Univ. of Queensland Papers, **1**, 3 (1959).

[10] Stookey, G. K., and Muhler, J. C., *Proc. Soc. Exp. Biol. Med.*, **101**, 379 (1959).

EFFECT OF OXYGEN ON THE INACTIVATION OF TRYPSIN BY IONIZING RADIATION

By Prof. J. A. V. BUTLER, F.R.S., and Dr. A. B. ROBINS
Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital), Fulham Road, London, S.W.3

A CONSIDERABLE number of discordant observations on the effect of oxygen on the sensitivity of enzymes to ionizing radiation is to be found in the literature. A recent extensive study of the inactivation of chymotrypsin[1] showed, somewhat unexpectedly, but in agreement with observations by Miss L. K. Mee[2], that in dilute aqueous solution the dose required to produce a given degree of inactivation was greater in the presence than in the absence of oxygen. In view of this it seemed desirable to examine the effect of oxygen on the sensitiveness of the solid enzyme, and it was found that in this case, with 15-MeV. electrons, oxygen had little effect.

In the case of a similar enzyme, trypsin, it has been reported[3] that with 2-MeV. electrons from a Van de Graaff generator, and with cobalt-60 γ-rays, the sensitiveness of the enzyme in the solid state is enhanced by oxygen by about 30 per cent. It therefore became necessary to examine further the behaviour of trypsin, to discover whether or not it behaves differently from chymotrypsin in this respect.

In the first place, experiments were carried out on dilute solutions, using techniques similar to those previously described[1]. Using 140-kV. X-rays, it was found that the degree of inactivation by a given dose was increased *in vacuo* by a factor of about 4 (Fig. 1). In the case of the solid enzyme, several series of experiments were performed, using different methods of preparing the solid phase. For accidental reasons, different sources of high-energy radiation had to be used in the various series. The results of these experiments are shown in Fig. 2. The experimental conditions are as follows:

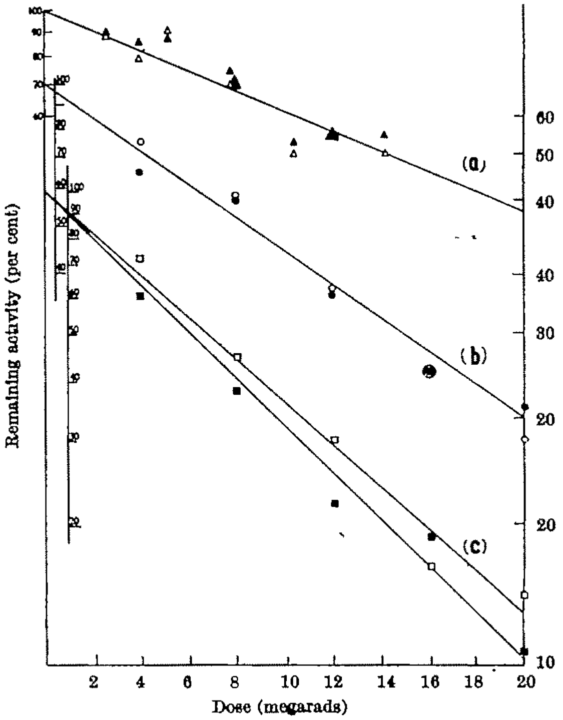


Fig. 2. Inactivation of solid trypsin by high-voltage electrons (conditions as in text). In oxygen: (*a*) △; (*b*) ○; (*c*) □. *In vacuo*: (*a*) ▲; (*b*) ●; (*c*) ■

(*a*) Trypsin films made by pumping off the water from a 1 per cent suspension of crystalline trypsin, supplied by the Worthington Biochemical Co. After the initial stage of evaporation, the liquid froze and the remaining water was pumped off. Irradiations were performed in either the 15-MeV. linear accelerator (300 rads per pulse of 1·3 × 10^{-6} sec.) at St. Bartholomew's Hospital Medical College, or the 4-MeV. (3 rads per pulse of 1·5 × 10^{-6} sec.) linear accelerator at the Mullard Research Laboratories, Salfords, Surrey.

(*b*) Crystalline trypsin in the form of a fine powder, as supplied by Worthington Biochemical Co. Irradiations carried out in the 4-MeV. linear accelerator (30 rads per pulse of 2·5 × 10^{-6} sec.) at the Wantage Radiation Laboratory of the Atomic Energy Research Establishment.

(*c*) Trypsin films made by dissolving the same trypsin in 10^{-3} *N* hydrochloric acid, freezing and pumping off the water. Irradiations as (*b*).

In all cases, when the enzyme was dry, the tubes were either sealed off *in vacuo*, after two flushings with argon, followed by evacuation to 0·05 mm. mercury pressure, or filled with oxygen and sealed. Enzyme activity was measured by Kunitz's casein method, as previously described[1].

The tubes were irradiated in pairs side by side, one evacuated and the

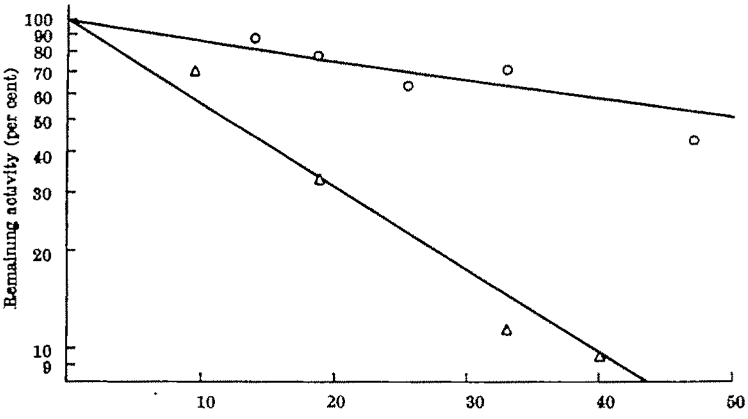


Fig. 1. Inactivation of trypsin in solution (0·028 per cent) by 140-kV. X-rays. ○, In air; △, *in vacuo*

other containing oxygen. It can be seen that in only 2 cases out of 17 did oxygen appear to increase appreciably the degree of inactivation as compared with the similar exposure *in vacuo*. (In some of the cases of series (*a*) the dosimetry appears to have been erratic, but this does not affect the conclusion stated.) In series (*c*) oxygen in fact decreased the inactivation to the extent of about 10 per cent.

It will be observed that the sensitiveness of the solid enzyme to irradiation is markedly modified by the mode of preparation in the solid film. Table 1 shows the mean values of D_{37} under the different conditions :

Table 1

Mode of preparation	D_{37} (megarads) In oxygen	 *In vacuo*
a. Film from aqueous suspension	20	20
b. Crystalline powder	11·8	11·8
c. Film from 10^{-3} *N* hydrochloric acid	9·8	8·8
d. Film with 25 per cent cysteine-hydrochloride	17·4	38

It is not clear whether these differences of sensitivity are due to changes in the state of the trypsin molecule, when treated in different ways, or to some modification of other substances present in small quantities. The initial activity of the enzyme was unaffected by these treatments. An experiment was performed to see the effect of a protective substance, cysteine, on the sensitiveness of the solid. Added in relatively large amount to the solutions of trypsin before evaporation, cysteine hydrochloride (weight ratio, cysteine hydrochloride/trypsin = 0·25) reduced the sensitiveness by a factor of 4 *in vacuo* and by only 2 in the presence of oxygen. It is therefore possible that the enhancements of sensitiveness by oxygen which have been reported were due to it reducing the degree of protection by a protective agent present.

These and the previous experiments show that, in aqueous solution at least, oxygen is capable of acting as a protective agent. Various explanations of this can be suggested ; for example, in the presence of oxygen, the primary H radicals will be replaced at least to some extent by O_2H. It is possible that O_2H is less effective than H in causing inactivation because it may react preferentially on the protein at points remote from the active enzyme centre. The effect of oxygen might therefore be to change the nature of the reaction from denaturation, which has been demonstrated in aqueous solutions[1], to a relatively innocuous oxidation. In the solid there does not seem to be any reason for expecting a similar situation. Alternatively, it is possible that oxygen, on account of its 'radical' nature, might be able to draw off the unbalanced charges present within the protein and thus localize the damage caused by them.

We are much indebted to Prof. J. Rotblat, St. Bartholomew's Hospital Medical College, London, to Messrs. T. R. Chippendale and D. R. Perry, Mullard Research Laboratory, Salfords, Surrey, and to Dr. R. Roberts and Mr. J. McCann, Atomic Energy Research Establishments, Wantage, for arranging the irradiations and for help in dosimetry.

This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research : Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

[1] Butler, J. A. V., Robins, A. B., and Rotblat, J., *Proc. Roy. Soc.*, A, (in the press).

[2] Mee, L. K., 26th Ann. Rep. British Empire Cancer Campaign, 318 (1958).

[3] Alexander, P., *Radiation Research*, 6, 653 (1957).

DISTRIBUTION AND PREVALENCE OF *FUSARIUM MONILIFORME* SHELD. (*GIBBERELLA FUJIKUROI* (SAW.) WR.) PRODUCING SUBSTANCES WITH GIBBERELLIN-LIKE BIOLOGICAL PROPERTIES

By PROF. W. L. GORDON

Plant Pathology Laboratory, Canada Department of Agriculture Research Station, Winnipeg

THE fungus *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw.) Wr.) is now generally recognized as the cause of the 'bakanæ' disease of rice (*Oryza sativa* L.) which has long been known to occur in Japan. The most characteristic symptom exhibited by diseased plants is a marked increase in height. In recent years this type of disease in rice has been reported from several other countries[1].

Kurosawa[2] first demonstrated, in 1926, that sterile filtrates of the 'bakanæ' fungus contained an active principle or growth stimulant which could cause a marked stimulation of growth in rice seedlings. Nine years later, Yabuta[3] announced that the active principle had been isolated. He gave it the name 'gibberellin' after the name of the perfect stage *Gibberella fujikuroi* (Saw.) Wr. of the 'bakanæ' fungus.

F. moniliforme Sheld. is widely distributed geographically, particularly on graminaceous plants. However, relatively few investigations have been carried out to determine if isolates of this fungus from hosts other than rice produce substances with gibberellin-like biological properties, which will be referred to in this article as 'gibberellins'. The results of the investigations published at the present time indicate that isolates of this fungus from hosts other than rice usually lack gibberellins, but occasional exceptions have been encountered. The detection of an isolate of *F. moniliforme* Sheld. possessing growth-stimulating properties has been reported by Nisikado[4], by Bugnicourt[5] and by Borrow, Bryan *et al.*[6] from sugar cane (*Saccharum officinarum* L.) ; by Nisikado and Miyawaki[7] from cotton (*Gossypium* sp.) ; and by Bugnicourt[5] from maize (*Zea mays* L.). The present investigation was undertaken to obtain additional information on the geographical distribution and prevalence of strains of *F. moniliforme* Sheld. producing gibberellins.

One hundred and five isolates of *F. moniliforme* Sheld. were included in this investigation. Of these isolates, eighty-four were classified as *F. moniliforme* Sheld., seventeen as the variety *subglutinans* Wr.

and Rg., and four as the variety *anthophilum* (A. Br.), Wr. Most of these isolates were received through the Commonwealth Mycological Institute, Kew, England; the others were received directly from research workers located in various geographical areas. The various isolates were received from time to time over the past twenty-five years. They were originally isolated from a total of thirty-five species of plants, one insect species, and from five miscellaneous substrates. They originated in twenty-nine geographical areas (Table 1).

The host plant employed for the detection of 'gibberellins' was the simple recessive mutant of *Zea mays* L., designated 'dwarf-1'. According to Phinney, West *et al.*[8] the qualitative responses of the mutant 'dwarf-1', in the seedling stage to gibberellic acid, to gibberellin A_1, and to gibberellin A_3 are similar. Seed of the mutant 'dwarf-1' was obtained through the courtesy of Dr. Bernard O. Phinney, Department of Botany, University of California, Los Angeles, California.

Before the various isolates were tested, each was established as a monosporous culture on potato sucrose agar (2 per cent agar, 2 per cent sucrose) slanted in 'Pyrex' test-tubes. Each test-tube measured 20 × 150 mm. and contained 10 ml. of the medium. The monosporous cultures were allowed to grow at least 10 days before they were employed in tests.

The various isolates were tested for 'gibberellins' by the following method. Two drops of the detergent 'Tween-20' were added to 100 ml. of sterile distilled water. 5 ml. of this solution were added to each monosporous culture. After 2 hr. the solution was decanted off into a 'Pyrex' glass vial and applied to seedlings of the 'dwarf-1' mutant with a medicine dropper. A few drops of the solution were applied in the axils of the first two seedling leaves. The seedlings were treated in this way twice a day for two days, and then were allowed to grow a further three days before final observations and measurements were made. Four seedlings were treated with the solution from each culture in each test. Seedlings were grown in flats kept on a window ledge in the laboratory in which the variation of temperature was 24°–30° C.

The growth response of seedlings treated with the extracts obtained from each of the various isolates was determined by measuring the distance from the apex of the coleoptile to the ligule of the second seedling leaf, to the nearest millimetre. The average of the measurements made on the four seedlings treated with the extract of a single isolate was compared with that of four untreated seedlings (treated with sterile distilled water with 'Tween-20' added at the level mentioned previously). The average growth response to the extracts of the various isolates tested was found to range from 0 to approximately 500 per cent greater than that of the untreated seedlings. Those isolates designated in Table 1 as being 'active' produced a growth increase more than 25 per cent greater than that attained by untreated seedlings.

It will be observed from the results presented in Table 1 that an appreciable number of the isolates produced 'gibberellins'. Thirty-five of the 105 isolates tested were rated as 'active'. Of the 35 'active' isolates encountered, 23 were classified as *F. moniliforme* Sheld., 11 as the variety *subglutinans* Wr. and Rg., and 1 as the variety *anthophilum* (A. Br.)

Table 1. GEOGRAPHICAL DISTRIBUTION BY HOST AND SUBSTRATE OF 105 ISOLATES OF *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw.) Wr.) TESTED FOR THE PRODUCTION OF 'GIBBERELLINS' ON THE MUTANT 'DWARF-1' OF *Zea mays* L.

Geographical origin	Host and substrate	Species and varieties*	No. of isolates 'active'	No. of isolates 'non-active'
Australia	*Triticum* sp.	F.m.	—	1
	Zea mays L.	F.m.s.	1	—
Canada				
Ontario	*Asparagus officinalis* L.	F.m.	1	—
	Prunus persica Batsch. rhizosphere	,,	—	1
	Zea mays L.	,,	4	4
	Zea mays L.	F m s.	3	—
	Pyrausta nubilalis (Hbn.) (insect)	,,	1	—
	Oil emulsion	F.m.	—	1
	Soil	,,	—	1
Manitoba	*Allium cepa* L.	,,	1	—
	Zea mays L	,,	2	2
Saskatchewan	*Pinus sylvestris* L.	,,	1	—
Ceylon	*Oryza sativa* L.	,,	1	—
Egypt	*Citrullus vulgaris* Schrad.	,,	1	1
	Gossypium sp.	,,	—	1
	Lycopersicum esculentum Mill.	,,	—	2
	Zea mays L.	,,	—	2
	Soil	,,	1	—
Finland	*Betula* sp.	,,	—	1
Formosa	*Oryza sativa* L.	,,	1	—
Ghana	*Zea mays* L.	,,	—	1
Honduras	Soil	,,	—	1
India	*Arachis hypogaea* L.	,,	2	—
	Ricinus communis L.	,,	—	1
	Triticum sp.	,,	—	2
	Zea mays L.	,,	—	1
Iraq	Soil	,,	—	2
Israel	*Sorghum* sp.	,,	1	—
	Zea mays L	,,	—	1
Jamaica	*Musa sapientum* L.	,,	—	1
Japan	*Oryza sativa* L.	,,	1	—
Kenya–Uganda	*Crotalaria juncea* L.	,,	—	1
	Saccharum officinarum L.	,,	—	1
	Solanum melongena L	F m a.	1	2
Mauritius	*Saccharum officinarum* L.	F m.s.	—	1
Netherlands	Culture solution	F m.	1	—
Nigeria	*Elaeis guineensis* Jacq	,,	—	2
N. Nigeria	*Pennisetum typhoideum* (L.) Rich.	,,	—	2
N. Rhodesia	*Zea mays* L.	,,	—	2
Nyasaland	*Coffea arabica* L.	,,	—	2
Pakistan	*Sorghum* sp.	,,	1	—
Portugal	*Linum usitatissimum* L.	,,	—	1
Sierra Leone	*Oryza sativa* L.	,,	1	1
South Africa	*Ananas sativus* Schult.	F.m s.	1	—
S Rhodesia	*Citrus* sp.	F.m.	—	1
	Dianthus caryophyllus L.	,,	—	1
	Nicotiana tabacum L	,,	1	—
	Zea mays L.	,,	—	2
	Zea mays L.	F.m.s	2	—
Tanganyika	*Musa sapientum* L.	,,	—	1
	Saccharum officinarum L.	F.m.	—	1
Trinidad	*Corchorus capsularis* L	,,	—	1
	Crotalaria usaramoensis E. G. Baker	,,	—	1
	Crotalaria valetonii Backer	,,	—	1
	Hibiscus esculentus L	,,	—	1
	Hibiscus sabdariffa L.	F.m s.	—	1
	Maranta arundinacea L.	F m	—	1
	Rotboellia exaltata L.	,,	—	1
	Saccharum officinarum L	F m.s.	—	1
	Sorghum vulgare Pers.	F.m.	1	2
	Urena lobata (L) Gaertn.	F.m.s.	—	1
	Zea mays L.	F.m.	—	1
	Copra	F.m a.	—	1
Uruguay	*Zea mays* L.	F.m.	—	2
United States				
Colorado	*Zea mays* L.	F.m s	1	—
Illinois	*Zea mays* L.	F m.	—	2
Minnesota	*Zea mays* L.	,,	—	1
	Zea mays L.	F.m.s.	—	1
Ohio	Sewage plant filter	F.m.	1	2
Virginia	*Zea mays* L.	F.m.s.	1	—
Washington	*Asparagus officinalis* L.	F.m.	—	1
	Hordeum brachyantherum Nevski	F.m.s.	1	—

---

* F.m. denotes *F. moniliforme* Sheld.; F.m s., the variety *subglutinans* Wr. and Rg.; F.m.a., the variety *anthophilum* (A. Br.) Wr.

Wr. Although the majority of the isolates tested gave no indication of producing 'gibberellins', a sufficiently large number of 'active' strains was obtained to demonstrate that they are present in widely scattered geographical areas, and may be encountered on a range of host plants and on other substrates. Whether strains possessing 'gibberellins' originated in one geographical area, for example, Japan, or in various areas from time to time, several factors may have influenced their dissemination. One factor that would undoubtedly play an important part in their distribution would be seed-transmission. *F. moniliforme* Sheld. can be transmitted by seed, both internally and externally on the seed surface. The introduction of infested seed into areas where *F. moniliforme* Sheld. had not occurred would provide a rapid and effective means of dissemination of the fungus, and might also serve to introduce strains capable of producing 'gibberellins'.

The results obtained from the present investigation have provided information additional to that previously reported in the literature on the host-range and geographical distribution of strains of *F. moniliforme* Sheld. which produce 'gibberellins'. It appears likely to me that if investigations are carried on in the future along this line 'active' strains of *F. moniliforme* Sheld. will be demonstrated to be even more prevalent and widespread than the results of this investigation have indicated.

[1] Stodola, Frank H., "Source Book on Gibberellin" (U.S. Department of Agriculture, 1958).

[2] Kurosawa, E., Nat. Hist. Soc. Formosa, 16, 213 (1926). (Transl. in *loc. cit.*, ref. 1).

[3] Yabuta, Y., *Agric. and Hort.*, 10, 17 (1935). (Abstr. No. 559, *loc. cit.*, ref. 1).

[4] Nisikado, Y., *Ber. Ohara Inst. Landwirtsch. Forsch.*, Kurashiki, Japan, 5 (1), 87 (1931). (Abstr. No. 316, *loc. cit.*, ref. 1).

[5] Bugnicourt, F., *Bull. Econ. de l'Indochine*, 45, 797 (1942).

[6] Borrow, A., Brian, P. W., Chester, V. E., Curtis, P. J., Hemming, H. G., Henehan, Catherine, Jeffreys, E. G., Lloyd, P. B., Nixon, J. S., Norris, G. L. F., and Radley, Margaret, *J. Sci. Food and Agric.*, 6, 340 (1955).

[7] Nisikado, Y., and Miyawaki, Y., *Nogaku Kenkyu*, 36, 417 (1944). (Abstr. No. 16909, *Biol. Abstr.*, 23; 1949).

[8] Phinney, Bernard O., West, Charles A., Ritzel, Mary, and Neely, Peter M., *Proc. U.S. Nat. Acad. Sci.*, 43, 398 (1957).

LOWER TERTIARY MICROFOSSILS FROM McMURDO SOUND, ANTARCTICA

By DR. LUCY M. CRANWELL (MRS. WATSON SMITH)
c/o Geochronology Laboratories, University of Arizona, Tucson

DR. H. J. HARRINGTON
Department of Geology, University of New England, Armidale, New South Wales

AND

I. G. SPEDEN
New Zealand Geological Survey, Lower Hutt

AN understanding of the climatic, biological and geological histories of Antarctica is important to many studies, such as those on the origin and dispersal of the floras and faunas of the southern hemisphere, on Quaternary glaciations, and on continental drift and polar wandering. Contributions have been made in reports on the Cretaceous and Tertiary sediments and fossils of the Graham Land region[1], the latest being by Cranwell[2]; but except for those reports there has been a considerable hiatus in our knowledge for the reason why Cretaceous and Tertiary fossiliferous sedimentary rocks have not been found in other parts of the Antarctic. This article records the finding of apparently Lower Tertiary sediments in the McMurdo Sound district of the Ross Sea region. The sediments are rich in microfossils, many of which have not been found previously in regions south of Australasia.

Structural considerations suggested to geologists of the New Zealand Geological and Survey Antarctic Expedition, 1958–59, that Cretaceous and Tertiary sedimentary rocks, similar to those of other circum-Pacific lands, could be expected to occur beneath the floor of the Ross Sea, and beneath the ice-sheet covering the greater part of Marie Byrd Land. It was plain that if rocks of those ages occurred they would not be accessible to direct geological observation, being hidden beneath the sea and ice, but it was considered that fragments of them might have been carried by ice to moraines in the McMurdo Sound region and to sea-floor deposits in the Ross Sea. Cretaceous or Tertiary sediments had not been found in the moraines by geologists of the Scott and Shackleton expeditions early in this century, but new searches were made at several localities. At Minna Bluff and White Island, Harrington and Speden, working independently, found in the moraines fragments of light-coloured fine-grained calcareous sediments which were immediately compared with certain distinctive sediments deposited in New Zealand during a marine transgression which occurred between the Late Cretaceous and the Oligocene[3,4]. They particularly resemble some units of a widespread calcareous mudstone facies, of which representatives are the Burnside Mudstone and parts of the Amuri Limestone[5]; and it is very doubtful if they would have been considered significant, or even noticed, but for this resemblance. The collectors naturally considered, therefore, and with considerable confidence, that their samples would be about Late Cretaceous or Lower Tertiary in age, and probably in the Upper Eocene–Oligocene part of that range, but others were sceptical and considered that they could have been derived from some of the finer-grained beds of the Upper Palæozoic and Lower Mesozoic Beacon Sandstone Formation[6,7]. Some specimens contain minute shell fragments, and one contains a fragment identified by Speden as part of a worm tube (? *Rotularia* sp.), which is not of value in age-determination (specimen *MS* 29, 7505*A*, New Zealand Geological Survey collections).

Afterwards, Mr. G. H. Scott, New Zealand Geological Survey, identified poorly preserved Foraminifera representing four genera in 7505*A*, a light-grey sandy mudstone from Minna Bluff. He states that "little can be said with confidence about the age of

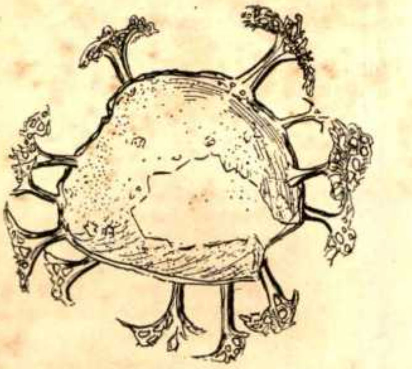


Fig. 1. *Hystrichosphaeridium* sp. from a mudstone fragment in a Minna Bluff moraine. Diameter, including appendages, about 100μ. This form has strong affinities with the *H. complex* group

the sample. In New Zealand *Angulogerina* of the type found in it does not occur prior to the Whaingaroan (Lower Oligocene); elsewhere the genus has Eocene representatives of the type discussed here, for example, *multicostata* Berquist from the American Jackson Formation, but Paleocene representatives seem to be lacking. It is probably correct to regard the *Angulogerina* of this fauna as indicating a post-Paleocene age. The occurrence of *Globoquadrina*, if correctly identified, would reinforce this age assignment, as this genus first appears in the Oligocene in New Zealand (Waitakian) and Australia".

The results obtained by Mr. Scott were not conclusive, but strongly supported the opinion held by Harrington and Speden, on lithological evidence, that the specimens are younger than Upper Palæozoic or Lower Mesozoic, and close to Eocene or Oligocene in age.

Fragments of specimens 7505 and 7505*A* were sent to Cranwell, and a small pollen component was recovered along with a wealth of hystrichosphaerid (Fig. 1) and dinoflagellate forms. Further study will be needed before adequate comparison can be made with the Australian and New Guinea microplankton described since 1953 in the pioneer researches of Cookson, Deflandre and Eisenack[8-11], and correlated by them, in some cases, with European finds in particular. At present it appears that faunal and floral elements point to some Cretaceous, or earlier, admixture, but much of this may be traced to redeposition, or to misinterpretation caused by our lack of knowledge of the time-range of hystrichosphaerids recorded solely, or with few exceptions, from the Cretaceous or earlier. Only in 1958 did Cookson and Eisenack begin to report Tertiary occurrences for some of these key Mesozoic forms.

The pollen grains are few in number but well preserved, though tending to stain lightly; they belong to groups already known at Seymour Island[3] from macrofossil and microfossil remains; but none of the types so far recognized is identical. No fern spores, no fungi, no cuticles and only a few tracheids (single broken shreds) were found. Species of southern beech (*Nothofagus*) predominate (Fig. 2), and there are ties, on one hand, with New Guinea, Australia, New Caledonia and New Zealand forms, either fossil or living, and on the other, a link, stronger than in the Seymour Island material, with certain characteristic South American forms. The conifers occur in lower frequencies and their types have not yet been sorted out to our satisfaction. Palmoid and proteaceous types occur, and a few others have been noted. The microplankton contains plani-spiral microforaminifera, and there are a few fragments which suggest alcyonarian spicules.

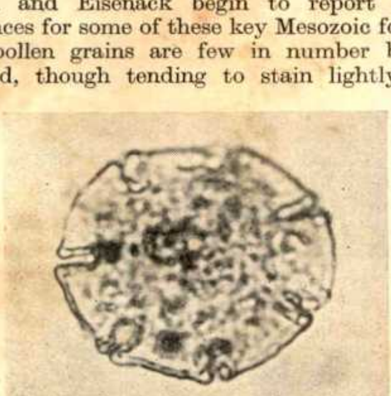


Fig. 2. Pollen-grain of *Nothofagus* sp. from a mudstone fragment in a Minna Bluff moraine. Diameter about 26μ

Dating of the pollen cannot yet be fixed: it is not likely to have originated earlier than the mid-Cretaceous, judging by work done in New Zealand by Couper[12], and it is probably not as recent as the Miocene cooling in the Graham Land region described by Adie[1]. As in the Seymour Island material, the pollen absences (for example, Compositae) might be taken to eliminate Miocene possibilities, but it must be remembered that the assemblage can only be a weak representative of the original communities since large grains, and insect-pollinated types, are less fitted to travel great distances in air currents, and we have here no suggestion of carriage by muddy rivers. The total evidence, of course, tends to indicate an age between the Late Cretaceous and the Oligocene, as indicated by the lithology, and the Foraminifera recorded by Mr. Scott.

The low frequencies—only a few grains per slide—and the restriction to small wind-pollinated types (mainly less than 35μ), coupled with the wealth of hystrichosphaerid and dinoflagellate remains, strongly indicate settling in offshore waters of normal salinity and low turbidity (cf. Orinoco Delta deposits described by Muller[13]) and at some distance from the land areas where temperate forests yielded the pollen rain. These conditions could well be matched during a marine transgression across a shallow continental shelf bordering a low, easily flooded land-mass, or by the existence of shallow marine troughs between island groups in a time of base-levelling and relative tectonic calm. It is conceivable, by comparison with New Zealand and other circum-Pacific lands, that island groups and marine troughs existed that were precursors of the ridges and depressions discovered buried beneath the ice of the Ross Sea–Weddell Sea region, as the result of a magnificent series of traverses by United States seismic-sounding parties[14].

In addition to the notes already given, we wish to stress that these are the first records, so far as we can ascertain, of dinoflagellates, hystrichosphaerids, microforaminifera, scolecodonts (annelid jaws: very rare), ? alcyonarian spicules, pollen, tracheids and spores (undetermined) from this area, and the first fossil occurrences of several of these groups south of Australasia.

Thanks are extended to the United States Navy for transport to Antarctica and localities in the Ross Sea region; to Messrs. A. C. Beck, E. B. Fitzgerald and other members of the expedition for co-operation in the field work under arduous conditions and for sharing notes and views; to Mr. G. H. Scott, New Zealand Geological Survey, for his work on the Foraminifera; and to Prof. Terah Smiley and his staff at the Geochronology Laboratories, University

of Arizona, and particularly to Mr. Bernard C. Arms for running our unpromising samples by a new silica depressant method[15].

[1] Adie, R. J., *Polar Record*, **8**, 502 (1957); **9**, 3 (1958).

[2] Cranwell, Lucy M., *Nature*, **184**, 1782 (1959).

[3] Grindley, G. W., Harrington, H. J., and Wood, B. L., *New Zealand Geol. Surv. Bull.*, n.s., 66 (1959).

[4] Hornibrook, N. de B., and Harrington, H. J., *New Zealand J. Sci. Tech.*, B, **38**, 657 (1957).

[5] Fleming, C. A., *Lex. Strat. Internat.*, **6** (4), (1959).

[6] David, T. W. E., and Priestley, R. E., Rep. Sci. Invest. Brit. Antarct. Exp. 1907–09, Geology, 1 (1914).

[7] Harrington, H. J., *Nature*, **182**, 290 (1958).

[8] Cookson, Isabel C., *Mem. Nat. Mus. Vict.*, **18**, 107 (1953).

[9] Deflandre, G., and Cookson, I. C., *C.R. Acad. Sci., Paris*, **239**, 1235 (1954).

[10] Deflandre, G., and Cookson, I. C., *Austral. J. Marine and Freshwater Res.*, **6**, 242 (1955).

[11] Cookson, Isabel C., and Eisenack, A., *Proc. Roy. Soc. Vict.*, **70** (n.s.), **19** (1958).

[12] Couper, R. A., *New Zealand Geol. Surv. Pal. Bull.*, **22** (1953).

[13] Muller, J., *Micropal.*, **5**, 1 (1959).

[14] Bentley, C. R., Crary, A. P., Ostenso, N. A., and Thiel, E. C., *Science*, **131**, 131 (1960).

[15] Arms, B. C., *Micropal.* (in the press).

AGE OF EMPLACEMENT OF GRANITES

By Dr. W. COMPSTON, Dr. P. M. JEFFERY and G. H. RILEY

Department of Physics, University of Western Australia, Nedlands, Western Australia

RADIOACTIVE age determinations are usually made on the separated mineral components of a rock rather than on the whole rock itself, and the age of emplacement of the latter, regarded as the time at which the various radioactive elements first became fixed into different mineral species, is then inferred from the ages of the minerals. This procedure is valid only when at least one of the minerals has remained a closed chemical system since first crystallization. As there is no independent means of recognizing a closed system, it becomes necessary in practice that the ages of all constituent minerals should agree before much confidence can be placed in any inferred age of emplacement. Even with this stipulation, the result is not conclusive, since it will also be met by the minerals of a completely recrystallized rock.

Several instances[1,2] have been reported in metamorphosed granitic rocks in which biotite yields a lower rubidium–strontium age than microcline, and each mineral in addition possesses different potassium–argon and rubidium–strontium ages; one case[3] was recently cited of a microcline which lost radiogenic strontium during metamorphism. The age of rock emplacement in such cases becomes less and less founded on verifiable fact, and some alternative means of determining this age is most desirable.

The fact that in some cases mineral grains are evidently open chemical systems does not necessarily mean that the rock as a whole must also be an open system. This was considered by Schreiner[4], who found experimentally that 'total rock' ages by the rubidium–strontium method were in reasonable agreement with pure mineral ages for the red granite of the Bushveld Complex. We have recently analysed total rock samples of a metamorphosed granite and associated pegmatites from Mundaring, Western Australia, in which pegmatitic muscovite and microcline were the only minerals to retain an old rubidium–strontium age. Although each total-rock sample was found to possess a different ratio of rubidium to strontium, they all gave the same age for a unique value of the ratio initial strontium-87/strontium-86, which was also the age given by the muscovite. We believe that this figure is the age of emplacement of the granite, and that total-rock analysis represents both the simplest and least ambiguous method of determining this age.

Analytical results for five total-rock and four mineral samples are listed in Table 1. The quantities directly measured for each sample are the present-day ratio strontium-87/strontium-86, using an unspiked aliquot of the sample in solution, and the ratio rubidium-87/strontium-86 by isotope dilution using other aliquots. (We find that calculation of the ratio strontium-87/strontium-86 from spiked strontium data is unreliable for samples rich in common strontium, due to variability in the ratio strontium-88/strontium-86 in the sample, and to enhanced magnification of mass-spectrometric random errors.) From the expression:

$$\text{Age} \simeq \frac{^{87}\text{Sr}^*}{\lambda\,^{87}\text{Rb}} = \frac{^{86}\text{Sr}}{\lambda\,^{87}\text{Rb}}\left[\left(\frac{^{87}\text{Sr}}{^{86}\text{Sr}}\right)_{\text{present}} - \left(\frac{^{87}\text{Sr}}{^{86}\text{Sr}}\right)_{\text{initial}}\right]$$

where $^{87}\text{Sr}^*$ denotes radiogenic strontium and λ the decay constant of rubidium-87, it may be seen that the ratio $\lambda\,^{87}\text{Rb}/^{86}\text{Sr}$ has been the time-rate of change (approximately) in the ratio $^{87}\text{Sr}/^{86}\text{Sr}$ of the sample for whatever period it has remained a closed chemical system. The term $(^{87}\text{Sr}/^{86}\text{Sr})_{\text{initial}}$ denotes the ratio for the system at the time it was generated: it constitutes in fact another unknown quantity besides age in the rubidium–strontium method. Mathematically, however, we may at first avoid attaching physical significance to this term by regarding it as the independent variable in an equation

Table 1

Mineral Data and Ages

	Rubidium (p.p.m.)	Common strontium (p.p.m.)	Radiogenic strontium (p.p.m.)	Age (m.yr.)
Muscovite from pegmatite	1,834	5·8	19·8	2,700
,, ,,	2,163	5·3	23·2	2,690
Microcline from pegmatite	1,125	27·8	10·3	2,300
Biotite from pegmatite	1,309	6·5	3·43	670
Micromuscovite from granite	501	144	5·48*	2,730

* Based on a strontium-87/strontium-86 ratio initially 0·70. Ages calculated using rubidium-87 decay constant of $1·386 \times 10^{-11}$ yr.$^{-1}$.

Total-rock Data

	Rubidium (p.p.m.)	Total strontium (p.p.m.)	^{86}Sr/^{87}Rb	^{87}Sr/^{86}Sr
Granite 1	165·5	129	0·266	0·842
Granite 2	186	129	0·236	0·864
Granite 3	226	106	0·157	0·945
Biotite–pegmatite	194	71	0·122	1·010
Muscovite–pegmatite	331	21·4	0·018	2·85

for age. The straight lines as given by the above expression have been plotted for each sample in Fig. 1. They converge very distinctly to the region:

$$^{87}Sr^*/^{87}Rb = 0{\cdot}0383\ ;\quad ^{87}Sr/^{86}Sr = 0{\cdot}700$$

On the assumption that the strontium throughout this granite was initially uniform in isotopic composition, it may be inferred now that: (i) each total rock sample has indeed remained a closed system with respect to rubidium and strontium back to the point in time defined by these co-ordinates; (ii) the variable ratio of strontium to rubidium is due to an initial inhomogeneity in the granite; and either (*iiia*) the age corresponding to this point, 2,700 m.yr., is the age of emplacement of the granite, or (*iiib*) 2,700 m.yr. is the age at which all earlier formed radiogenic strontium in the system diffused out from the rubidium-rich minerals and became completely mixed with common strontium throughout the granite. In either case, the ratio strontium-87/strontium-86 of the system at this time was 0·700 throughout.

The alternatives in inference (iii) simply represent the fundamental ambiguity in radioactive age determinations mentioned initially, which is present even in a rock, the minerals of which all give the same age as the whole-rock samples. However, in the future it may be possible to eliminate one of these alternatives by considering the absolute value of the ratio strontium-87/strontium-86 at the point of concurrence. Meteoritic strontium, the strontium-87/strontium-86 ratio of which is about 0·685 (ref. 5) presumably represents the source from which the present-day common strontium of the crust evolved. If the value of the latter is approximately 0·715 (a little greater than the average present-day ratio in basic igneous rocks as measured in this laboratory), and if its evolution has been approximately linear with respect to time, then a granite formed from average crustal strontium 2,700 m.yr. ago should possess an initial strontium-87/strontium-86 ratio of about 0·700. This in fact is the value found above, so that the granite total-rock age could be interpreted on this picture specifically as the age of emplacement. However, the assumptions concerning the sampling and evolution of crustal strontium, though reasonable, have not yet been substantiated experimentally.

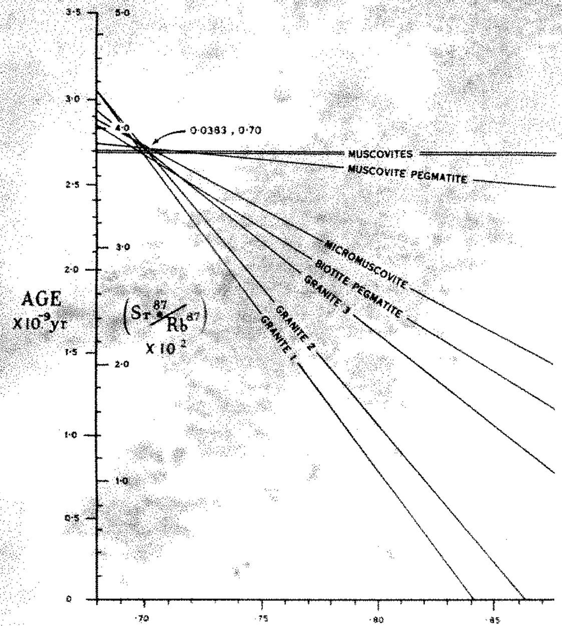


Fig. 1

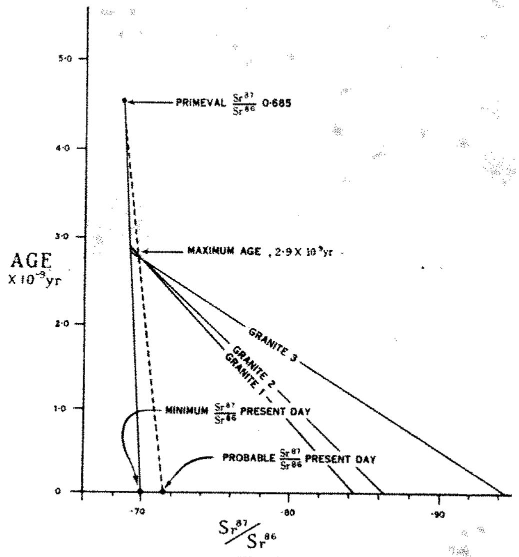


Fig. 2

In any event, it is possible still to set an upper limit to the age of the granite, if it was formed directly or indirectly by some process of differentiation from mantle material. Taking 0·700 as the value of the ratio strontium-87/strontium-86 for the present-day mantle, and again assuming a linear evolution of this ratio from primeval strontium, then the maximum age of the granite becomes 2,900 m.yr. (Fig. 2). Even in the most unlikely case that essentially primeval strontium was incorporated with the granite, its age still could be no greater than about 3,000 m.yr.

One further result follows if 2,700 m.yr. is taken as the age of emplacement of the granite. Fig. 1 shows that the pegmatites also have this age, thereby confirming the widely held premise that pegmatites can form immediately on the solidification of a granite.

Finally, as regards the ages of the mineral, we wish to emphasize that none of the potassium feldspars from these granitic rocks exhibits complete preservation of the 2,700 m.yr. event. Pegmatitic microcline comes closest at 2,300 m.yr., whereas granitic microclines show any 'age' down to about 650 m.yr., which is also the age registered by all biotites. Pegmatitic muscovite and micromuscovite, formed in the granite during saussuritization of the plagioclase feldspar, alone show complete retention. The latter shows, incidentally, that saussuritization was definitely a late-stage magmatic process in this case.

Full details of these age determinations will be reported elsewhere. We are grateful to Dr. A. F. Wilson and Mr. I. Martin, of the Department of Geology, for helpful discussion and practical assistance, and to the Research Grants Committee of the University of Western Australia for financial support.

[1] Tilton, G. R., Wetherill, G. W., Davis, G. L., and Hopson, C. H., *Bull. Geol. Soc. Amer.*, **69**, 1469 (1958).

[2] Long, L. E., Kulp, J. L., and Eckelmann, F. D., *Amer. J. Sci.*, **257**, 585 (1959).

[3] Compston, W., and Jeffery, P. M., *Nature*, **184**, 1792 (1959).

[4] Schreiner, G. D. L., *Proc. Roy. Soc.*, A, **245**, 112 (1958).

[5] Schumacher, E., Proc. Second Conf. "Nuclear Processes in Geologic Settings", Pub. 400, National Research Council, Washington, D.C. (1956).

LETTERS TO THE EDITORS

GEOPHYSICS

A Telemetered Seismic Net in Tasmania

Work during the past eighteen months towards the establishment of a telemetered seismic net in Tasmania has involved research in which electronics and seismology have been brought into close contact. Information about the net itself will be published in detail elsewhere, but the purpose of this communication is to describe new ideas which have arisen from contact between the two fields. The developments have followed two lines. First, the application of electronic amplifiers and the principles of feedback servomechanisms to the design and construction of seismographs. Secondly, and perhaps more important, has been the consideration of problems in observational seismology from the point of view of information theory as the problem of extracting a message from a noisy background. This, by analogy with other fields, has led to the consideration of methods whereby the discrimination of seismographs against background noise could be improved.

Our electronic seismograph uses a transducer with variable reluctance, but with an a.c. magnet; the output then consists of amplitude-modulated alternating current which is easy to amplify and telemeter. The response of the seismograph can be readily controlled by feeding back to the pendulum, in the correct proportion, the demodulated output of the amplifier together with its derivative and integral. For example, Fig. 1 shows the performance of conventional seismographs as given by Willmore[1], to which we have added for comparison the performance of our seismograph.

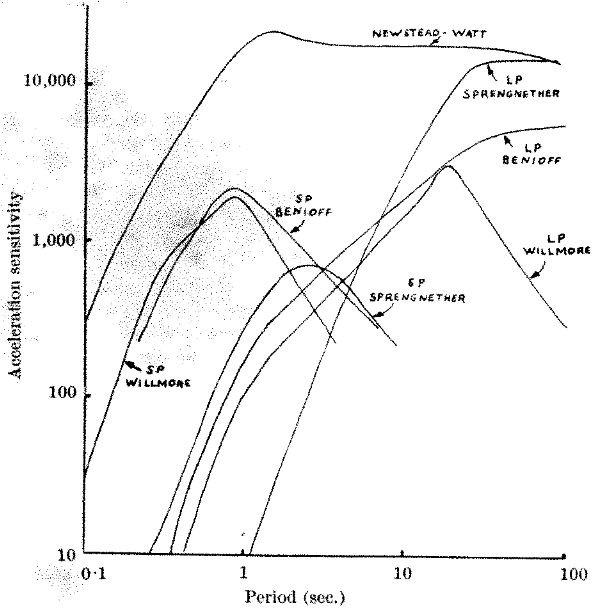


Fig. 1. Diagram showing performance of conventional seismographs given by Willmore (ref. 1) to which we have added for comparison the performance of the a.c. seismograph

With the particular combination of feedback used, it will be seen that it acts as an accelerometer between 1 and 100 sec., and its response is above the envelope of the performance shown for the conventional seismographs. Now that the performance is well under control, the question arises as to the best way to adjust it for various purposes. Seismologists have traditionally thought in terms of periods and damping, and various adjustments[2] are used for particular instruments, most of which are highly resonant. As shown, our seismograph has been adjusted as a broad-band accelerometer; this, however, is purely for comparison and it could equally well be adjusted in other ways. The problem of what characteristics it should in fact have to obtain optimum performance depends on the statistics of the signal and the message, and these have received only scant study by seismologists. For the present, therefore, we propose to record the whole of the information contained in the band and experiment with filtering and other processes on the record itself. Provided that external noise is the factor which limits the performance, this procedure will not affect the signal-to-noise ratio in the recorded information.

Willmore[3] has considered the limitation of sensitivity in seismographs which do not use amplifiers. If amplifiers are used, then the limitations he has discussed do not apply—the absolute level of sensitivity shown in Fig. 1 was arbitrarily chosen for the purpose of comparison, and it could be increased by several orders of magnitude if required. When sensitivity is not the limiting factor, the signal-to-noise ratio becomes apparent as the limit of resolution, and it is necessary to consider various noises. Seismologists do not appear to have adopted standard methods of specifying ground movements, although the displacement of the ground is often quoted in microns. Without a more complete knowledge of the spectrum, this is not very useful for comparing instruments which are to be used at other frequencies, and in what follows we shall mean the equivalent displacement of the ground in microns at 1 c./s., the figures given being orders of magnitude only. Background ground movement depends on the site and the particular day, and may range from 0·1 to 10 microns. In our seismograph, amplifier noise corresponds to a minimum detectable signal of 10^{-5} micron. This should be increased by an unknown amount to take account of Barkhausen noise in the transducer. We have not been able to estimate the amount of this noise, but indications are that it is very small. There remains finally the ultimate limit of seismometry—the Brownian motion of the pendulum—which we roughly estimate for our seismograph to correspond to a signal of less than 10^{-5} micron.

At present, background noise predominates; but preliminary experiments conducted in Hobart suggest that noise recorded at sites separated by a few miles is largely uncorrelated. If this is so, it will be possible to resolve discrete signals out of the background by measuring the correlation between signals received at different sites. This idea was developed for radio astronomy, and although the techniques are more difficult in the seismic case they are still possible. We are designing and propose to construct a correlation machine to measure in pairs the correlation between the records of the various stations in our net.

Initially we are using pen-and-ink recording on paper; however, we are working simultaneously on an arrangement using magnetic recording on tape with electronic reduction of the information. The magnetic recording will be done at tape speeds of ¼ in. per sec. and replayed at much higher speeds. This will reduce the time of interpreting the records, and by raising the significant frequencies will make filtering and other analogue operations on these signals much easier. For example, it will be possible immediately to obtain the spectra of various natural and artificial seismic events from the tape recordings, and also to produce records from the broad-band recordings identical with those which would have been produced by highly resonant seismographs located in the band. Eventually, it will be possible to produce tapes which can be fed into digital computers for processing in various ways.

We wish to acknowledge the help provided by Prof. S. Warren Carey, professor of geology in the University of Tasmania, who initiated the idea ofthe telemetered net and who has also provided many helpful discussions and ideas.

GORDON NEWSTEAD
P. A. WATT*

Department of Electrical Engineering,
University of Tasmania, Hobart.

* General Motors Holden Research Student.

[1] Willmore, P. L., *Bull. Seis. Soc. Amer.*, **49**, 99 (1959).

[2] Jeffreys, H., and Jeffreys, B. S., "Methods of Mathematical Physics", 248 (Cambridge, 1956).

[3] Willmore, P. L., *Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **6**, 129 (1950).

METEOROLOGY

Sodium/Potassium Ratio in Rain-water

DR. B. C. V. ODDIE has commented[1] on a portion of my recent article "Surface of the Ocean as a Source of Air-Borne Nitrogenous Material and Other Plant Nutrients"[2] with particular reference to the sodium/potassium ratio in rain-water. In this article I presented results of the analysis of New Zealand snows and proposed that there exists on the surface of the ocean a very thin layer which is rich in potassium, nitrogenous material and other substances as a result of the activities of micro-organisms. It was suggested that portions of this layer are transferred to the atmosphere by the bursting of bubbles in 'white caps' and thence to the land. I referred to the fact that the sodium/potassium ratio in rain is often markedly lower than that in bulk sea-water and suggested that the excess potassium was coming from the surface layer described above. Oddie directs attention to the fact that the low sodium/potassium ratios commonly recorded at inland collecting stations are scarcely ever observed at exposed coastal stations in Europe and North America and states that in general the more maritime the situation of a station the more closely does the ratio approximate to that of sea-water (that is, 27). He makes reference to results from the Shetland Islands. Oddie further states, however, that this is evidence against my suggestion, at least for European and American rains.

Table 1. SODIUM/POTASSIUM RATIOS OF COASTAL NEW ZEALAND SNOWS

	Distance from sea (miles)	Sodium (p.p.m.)	Potassium (p.p.m.)	Sodium/potassium
Snow collected May 3, 1958, on Mt. Egmont at 6,000 ft.	20	0·68	0·24	2·8
Snow collected April 27, 1958, on Tasman Glacier at 7,000 ft.	25	0·20	0·18	1·1
Snow collected August 22, 1958, at Temple Basin, Arthurs Pass, at 5,000 ft.	30	0·04	0·02	2
Sea-water		11,000	410	27

In the case of snows (Table 1) collected close to the sea on the west coast mountains of New Zealand the potassium must come from the ocean as there is no industry or for that matter land to act as its origin. In the case of the European and North American rains the problem perhaps is complicated by fuel combustion, industry, etc., and it is not possible for me to say how much of the excess potassium comes from the ocean or from other sources. However, Oddie is scarcely justified in ruling out my hypothetical mechanism as a source of some of the excess potassium in European rains on the evidence that the sodium/potassium ratio approaches 27 as one approaches an exposed coast. In such considerations one must rather consider the total amount of potassium deposited each year. To illustrate this, let us take Oddie's own example of Sweden[3]. The yearly integrated sodium/potassium ratio decreases from 10 on the coast to 1·7 at 200 km. from the sea. If instead the potassium deposited per annum is taken it is seen to be[3] 3·8 kgm./har. on the coast dropping to 2·4 kgm./har. 200 km. inland. The high sodium/potassium ratios on the coast are caused not by low potassium deposition but by high sodium deposition due probably to wind-blown bulk sea-water. On the coast in New Zealand this can be very great (near Wellington airport (Rongotai), for example, 210 lb./acre/yr. of chlorine are deposited[4]); this will raise the sodium/potassium ratio toward that of bulk sea-water. This effect (as does the sodium/potassium ratio) drops off rapidly with distance, presumably due to the large size of the wind-blown sea-water drops. In my discussion of the snow analyses[2] I corrected for the "wind-blown sea-water effect" by considering only "the excess potassium" which was defined thus:

excess potassium ion concentration = potassium ion concentration − 1/27 sodium ion concentration

Nevertheless one can, as is seen from Table 1, obtain snow samples near the coast with sodium/potassium ratios as low as 1–3 which Oddie claims are only found at inland collecting stations. It should be noted, however, that these were all taken at high altitudes, and it is possible that the heavier wind-blown bulk sea-water salt does not reach these altitudes. Another point is that in collecting fresh snow one obtains the precipitations of only an hour or so, whereas if samples of rain-water are collected over relatively long periods (weeks) an integrated value is obtained. Thus any period of high wind will deposit wind-blown bulk sea-water and so raise the average sodium/potassium ratio of the rain. I would suggest that individual rain showers be collected over short periods of time (for example, ½ hr.) at the European coastal stations in question (for example, Lerwick). It seems probable that some of these (collected on days with no high wind) will give sodium/potassium ratios approaching those of inland stations.

A. T. Wilson

Victoria University of Wellington,
Wellington,
New Zealand.

[1] Oddie, B. C. V., *Nature*, **184**, 1791 (1959).
[2] Wilson, A. T., *Nature*, **184**, 99 (1959).
[3] Emanuelsson, A., Eriksson, E., and Egnér, H., *Tellus*, **6**, 3, 261 (1954).
[4] Blackmore, L. C., *N.Z. J, Sci. and Tech.*, **35**, 193 (1953).

PHYSICS

Velocity of Light in a Magnetic Field

One consequence of classical electromagnetic theory is that the velocity of light *in vacuo* should be unaffected by superposed magnetic or electric fields; this conclusion is worth checking experimentally whenever a sufficient advance occurs in precision of observation. As regards the constancy of the velocity of light through a vacuum in the presence of a transverse magnetic field, the most precise observations higherto made are probably those of Banwell and Farr[1]. These investigators showed in 1940 by an interferometric technique with photoelectric recording that in a field of 20,000 oersted the change of velocity, if it existed, was unlikely to be much more than an increase of about 30 cm./sec.; their probable error was about 18·6 cm./sec.

Recent developments[2] in the photoelectric detection of small deflexions of a beam of light have made it possible to look for deviations of such a beam when passing through a transverse magnetic field shaped to resemble an optical prism; this shape of field was first applied by Rabi[3] to improve the accuracy of the Stern–Gerlach technique.

The photoelectric detection system has a root-mean-square error of about $1{\cdot}4 \times 10^{-11}$ radian for a bandwidth of 1 cycle/sec.; it has been used to look for deviations of the light beam when a field of about 8,000 oersted is switched on and off for alternate 10-sec. periods. By taking 400 observations, giving a total observing time of about 8,000 sec., the error in comparing the directions of the light beam before and after passage through the prismatic field has been reduced to a root-mean-square value of $5{\cdot}5 \times 10^{-13}$ radian. The average change in direction actually found was $1{\cdot}8 \times 10^{-13}$ radian, away from the apex of the prism; since this was only about one-third of the root-mean-square error, we may conclude that no significant deflexion was observed. For nearly one-half of all the observations, unpolarized white light was used; in the remainder, the same light was plane polarized, with its electric vector first parallel to the magnetic lines of force, and afterwards at 45° to this direction.

The effective prism angle was about 100°; the angular root-mean-square uncertainty of $5{\cdot}5 \times 10^{-13}$ radian therefore corresponds to a root-mean-square uncertainty in the constancy of velocity (or of refractive index of the magnetic field) of about 2·3 parts in 10^{13}. Should the velocity of light be subject to a simple change by as much as 100 micron/sec. in a transverse field of 8,000 oersted, the change ought to have been detected.

While this negative result may have little consequence, the figures indicate that optical deflexion measurements by photoelectric methods can be comparable in precision with maser experiments[4] and Mossbauer techniques[5].

R. V. Jones

Department of Natural Philosophy,
Marischal College,
Aberdeen.

[1] Banwell, C. J., and Farr, C. C., *Proc. Roy. Soc.*, A, **175**, 1 (1940).
[2] Jones, R. V., and Richards, J. C. S., *J. Sci. Instr.*, **36**, 90 (1959).
[3] Rabi, I. I., *Nature*, **123**, 163 (1929).
[4] Cedarholm, J. P., and Townes, C. H., *Nature*, **184**, 1350 (1959).
[5] Moon, P. B., *Nature*, **185**, 427 (1960).

'Prize': a Pre-ionized 'Theta' Pinch

Work has recently begun here on an experiment designated 'Prize'.

'Prize' is an electromagnetic shock-tube using pre-ionization in the Z direction followed by a theta pinch; its main function is to form a high-temperature plasma in deuterium gas by shock heating[1] without the ubiquitous trapped magnetic field usually associated with theta pinches and described elsewhere[2,3].

In the conventional theta pinch the magnetic field is able to penetrate the cold gas before the initial formation of the current sheet. This trapped magnetic field reduces the temperature of the imploding shocked gas since work is done in compressing it; the field also gives rise to instabilities on the second half-cycle of the discharge[3]. In earlier experiments at Foulness other methods of eliminating trapped magnetic field were tried including the use of a d.c. bias magnetic field to cancel out the trapped field and also plasma injection using a Kolb type '*T*' tube. In 'Prize' a thin annular cylinder of high-conductivity plasma is formed by a linear pinch before the azimuthal currents in the theta piece set up a longitudinal magnetic field. The magnetic piston set up by the currents in the theta piece then drives the thin annular current sheet towards the axis of the shock tube and, due to the high conductivity of the initial pinch, the diffusion of magnetic field into the plasma is considerably reduced.

Figs. 1 and 2 show the geometry of 'Prize'. The linear Z pinch is set up between the annular electrodes at each end of the quartz tube; the 'backstrap' required to form the initial axial current discharge near the walls of the discharge tube, at the point of minimum inductance, is the thin slotted copper cylinder on the outside of the tube. The cylinder is,

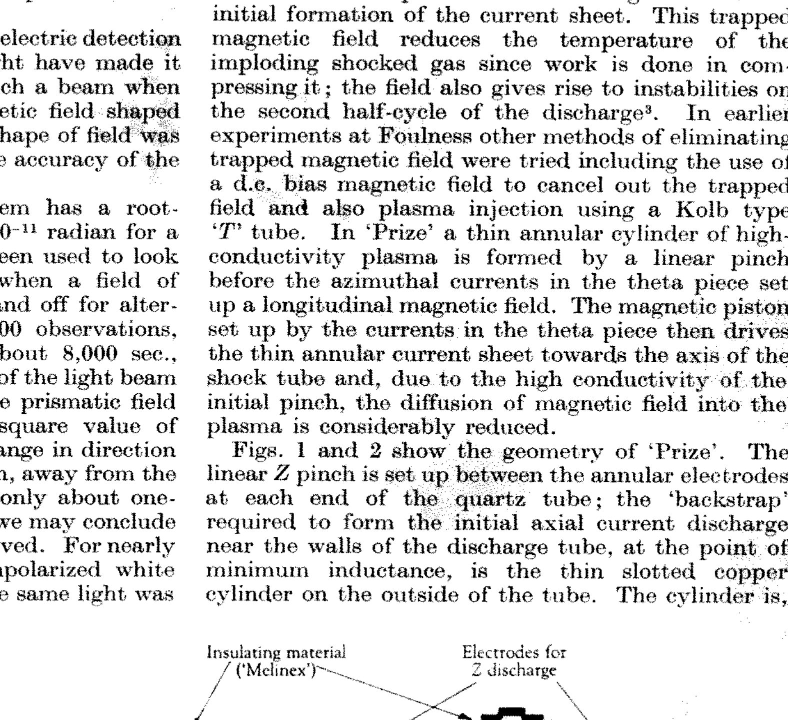


Fig. 1. Cross-section of 'Prize'

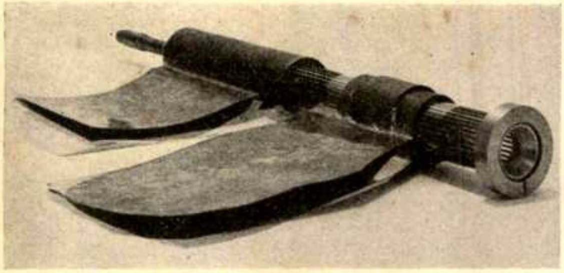


Fig. 2. 'Prize'

of course, slotted to allow the magnetic field set up by the theta piece to penetrate into the quartz tube.

Fig. 3 shows a schematic diagram of the circuitry associated with 'Prize'. Switching has been designed so that the linear pinch does not move appreciably before the theta voltage is applied. The switching arrangement is a simple but effective explosive sandwich layer consisting of three copper strips separated by 'Melinex', the order of the strips being, from top to bottom, Z live, common earth, theta live with the explosive uppermost. This ensures that the theta voltage is applied approximately 0·1 μsec. after the Z voltage.

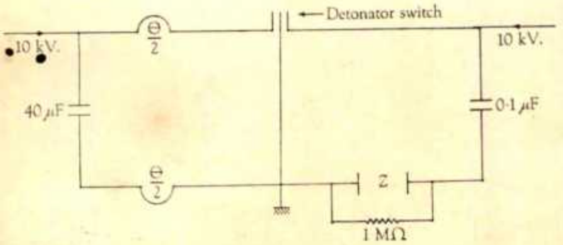
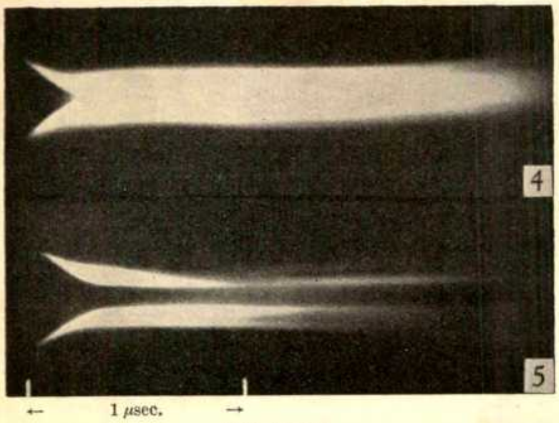


Fig. 3. Schematic diagram

Our early experiments have been concerned with the synchronization of events, and for this purpose we have used convenient values of voltage, 10 kV., and stored energy, theta 2 kilojoules, Z pinch 5 joules, and a theta piece consisting of a single copper turn. Figs. 4 and 5 show streak camera records (radius time curves) of the motion of the shock fronts for 'Prize' fired with and without the Z pre-ionization and an initial deuterium pressure of 1 mm. Fig. 4 shows no trapped magnetic field with a completely converging shock system on the first half-cycle of the theta discharge and Fig. 5 appreciable trapped magnetic field.



Figs. 4 and 5

We are now entering the second phase of the experiment in which we intend to apply more energy to a Scylla[4] type theta piece.

R. D. Medford
A. L. T. Powell
J. D. Herbert
R. C. Pottinger
J. K. Wright

Atomic Weapons Research Establishment,
Foulness,
Southend-on-Sea,
Essex.

[1] Wright, J. K., *Proc. Phys. Soc.* (in the press).

[2] Wright, J. K., Eeles, W. T., and Herbert, J. D., *Nature*, **183**, 1665 (1959).

[3] Bodin, H. A. B., Green, T. S., Niblett, G. B. F., and Peacock, N. J., Proc. Fourth Intern. Cong. on Ionization in Gases, Uppsala (1959).

[4] Elmore, W. C., Little, E. M., and Quinn, W. E., *Phys. Rev. Letters* (July 1, 1958).

Ultra-High Resolution γ-Ray Resonance in Zinc-67

We wish to report the observation of nuclear resonance absorption (Mössbauer effect[1]) of the 93 keV., 9·4 μsec. γ-ray[2] of zinc-67. The energy width of this line is $4 \cdot 84 \times 10^{-11}$ eV., and the fractional energy resolution, defined as the ratio of twice the natural line width to the γ-ray energy, is 1 part in 10^{15}, and is 10^{3} fold narrower than that reported[3] for iron-57. By the same token, the resonance is difficult to observe, because it is easily destroyed by small-amplitude sound vibrations and broadened and weakened by nuclear electric quadruple interactions in the crystals[4].

A search for the resonance was made using a mechanically rigid package of absorber and source, suspended by threads inside a liquid-helium cryostat. The resonance condition was destroyed by applying an external magnetic field to the absorber but not the source, making use of the nuclear Zeeman effect.

A source of 78-hr. gallium-67 was prepared by deuteron bombardment of a ceramic zinc oxide slab. Gallium-67 decays by electron capture to excited states of zinc-67. Following annealing of the source in a helium atmosphere for 18 hr. at 366° C., the source and a ceramic zinc oxide absorber (thickness 5·6 gm./cm.^{2}) were placed in a shock-mounted helium cryostat. A solenoid surrounding the absorber provided a magnetic field. The source was mounted at a distance of 1·5 cm. from the absorber, and was shielded from the magnetic field by a superconducting lead foil. The experiments were performed at temperatures below the helium λ point, thereby eliminating boiling and assuring equality of source and absorber temperatures. Freezing the nitrogen radiation shield prevented vibrations due to boiling liquid.

Determinations were made of the increase in transmission of the 93-keV. gamma radiation through the zinc oxide absorber on application of a magnetic field to the absorber. A field of 150 oersted is expected to destroy the resonance condition completely, assuming no line broadening. With an applied field of 500 oersted the low-temperature transmission was found to increase by (0·080 ± 0·008) per cent over the zero field value. After correction for background in the γ-ray spectrum the transmission increase is (0·240 ± 0·025) per cent.

Control experiments were run at room temperature, where no resonance is expected, using the 93-keV.

γ-ray, and at low temperatures using a 184-keV. non-resonant γ-ray. An unannealed zinc oxide absorber was studied. Measurements were taken on annealed (14 hr. at 650° C.) and unannealed zinc spinel (zinc oxide–alumina). Because of difficulty in placing the active gallium atoms in the proper lattice positions in the spinel, no resonance was expected, and none was observed. The results of all our measurements are summarized in Table 1. The magnetic fields used were in all cases approximately 500 oersted. The only significantly non-zero resonance is found in the annealed zinc oxide at low temperatures.

Table 1

Material	Annealed	γ-Energy	Temperature (° K.)	Resonance (per cent)
ZnO	yes	93 keV.	$<2\cdot17$	$0\cdot080 \pm 0\cdot008$
ZnO	no	93	$<2\cdot17$	$-0\cdot06 \pm 0\cdot06$
ZnO	yes	93	300	$0\cdot005 \pm 0\cdot003$
ZnO	yes	184	$<2\cdot17$	$0\cdot02 \pm 0\cdot02$
Spinel	yes	93	$<2\cdot17$	$0\cdot016 \pm 0\cdot014$
Spinel	yes	93	300	$0\cdot02 \pm 0\cdot03$

Despite the minute resonance strength observed in zinc oxide, the ratio of the resonance strength to the energy resolution is larger than for any other resonance thus far reported (about three times larger than has been obtained with the 14-keV. line in iron-57[3]), and hence the 93-keV. γ-ray of zinc-67 provides the possibility for the most precise nuclear clock available. We are at present attempting to enhance the observable resonance through the utilization of resonant scattering methods, and are studying the isotope shift expected when the isotopic constitutions of source and absorber are different.

We wish to express our thanks to Stephen Stoddard and Robert Cowan for preparing the zinc oxide samples, to Donald R. F. Cochran for help with irradiations, and to J. G. Dash for a number of helpful discussions.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

D. E. NAGLE
P. P. CRAIG
W. E. KELLER

University of California,
Los Alamos Scientific Laboratory,
Los Alamos, New Mexico.

---

[1] Mössbauer, R. L., *Z. Phys.*, **151**, 124 (1958); *Naturwiss.*, **45**, 538 (1958); *Naturforsch.*, **14**, *a*, 211 (1959). Craig, Dash, McGuire, Nagle and Reiswig, *Phys. Rev. Letters*, **3**, 221 (1959). Lee, Meyer-Schutzmeister, Schiffer and Vincent, *ibid.*, **3**, 223 (1959).

[2] Strominger, Hollander and Seaborg, *Rev. Mod. Phys.*, **30**, 585 (1958).

[3] Pound, R. V., and Rebka, jun., G. A., *Phys. Rev. Letters*, **3**, 554 (1959). Schiffer, J. P., and Marshall, W., *Phys. Rev. Letters*, **3**, 556 (1959).

[4] Pound, R. V., *Phys. Rev.*, **79**, 685 (1950).

Mass of Elementary Particles

PROF. A. J. RUTGERS in *Nature* of September 19, 1959, and Dr. R. L. Worrall in *Nature* of February 27, 1960, pointed out that the ratio of proton to electron mass could be calculated from simple functions. It appears that the masses of most elementary particles can be calculated, approximately, using three quantities, h, Planck's constant, a, the fine structure constant, and e, the base of the natural logarithms. The calculated values obtained are in good agreement with the known values.

Worrall suggests the following equation for calculating the mass of the proton:

$$M_p = \text{mass proton} = (10^4/2e)\ M_e$$

where M_e is the mass of the electron. Since $e^2 \sim 10^3 a$, it is possible that the fine structure constant is involved. $M_p \sim (5e/a)\ M_e$.

Meson masses can be calculated in the following way:

$$\begin{array}{lll} \text{Mu meson}: 1/e\ (4/a)\ M_e & \sim & 202\ M_e \\ \pi \text{ meson}: (2/a)\ M_e & \sim & 274\ M_e \\ K \text{ meson}: (7/a)\ M_e & \sim & 959\ M_e \\ \text{Hyperon}: (7/5)\ M_p & \sim & 2{,}585\ M_e \end{array}$$

The observed masses are almost exactly equal to the calculated masses.

The hyperons may have the following structure:

$$\begin{array}{lll} 1{,}840 + 959/e + 959/e & \sim & 2{,}545\ M_e \\ 1{,}840 + 959/e + 274/e & \sim & 2{,}295\ M_e \\ 1{,}840 + 959/e & \sim & 2{,}190\ M_e \end{array}$$

Since a binding energy may also be present, these calculated values are not unreasonable. However, if they are correct the factor e appears to be important. There is a mass decrease on particle formation through action of the factor $1/e$ as suggested by Worrall. However, the factor could be $1/(10^3 a)^{1/2}$.

The electron mass can be expressed in terms of frequency and c^2 by the equation:

$$\begin{gathered} h/M_e = c^2/v \sim 7\cdot3 \text{ cm.}^2/\text{sec.} \\ 7\cdot3 \sim 10^3 a \sim e^2 \\ h/e^2 \sim 9 \times 10^{-28} \end{gathered}$$

There are now three nearly equal quantities involved in mass calculations. Meson masses can be expressed as follows:

$$\text{Mass of mu meson} = (1/e)\ 4\ h/a\ (c^2/v)$$

It seems reasonable to suppose there is some connexion between the three quantities in the above equation. The ultimate equation may involve only h/c^2, a conversion factor dependent on the units used, and an energy-level factor.

In view of the importance of the problem, the above relationships perhaps deserve consideration.

S. C. HORNING

200 E. Rose Valley Road,
Wallingford, Pa.

BIOPHYSICS

Flow of Blood through Narrow Tubes

IN a recent communication, Haynes[1] describes experiments on the flow through capillary tubes of suspensions of erythrocytes in standard acid–citrate–dextrose and proposes an equation relating volume flow in unit time to applied pressure. He also refers to my use of Casson's equation[2] for somewhat similar results obtained by various authors on blood (treated with coagulants) from a number of species[3,4]. Although Haynes's comments are entirely correct so far as they go, it seems that the matter requires further clarification.

The essential point is that, to further our understanding of the sigma phenomenon in full blood, it is greatly advantageous to be able to describe the flow-curves over a wide experimental range of shear-rate by means of two parameters the variation of which with capillary radius can then be quantitatively studied. Such studies would be less interesting for suspensions of erythrocytes alone than for full blood, except that Dr. Haynes evidently finds (private communication) no difference in the shapes of the pressure-flow curves.

From the form of Casson's equation, it is clear that it cannot express a fundamental law of flow. For example, a reversal of the direction of stress would introduce imaginary quantities; but the straight lines obtained when the square root of shear-rate is plotted against the square root of stress (both at the capillary wall) serve our purpose, since any straight line is definable by its slope and its intercept on extrapolation to some axis. By 'yield-value' is meant only the extrapolated intercept of these straight lines extended to the stress axis.

In a second communication, Reiner and Scott Blair[4] calculated the curvature which would take place if the same equation were to hold for any system down to an experimentally determinable yield-value. We would certainly not have wished to imply that blood has a yield-value in this sense, since none of the published results appeared, at the time, to cover a low enough range of shear-rates to decide the point.

Since these communications were published, more systems have been found to follow Casson's equation (see Heinz[5]), and the extension proposed by us for low shear-rates may well be applicable to some of them.

I am indebted to Dr. R. H. Haynes for his kindness in elucidating a number of points in private correspondence.

G. W. Scott Blair

National Institute for Research in Dairying,
University of Reading.
March 22.

[1] Haynes, R. H., *Nature*, 185, 679 (1960).
[2] Casson, N., chapter in "Rheology of Disperse Systems", edit. by Mill, C. C. (Pergamon Press, London, 1959).
[3] Scott Blair, G. W., *Nature*, 183, 613 (1959).
[4] Reiner, M., and Scott Blair, G. W., *Nature*, 184, 354 (1959).
[5] Heinz, W., *Materialpruf.*, 1 (9), 311 (1959).

METALLURGY

Optical Properties of Bismuth

As part of a programme to investigate applications of the polarizing microscope to metallography, a study has been made using bismuth single crystals. The single crystals were prepared from material of a purity not less than 99·99 per cent bismuth, by controlled solidification from a capillary tube. As a check on purity, X-ray measurement of the unit cell dimensions gave values of $a = 4·5366$ kX., $c = 11·8402$ kX., indexed on a hexagonal basis. Sections of the various crystals were machined flat and electropolished[1]. The orientation of each crystal was determined using the polarizing microscope, a few of the orientations being checked by X-ray back reflexion[2].

The directions of complete extinction (uniradial directions) of each section were set at 45° to the plane of vibration of the polarizer and the rotation of the analyser found which produced extinction in monochromatic light. After rotation of the crystal on the stage by 90° another measurement of the analyser rotation in the opposite sense was obtained. The difference between these two measurements gave twice the analyser rotation angle.

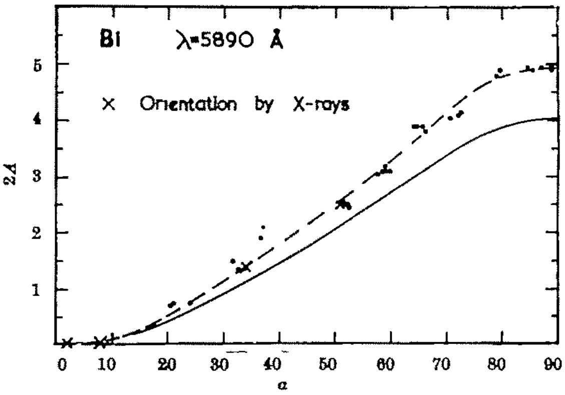


Fig. 1. $2A$, Analyser rotation angle × 2; α, angle between basal plane and plane of section; – – – – –, experimental curve; ———, experimental curve corrected for reflector rotation

Fig. 1 shows the experimental results, using yellow light (5890 Å.) with $2A$, twice the angle of analyser rotation, plotted against the angle α between the optic axis and the normal to the plane of section. The broken line represents the best curve through the experimental points while the solid curve gives the true rotations after making correction for the rotation due to the reflector slip of the microscope. Rotations due to phase differences are included in the rotation angles shown in Fig. 1. These rotations are small and within experimental error, the maximum phase difference at this wave-length being 1·1°. Measurements of phase difference and their effects are shown in Table 1, the figures in the columns headed L being obtained with an elliptic compensator in the tube slot of the microscope.

The reflectivities in the two uniradial directions of a crystal with $\alpha = 87°$ were measured using a Cooke, Troughton and Simms visual microphotometer (Berek type) with a basal section of quartz as a standard. The reflectivities at three wave-lengths and their ratios are given in Table 1, together with

Table 1. Bismuth Single Crystal. Sign of Rotation Negative. Optic Axis [111] inclined 3° to Section Surface. $\alpha = 87°$

Wave-length (Å.)	4860		5890		6560	
Microscopy		L*		L		L
$2A$, analyser rotation angle × 2	−4·93	−5·23	−4·95	−5·1	−4·35	−4·5
Angle $2A$ corrected for reflector rotation	−4·02	−4·26	−4·04	−4·16	−3·54	−3·67
Phase difference $(\Delta e - \Delta o)$		−2·79°		−1·09°		−1·09°
Reflectivity ratio (intensities) Re^2/Ro^2	0·869	0·863	0·869	0·865	0·884	0·880
Photometry						
Re^2, reflectivity of vibrations in axial plane	56·3%		63·1%		67·1%	
Ro^2, reflectivity of vibrations in basal plane	64·9%		72·6%		75·4%	
Reflectivity ratio (intensities) Re^2/Ro^2	0·868		0·870		0·890	

Refractive indices measured at wave-length 4861 Å. (A. P. Lenham)
Optic axis $n'_e = 1·20–2·47i$
Basal plane $n'_o = 0·89–2·58i$

Calculated values

Reflectivity Re^2	Reflectivity Ro^2	Reflectivity ratio Re^2/Ro^2	Phase difference $(\Delta e - \Delta o)$
56·1 %	65·1%	0·861	−1·6°

* L, Elliptic compensator used to measure phase difference.

ratios calculated from analyser rotations. The ratio of reflectivities calculated from values of the optical constants (Lenham, A. P., private communication) for the same crystal, is included for comparison.

Measurement of the analyser rotation angle thus provides a rapid method of determining the tilt of the optic axis ([0001] on hexagonal indexing, [111] on both rhombohedral descriptions). The accuracy is probably limited to about ± 5° with standard equipment, but the method can be used with polycrystalline samples even if the grain size is small.

H. D. Mallon
I. G. Runciman

Metallurgy Branch,
Royal Military College of Science,
Shrivenham

[1] Hare, G. A., and Mallon, H D., *Metallurgia* (in the press).

[2] Mallon, H. D., and Wilson, C. G., *Brit. J. App. Phys.* (in the press).

Effect of Moisture on Carboxylic Acid Adsorption to Steel

Qualitative evidence has been given[1] that oils compounded with efficient dicarboxylic (alkylated succinic acids) rust inhibitors will not prevent rusting at certain low concentrations of the additive. When oil at these low concentrations of inhibitor was saturated with water, however, rust protection was obtained. Von Fuchs attributed this behaviour to the chemical reaction of iron with water to form ferrous hydroxide, which in turn can react with the acidic inhibitor to form a tenacious film of soap on the metal surface. Another investigation[2], using stearic acid labelled with carbon-14, demonstrated that the acid is adsorbed more readily to ferrous surfaces from hydrocarbon solution containing entrained moisture than from a relatively dry solution. This phenomenon of enhanced adsorption to the metal surface was explained by Ries *et al.* as probably being due to an increase in the oxide coating produced by the presence of moisture.

In this work it was discovered that the adsorption could be enhanced not only by moisture in the oil, but also by an invisible layer of moisture adsorbed on the metal surface prior to application of the oil. This suggested a means of determining the mechanism of the water catalysis, since if the phenomenon is due to an increase in oxide surface, the effect would be observed on a surface originally treated with moisture even if it were dried thoroughly before applying the inhibited oil.

To determine the relative amounts of carboxylic acid adsorbed from an oil solution on to the back surface of a polished steel planchet, an alkylated succinic acid labelled with carbon-14 was used. Three drops of a 0·015 per cent solution of the acid in mineral oil were deposited on a planchet surface. After 2 min. of contact at room temperature, the oil was blotted off thoroughly with filter paper and the radioactivity remaining on the planchet determined. This residual activity is equal to the activity adsorbed to the surface plus the activity remaining in the thin film of oil not removable by blotting. Any increase in this total residual activity resulting from variations in preparation of the metal surface must be due, of course, to increased adsorption of the radioactive species to the surface. Treatment of the polished planchets before depositing the radioactive oil consisted of exposure to a column of steam for varying periods of time ranging from 30 sec. to 4 min. After this exposure, the visible layer of condensed steam was allowed to evaporate, leaving behind the invisible film of adsorbed moisture. Half the metal samples thus obtained were immediately treated with inhibited oil. The other half were dried in an oven at 120° C. for 3 days to remove the invisible adsorbed film of moisture, before application of the oil. The results of the experiments are given in Table 1.

Table 1. EFFECT OF MOISTURE ON ADSORPTION OF AN ALKYLATED SUCCINIC ACID ON TO SMOOTH STEEL SURFACES

Sample No.	Exposure to steam (sec.)	Resulting condition of surface	Heat drying treatment after steam exposure	Residual activity after blotting off oil (counts/min)
1	0			438
2	0			464
3	30	no visible rust	none	824
4	30	no visible rust	120° C. for 3 days	372
5	30	no visible rust	120° C. for 3 days	398
6	60	incipient rusting	none	1,155
7	60	incipient rusting	none	1,451
8	60	incipient rusting	120° C. for 3 days	534
9	60	incipient rusting	120° C. for 3 days	464
10	240	heavy rusting	none	1,833
11	240	heavy rusting	120° C. for 3 days	568

It can be seen that even if the surface oxide area of a steel specimen is enormously increased through exposure to moisture, there is little increase in absorption if the surface is dried thoroughly before applying the oil. On the other hand, surfaces exposed to moisture under conditions resulting in very little increase in the surface oxide area will undergo a tremendous increase in adsorptive capacity for carboxylic acids if the adsorbed layer of water molecules is not removed before treatment with the acid. The effect of water in increasing the adsorption of carboxylic acids from oil solution on to iron surfaces is consequently not due primarily to an increase in the surface oxide area of the metal, but rather to direct participation of the water at the time of the adsorption reaction.

The opinions or assertions contained in this communication are our own and are not to be construed as official or reflecting the views of the Naval Service at large.

M. E. Schrader
J. L. Kalinsky

Material Laboratory,
New York Naval Shipyard,
Brooklyn 1, New York.

[1] von Fuchs, G. H , "Evaluation and Performance of Turbine Oils" A.S.T.M. Spec. Tech. Pub. No. 211, 93 (1956).

[2] Ries, jun., H. E., Cook, H D., and Loane, C M., "Evaluation and Performance of Turbine Oils", A.S.T.M. Spec. Tech. Pub. No. 211, 55 (1956).

RADIATION CHEMISTRY

Chemical Effects of Ionizing Radiation on Deoxyribonucleic Acid in Dilute Aqueous Solution

When purine and pyrimidine nucleotides in dilute aqueous solution are irradiated with ionizing radiation they are destroyed by two pathways[1]. The minor pathway is attack upon the sugar moiety followed by release of free base[1]. Details of the mode of sugar attack have not been established; but possible reactions have been suggested by Daniels *et al.*[2]. The major pathway is attack of the base moiety which with purines in the absence of oxygen yields the corresponding formamido-pyrimidine nucleotide[3]. When pyrimidine nucleotides are irradiated in the absence of oxygen sugar phosphate is liberated, but there is no ultra-violet absorbing product arising from base attack. When oxygen is present during irradiation G-values (molecules per 100 eV.) for nucleotide destruction are increased 2–3 times[4]. For purine nucleotides the increased degradation in oxygen is almost entirely an augmented base attack, but no ultra-violet product arising from it is found[4]. When pyrimidines are irradiated in the presence of oxygen hydroxy-hydroperoxides are formed[5]. G-values for destruction of pyrimidines in the presence of oxygen are greater than those for purines[1,4] and suggest that when deoxyribonucleic acid is irradiated pyrimidines will be destroyed to a greater extent. Extrapolation of the effects of radiation upon nucleotides to effects upon deoxyribonucleic acid is complicated in an uncertain way by the influence of internucleotide linkages and hydrogen bonding of base pairs. This communication reports the amounts of base and sugar destroyed when aqueous solutions of calf thymus deoxyribonucleic acid are irradiated.

To determine whether radiochemical changes varied with different samples of deoxyribonucleic acid the chemical changes were compared after irradiating samples of calf thymus deoxyribonucleic acid from four separate preparations. Solutions of approximately 5 mgm. acid/ml. were prepared with triple-distilled water and neutral phosphate buffer added (final concentration 10^{-2} M). Air bubbles were removed by cautious evacuation, but solutions were irradiated under air. Solutions were irradiated with 15-MeV. electrons to a dose of 10^6 rads. It is assumed that the initial 7 × 10^5 rads use up all dissolved oxygen[1] and since the dose is delivered within 90 sec. the remaining 93 per cent of the dose is delivered to an oxygen-free solution. Samples of control and irradiated solutions were hydrolysed in hot perchloric acid and their base compositions determined by paper chromatography[7]. The total base change was 10 per cent of the control. G-values for bases changed were calculated and are given in Fig. 1. There is little variation between samples of deoxyribonucleic acid, and thymine is destroyed to the greatest extent. Perchloric acid hydrolysis gives a low value of thymine[7], and it seemed possible that as irradiated material is degraded the yield of thymine may be further lowered, giving an artificially high value for G(–thymine). However, when the hydrolysis was repeated with formic acid at 175° C., which does not give a low value for thymine[7], G-values were essentially the same as obtained after perchloric acid hydrolysis. When samples of irradiated deoxyribonucleic acid are run on paper in an n-propanol–water solvent[8] all phosphates remain at the origin and free bases can be isolated. Adenine, guanine, cytosine and thymine were isolated when 1-ml. samples of irradiated deoxyribonucleic acid were run on paper, and their yields were determined from the ultra-violet absorption of their eluates (Fig. 2). Amounts of base released, that is, sugar attacked, are approximately one-quarter of the amounts of base destroyed. G-values for adenine and cytosine released are slightly higher than those for guanine and thymine. It is not readily possible to determine amounts of free base, if any, present in the control solution. If any free base is present it will only strengthen the conclusion that base attack is the major reaction.

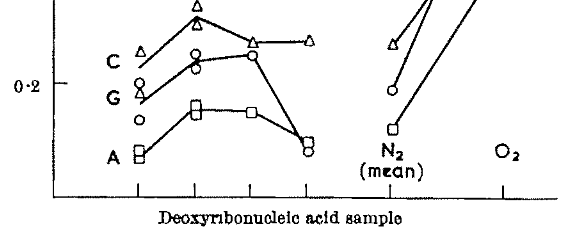


Fig. 1. G-values for bases destroyed when aqueous solutions of calf thymus deoxyribonucleic acid (5 mgm./ml.) are irradiated with 15-MeV. electrons. □, Adenine; ○, guanine; △, cytosine; ●, thymine

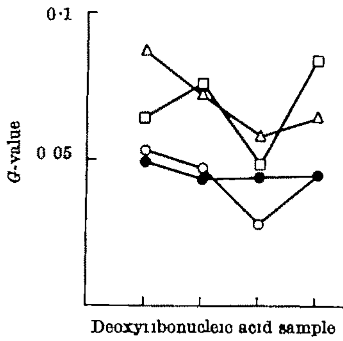


Fig. 2. G-values for bases released when aqueous solutions of calf thymus deoxyribonucleic acid are irradiated with 15-MeV. electrons in the absence of oxygen. □, Adenine; ○, guanine; △, cytosine; ●, thymine

In addition to free bases, 2 : 4-diamino-5-formamido-6-hydroxypyrimidine is found in irradiated deoxyribonucleic acid and arises from attack on the guanine moiety[3]. Amounts of 2 : 4-diamino-5-formamido-6-hydroxypyrimidine are smaller than G(–guanine), but are increased by warming the irradiated deoxyribonucleic acid solution, at pH 7 and 80° C., for 1 hr. It is assumed that attack upon guanine yields 2 : 4-diamino-5-formamido-6-hydroxypyrimidine attached to the sugar by a labilized glycosidic linkage. Attack on adenine forms the corresponding formamido-pyrimidine[4], but none could be found in the irradiated deoxyribonucleic acid. However, amounts of adenine changed are small and the formamido-pyrimidine could easily escape detection.

A solution of deoxyribonucleic acid, concentration 2 mgm./ml., was irradiated to 1·7 × 10^6 rads, the solution being kept saturated with oxygen during irradiation. Control and irradiated solutions were hydrolysed in perchloric acid and the base composition determined (Fig. 1). While the total amount of base destroyed is 2·5 times greater in the presence of oxygen, the relative amounts of each base destroyed are approximately the same as when oxygen is absent. The G-value for adenine released in the presence of oxygen is 0·06, which is close to the value in the absence of oxygen. This is consistent with the finding with purine nucleotides that enhancement by oxygen is an increased attack upon the base moiety.

When tissue is irradiated, it is likely that the effects of the indirect action will be the same as *in vitro*. Assuming *G*-values for an aqueous solution, irradiation of tissue to a dose of 10^3 rads will change one base in 10^4. If it is assumed that cell constituents, adjacent to nucleic acid, compete 10 times (or 100 times) more efficiently than deoxyribonucleic acid for radicals there will be one nucleotide changed in 10^5 (or 10^6) per 10^3 rads. Damage of this extent would be expected to interfere severely with the function of the cell. The changes produced in the absence of oxygen will be removal of pyrimidines and conversion of purines to formamido-pyrimidines. Since the latter have labile sugar-linkages the ultimate result may be removal of purines. For every four bases removed one sugar will be attacked and presumably the sugar–phosphate backbone will be broken. Oxygen, present during irradiation, will increase the amount of base destroyed by a factor of 2·5, but sugar breakage will be little changed. Thus the indirect action of ionizing radiation upon the bases of deoxyribonucleic acid seems to be adequate to account for observed biological damage and for the increase in damage of approximately 2·5 times in oxygen, observed for a wide array of biological changes[9].

The action of alkylating agents on deoxyribonucleic acid sheds further light on the chemical changes in deoxyribonucleic acid which may be important biologically. P. Brookes and P. D. Lawley (personal communication) have shown that when deoxyribonucleic acid is treated with low doses of an alkylating agent, guanine is alkylated to a much greater extent than the other three bases. Alkylation of the guanine moiety labilizes the glycosidic link, which is slowly hydrolysed.

It is interesting to speculate that biological changes brought about by alkylating agents and ionizing radiation are associated with removal of guanine from deoxyribonucleic acid. Further, radiobiological changes not produced by alkylating agents may be associated primarily with removal of thymine.

I am indebted to Prof. J. A. V. Butler, who so kindly supplied samples of calf thymus deoxyribonucleic acid, and gratefully acknowledge financial support by the William Shepherd Fellowship. This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research : Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

G. HEMS

Chester Beatty Research Institute,
Institute of Cancer Research,
Royal Cancer Hospital,
Fulham Road, London, S.W.3.

---

[1] Scholes, G., and Weiss, J., *Exp. Cell. Res.*, Supp. 2, 219 (1952).

[2] Daniels, M., Scholes, G., and Weiss, J., *J. Chem. Soc.*, 3771 (1956).

[3] Hems, G., *Nature*, 181, 1721 (1958).

[4] Hems, G., *Rad. Res.* (in the press).

[5] Scholes, G., and Weiss, J., *Nature*, 185, 305 (1960).

[6] Barron, E. S. G., Johnson, P., and Cobure, P., *Rad. Res.*, 1, 410 (1954).

[7] Wyatt, G. R., *Biochem. J.*, 48, 584 (1951).

[8] Korn *et al.*, *J. Amer. Chem. Soc.*, 75, 3610 (1953).

[9] Gray, L. H., *Rad. Res.*, Supp. 1, 73 (1959).

CHEMISTRY

The Tesla-coil Method for producing Free Radicals from Solids

MOST of the methods in current use for producing radicals from crystalline solids for study by electron spin resonance involve the use of high-energy radiation and therefore require comparatively expensive and elaborate equipment. Papazian[1,2] showed that several substances, including hydrazoic acid and methyl iodide, condensed from the vapours at liquid-nitrogen temperature developed colour when sparked with a Tesla-coil ; this was attributed to free-radical formation. Using the electron spin resonance technique we have found that radical concentrations as high as 10^{18}/gm. (approximately 10^{-3} mole $l.^{-1}$) can be obtained by applying the discharge from an ordinary vacuum leak-tester to finely ground crystals of many organic substances contained in partially evacuated electron spin resonance specimen tubes. For low-melting solids, for example some vinyl monomers, the following procedure is sometimes convenient. The degassed liquid is frozen in a thin layer on the walls of the evacuated tube, which is then cooled to −195° C. and vibrated vigorously. The crystals are thus detached from the walls and deposited in a fine powder at the bottom of the tube. A suitable gas at a pressure of about 0·1 mm. mercury is admitted and the probe of the Tesla-coil applied in the neighbourhood of the crystals, the tube being maintained at a low temperature and preferably vibrating. With high-melting solids it suffices to grind the crystals finely in a mortar before introduction into the specimen tube. Nitrogen, hydrogen, argon and oxygen have been used, in order of decreasing effectiveness. The presence of a gas is desirable but not absolutely essential. The spectrum obtained is independent of the nature of the gas. Radical concentrations of the order of 10^{-4} mole $l.^{-1}$ are often produced in a few seconds by this technique. Substances examined include glycine, diketopiperazine, acrylamide, potassium and lithium methacrylates, acrylic, methacrylic, *n*-butyric and itaconic acids, acrylonitrile and polyacrylonitrile, all of which gave strong radical spectra. Surprisingly, a negative result was obtained with azo-*bis*-*iso*butyronitrile. The radicals from these compounds show widely differing thermal stabilities and reactivities towards oxygen.

Methacrylic acid was selected for further study. The spectra obtained were identical to those produced by γ-irradiation of methacrylate polymers[3]. The limiting radical concentration which could be obtained with prolonged excitation by the Tesla-coil at about −195° C. was approximately 10^{-3} mole $l.^{-1}$. It is interesting that this value is within an order of magnitude of the number of radicals in a unimolecular layer on the surface of the crystals (estimated from simple microscopic examination of the crystal size), and we believe that the radicals formed with excitation by the Tesla-coil reside mainly on the surface initially. In agreement with this it was found that at − 78° C. the radicals react with oxygen to form new radicals with an asymmetric spectrum of the type given by *R*OO· (ref. 4) in a time too short to permit observation with the present apparatus, that is to say, within 30 sec. On the other hand, the reaction with nitric oxide at a pressure of 17 mm. mercury at the same temperature is comparatively slow, with a half-life of about 1 hr.

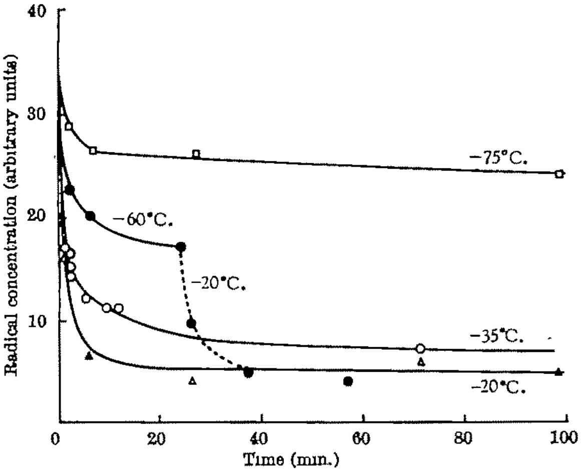


Fig. 1. Decay of surface radicals on methacrylic acid crystals at various temperatures. Scale of radical concentration is arbitrary, but 30 units = 10^{-3} mole l.$^{-1}$, approximately. Different symbols are used to distinguish between different experiments

On warming a specimen containing the initial radicals to 0° C. for 5 min. the radical concentration decays to the limit of detectability (10^{-6} mole l.$^{-1}$ approximately). The effects of warming to various temperatures between −195° C. and 0° C. are shown in Fig. 1. The abscissa represents the total time at the appropriate temperature; spectra were always taken with the specimen at −195° C. At each temperature there is an initial comparatively rapid decay to an almost stationary value, and is found to be inversely proportional to the temperature.

The dotted curve shows the result of an experiment at two temperatures. After excitation by the Tesla-coil, the tube was warmed for 24 min. to −60° C. to achieve the stationary concentration at this temperature, and then warmed to −20° C. for successive short periods. This treatment resulted in a decay in radical concentration to the stationary value for −20° C.

These results are understandable if the radicals on the surface of the crystals are immobile at −195° C. but became progressively mobilized as the temperature is raised. Such would be the case if the energies binding the radicals to the surface were distributed over a wide spectrum. Possibly the radicals are not entirely monomeric; the mobility would then depend on the degree of polymerization.

With repeated excitation by the Tesla-coil at −195° C. and warming to 13° C. a high radical concentration (10^{-3} mole l.$^{-1}$) may be built up. These radicals are stable at 13° C., but react rapidly with oxygen. It would appear that a surface polymerization had occurred in this experiment, producing large immobile radicals. In a similar experiment with *n*-butyric acid no such effects were observed.

These experiments illustrate some of the possible uses of this simple technique, which may have applications not only in the study of free radicals, but also in the investigation of surface reactions.

C. H. Bamford
A. D. Jenkins
J. C. Ward

Research Laboratory, Courtaulds, Ltd.,
Maidenhead, Berks.

---

[1] Papazian, H. A., *J. Chem. Phys.*, **27**, 813 (1957).

[2] Papazian, H. A., *J. Chem. Phys.*, **29**, 448 (1958).

[3] Abraham, R. J., Melville, H. W., Ovenall, D. W., and Whiffen, D. H., *Trans. Farad. Soc.*, **54**, 1133 (1957).

[4] See, for example, Whiffen, D H., *Makromol. Chem.*, **34**, 170 (1959).

Polymerization of Crystalline Methacrylic Acid initiated by Ultra-violet Radiation

In recent years it has been shown that a number of crystalline vinyl monomers polymerize when irradiated by γ-rays[1–4] or high-energy electrons[5]. However, there appears to be no report in the literature of the ultra-violet initiation of solid-state polymerization, although this process could, in principle, facilitate elucidation of the mechanism of the reaction.

We have found that crystalline methacrylic acid (m.p. 16° C.) may be polymerized by radiation from a high-pressure mercury arc using a quartz optical system, or with azo-*bis*-*iso*butyronitrile as photosensitizer using a 'Pyrex' glass system. In these experiments the crystals had a water content of approximately 0·01 per cent w/w; the presence of some water appears necessary for polymerization, at least in the sensitized reaction. In this latter case the rate falls off after a comparatively small conversion which increases with the concentrations both of the sensitizer and water at 13° C. On the other hand, the unsensitized reaction is autocatalytic in the early stages and may ultimately lead to complete conversion.

The rate in the early stages of the sensitized reaction is proportional to the first power of the light intensity and of the concentration of sensitizer. Measurements of the kinetic chain-length made using sensitizer labelled with carbon-14 ($4·3 \times 10^{-3}$ mole l.$^{-1}$) give values of approximately 700 in the early part of the reaction, substantially independent of the light intensity. This corresponds to a rate of chain starting of $5·0 \times 10^{-7}$ mole l.$^{-1}$ sec.$^{-1}$ under our standard 'high-intensity' conditions, and a rate of polymerization of $3·5 \times 10^{-4}$ mole l.$^{-1}$ sec.$^{-1}$. Under the same conditions the decomposition of the sensitizer was followed by observing the nitrogen evolution, and thus the efficiency of initiation was estimated. It turns out to be approximately 0·5, that is, not very different from that found in liquid-phase polymerizations.

After irradiation radicals can be detected in the frozen mass by electron spin resonance. Their concentration increases with the period of irradiation, and also strongly with the sensitizer concentration. In the range of sensitizer concentrations studied (up to $1·3 \times 10^{-2}$ ml.$^{-1}$) only a small fraction of the total radicals produced by the light—approximately 10 per cent—become permanently trapped. These radicals are stable for long periods at 0° or 13° C., no detectable change occurring during 17 hr. at 0° C. The permanently trapped radicals are apparently located in sites unsuitable for further propagation, since no after-effect could be detected even in periods up to 17 hr. at 13° C. The spectrum of the radicals is the same as that observed in γ-irradiated methacrylate polymers by Abraham, Melville, Ovenall and Whiffen[6]. On admission of oxygen the spectrum changes to the asymmetric type shown by $RO O·$ radicals[7].

When irradiation is carried out in the presence of oxygen which is admitted to the system after crystallization is complete the polymerization proceeds normally. Since the liquid-phase photopolymerization is strongly inhibited by oxygen the propagating radicals in the solid must be inaccessible to oxygen. On the other hand, the permanently trapped radicals appear to be situated on the surface of the solid.

The degrees of polymerization of the polymers, determined viscometrically, varied in a rather erratic manner, but were generally around 4,000, independent of the rate of initiation. Since this value is considerably greater than the kinetic chain-length, the polymers must be markedly heterodisperse, perhaps owing to the fact that the sensitizer in these experiments was not uniformly distributed throughout the specimens. The crystals were prepared by freezing solutions of the sensitizer in the liquid monomer, and it was shown by ultra-violet absorption measurements that the first crystals to separate contained a relatively low concentration of sensitizer.

The above experiments do not establish that propagation through the crystal lattice occurs. The actual locus of polymerization is being determined by irradiating both large single crystals and thin crystal layers coupled with microscopic observation. Preliminary results indicate that the polymerization is at least partly a phase-boundary reaction.

C. H. BAMFORD
A. D. JENKINS
J. C. WARD

Research Laboratory, Courtaulds, Ltd.,
Maidenhead, Berks.

[1] Mesrobian, R. B., Andor, P., Ballantine, D. S., and Dienes, G. J., *J. Chem. Phys.*, **22**, 565 (1954).
[2] Schulz, R., and Henglein, A., *Angew. Chem.*, **67**, 232 (1955).
[3] Restaino, A. J., Mesrobian, R. B., Morawetz, H., Ballantine, D. S., Dienes, G. J., and Metz, D. J., *J. Amer. Chem. Soc.*, **78**, 2939 (1956).
[4] Morawetz, H., and Fadner, T. A., *Makromol. Chem.*, **34**, 162 (1959).
[5] Lawton, E. J., Grubb, W. T., and Balwit, J. S., *J. Poly. Sci.*, **19**, 455 (1956).
[6] Abraham, R. J., Melville, H. W., Ovenall, D. W., and Whiffen, D. H., *Trans. Farad. Soc.*, **54**, 1133 (1958).
[7] See, for example, Whiffen, D. H., *Makromol. Chem.*, **34**, 170 (1959).

A Monte Carlo Equation of State for Mixtures of Hard-Sphere Molecules

PROGRESS in the theory of mixtures is limited by the lack of adequate approximate solutions of the classical many-body problem. Thus at densities greater than those appropriate to the virial expansion no satisfactory estimate of the properties of mixtures is possible. However, the Monte Carlo method enables the evaluation of the many-dimensional configurational integral to be performed by a sampling procedure. The method is applicable to any form of intermolecular potential.

The preliminary investigations of the properties of mixtures were made on mixtures containing two types of hard-sphere molecules with a ratio of diameters $\sigma_\beta/\sigma_\alpha = 1{\cdot}667$. Systems of 32 and 64 molecules were studied, the molecules being confined in a cubic space by means of periodic boundary conditions[1-3]. Initially the two species of molecules were distributed randomly on a face-centred or simple cubic lattice. New configurations were generated by moving one particle at a time, and the results analysed in terms of three cumulative distribution functions, corresponding to the three types of molecular interaction in the mixture. A check of the method, using 'mixtures' of molecules of equal size, showed internal consistency among the distribution functions and good agreement with the results for single-component systems obtained by Wood and Jacobson[4] and Alder and Wainwright[5]. In the case of mixtures the validity of the method was examined by comparing the results obtained from systems with different numbers of molecules and with differing distributions of the two species on the initial lattice. The agreement is illustrated by the following values of pV/RT for an equimolar mixture at a reduced density, $1/V^*$, of 0·5: 32 molecules, 2·95; 32 molecules, initial distributions interchanged, 3·07; 64 molecules, 3·01;

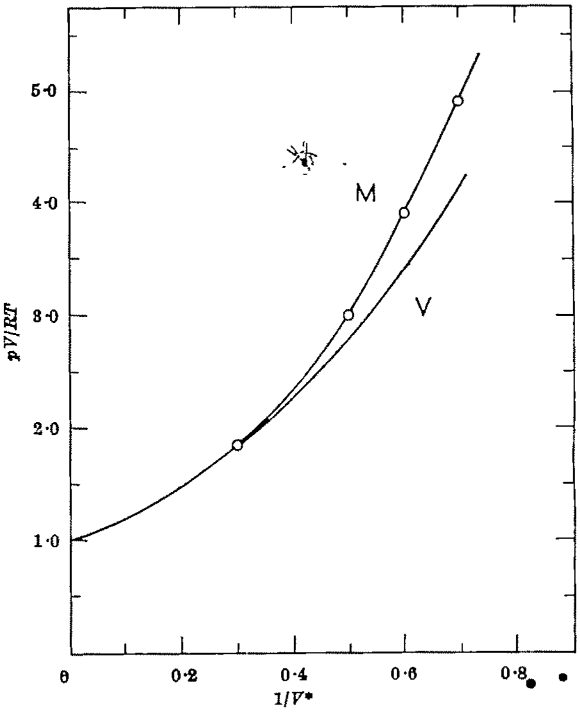


Fig. 1. pV/RT as a function of $1/V^*$ for an equimolar mixture of hard spheres for which $\sigma_\beta/\sigma_\alpha = 1{\cdot}667$. The lower line ($V$) represents the results of the virial expansion and the upper line (M) is that obtained from the Monte Carlo calculations

where N_α is the number of molecules of type α and σ_α is their diameter. V is the volume of the system.

Fig. 1 shows the equation of state for molecules of the given size ratio in an equimolar mixture over a range of density. The lower curve represents the results obtained from the virial expansion[6], which are consistent with the Monte Carlo results at lower densities but deviate markedly at higher densities.

A full investigation is now being undertaken to determine the effect of different size ratios and to examine the thermodynamic properties of mixtures of varying composition.

The calculations were performed on the Ferranti Mercury computer at the Computing Laboratory, University of Oxford. Considerable computing time has been required, and we wish to thank Miss S. A. Tilley for her interest and assistance.

E. B. SMITH
Physical Chemistry Laboratory,
K. R. LEA
Clarendon Laboratory,
University of Oxford. April 12.

* $\dfrac{1}{V^*}$ is defined as $\dfrac{N_\alpha\,\sigma_\alpha^3 + N_\beta\,\sigma_\beta^3}{V}$

[1] Metropolis, Rosenbluth, Rosenbluth, Teller and Teller, *J. Chem. Phys.*, **21**, 1087 (1953).
[2] Rosenbluth, M. N., and Rosenbluth, A. W., *J. Chem. Phys.*, **22**, 881 (1954).
[3] Wood, W. W., and Parker, F. R., *J. Chem. Phys.*, **27**, 720 (1957).
[4] Wood, W. W., and Jacobson, J. D., *J. Chem. Phys.*, **27**, 1207 (1957).
[5] Alder, B. J., and Wainwright, T. E., *J. Chem. Phys.*, **27**, 1208 (1957).
[6] McLellan, A. G., and Alder, B. J., *J. Chem. Phys.*, **24**, 115 (1956).

Spectroscopic Applications of Photographic Emulsion Mosaics

A COMPREHENSIVE spectral survey over as wide a wave-length range as possible is a frequent early requirement during spectroscopic studies of terrestrial and astronomical light sources. Such surveys are often made with low-dispersion prism spectrographs, and sometimes with grating instruments.

The availability of Kodak *O* to *Z* emulsions[1] (and similar emulsions of other manufacturers, for example Ilford *Q* emulsions), each sensitized to have a maximum response in a different wave-length region, enables a spectroscopic survey to be made by a sequence of separate exposures of different emulsions, each selected on the basis of wave-length range of maximum sensitivity. In cases where only one exposure is possible or practicable (for example, to transient and/or very feeble light sources) one specific emulsion (for example, 1–*N* or 103 *aF*) is often used as the most acceptable compromise for high sensitivity over as wide a wave-length range as possible. The inherent variations in the sensitivity of a single emulsion over the wide wave-length range often give rise to non-uniformly exposed plates.

The availability of the Kodak emulsions on films, however, makes it possible to assemble mosaics made up of two or more segments of different emulsions, each easily cut to a length specific to the wave-length range of its maximum sensitivity. For example, the "Kodak Data" book[1] specifications of relative emulsion sensitivity (defined therein as the reciprocal of the exposure to tungsten radiation in metre candles seconds which will produce a density of 0·6 above gross fog when the material is developed for the recommended time in Kodak developer *D*–19) show that a mosaic of optimum sensitivity to 9000 Å. may be assembled by using type *O* emulsion to 5000 Å., type *F* emulsion between 5000 Å. and 7000 Å., and type *N* emulsion between 7000 Å. and 9000 Å. In addition, the range of optimum sensitivity can be extended, if required, to 12,000 Å. by using hypersensitized *M* emulsion between 9000 Å. and 9800 Å., hypersensitized *Q* emulsion between 9800 Å. and 10,200 Å., and hypersensitized *Z* emulsion between 10,200 Å. and 12,000 Å.

The gain in sensitivity obtained by the use of an optimum emulsion mosaic in place of a single emulsion is illustrated in Fig. 1, compiled from individual sensitivity curves given in the "Kodak Data" book. An emulsion mosaic assembled in the manner specified above is a detector the sensitivity of which as a function of wave-length is an envelope of the individual curves of Fig. 1. The response of *O* emulsions is not given in the "Kodak Data" book below 4000 Å., but, as is well known, *O* emulsions perform adequately between 2000 Å. and 5000 Å. The mosaic sensitivity can be extended to shorter wave-lengths by use of Ilford *Q* emulsions or other Schumann type emulsions.

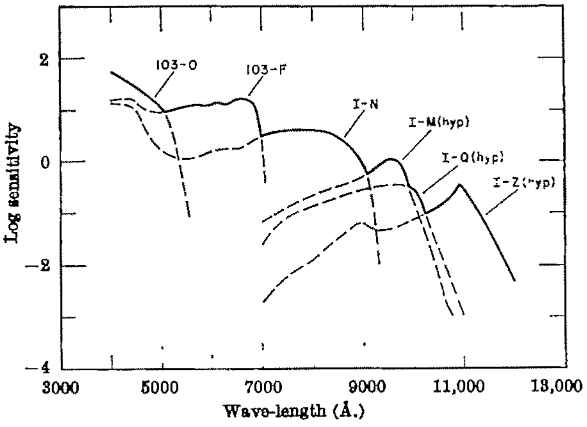


Fig. 1. Relative sensitivity of Kodak emulsions and optimum sensitivity of emulsion mosaic (solid curve)

The practicability of using emulsion mosaics has been tested by using segments of 103–*aO*, 103–*aF*, and 1–*N* 16 mm. film in conjunction with Hilger medium quartz and medium glass spectrographs. A flexible rectangular brass plate (10 in. × 4 in.), to which brass guides were attached to hold the film segments, was used in the spectrograph plate holder in place of the usual glass plate. Each segment of film, of a length appropriate to its wave-length range of maximum response, was cut with slightly oblique ends, which matched those of its neighbours. In this way no spectral features were lost at the boundaries between segments. The mosaic, and separate strips of *O*, *N*, and *F* film equal in length to the mosaic, were exposed for equal times to a microwave discharge through carbon dioxide the spectrum of which is rich in carbon monoxide features over the entire wave-length range of each spectrograph. In contrast to the abrupt variations in exposure obtained along each of the single emulsions, a relatively uniformly exposed spectrum was obtained in each case on the mosaic as expected.

The invaluable assistance of Mr. G. E. Beale, jun., in this work is gratefully acknowledged.

R. W. NICHOLLS*

National Bureau of Standards,
Washington, D.C.

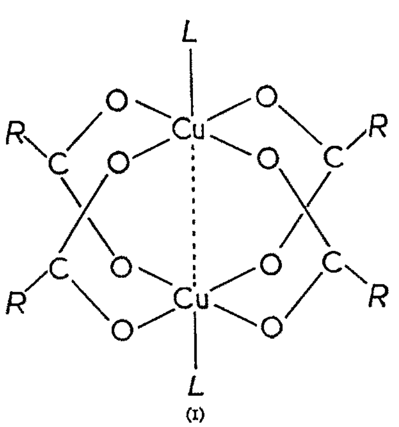
---

* Temporarily on leave of absence from Department of Physics, University of Western Ontario, London, Canada.

[1] "Kodak Photographic Plates for Scientific and Technical Use", seventh ed. (Rochester, New York, 1953).

Nature of Cupric Alkanoate Solutions

THAT the cupric salts of alkanoic acids occur in the solid state in the form of dimeric molecules is shown by van Niekerk and Schoening's X-ray analysis of cupric acetate hydrate (I, $R = CH_3$, $L = H_2O$)[1] and by Martin and Waterman's magnetic studies of the acetate and some higher homologues in hydrated and anhydrous forms[2]. Tsuchida and Yamada have shown that a further characteristic of this structure is the occurrence of an absorption band about 375 mμ, polarized in the copper–copper axis, in addition to the usual 'copper band' about 700 mμ[3,4].



(I)

Martin and Waterman extended their observations to the dissolved state and showed that the dimeric structure persisted in dioxane solution, arguments from the magnetic properties being supported by cryoscopic measurements of molecular weight and the appearance of an absorption band about 375 mμ[5]. Since the anhydrous compounds were found to be insoluble in non-donor solvents (though some of the higher homologues became dispersed), the species present in solution were presumably dioxane solvates (I, $L = C_4H_8O_2$).

Further evidence of the existence of dimeric molecules in solution is provided by a study of the distribution of cupric propionate between water and chloroform in the presence of propionic acid[6], distribution constants of the form :

$$k = \frac{[\mathrm{Cu}]_{\text{aqueous phase}}}{\sqrt{[\mathrm{Cu}]_{\mathrm{CHCl_3}\text{ phase}}}}$$

being interpreted in terms of the partition equilibrium:

$$2\,\mathrm{CuPr}^+ + 2\,\mathrm{Pr}^- \rightleftharpoons \mathrm{Cu_2Pr_4}$$

Table 1. DISTRIBUTION CONSTANT AND PROPIONIC ACID CONCENTRATION

$[\mathrm{CuPr_2}]$ (mole/l.)	0·039	0·039	0·055	0·055	0·055	0·077	0·077	0·077
[HPr] (mole/l.)	0·14	0·20	0·115	0·20	0·29	0·16	0·28	0·44
k	0·45	0·34	0·45	0·38	0·32	0·43	0·34	0·28
$k\sqrt{[\mathrm{HPr}]}$	0·17	0·15	0·15	0·17	0·17	0·17	0·18	0·19

Variation of the values of k with propionic acid concentration was attributed to the suppression of hydrolysis, but it is now suggested that this variation, which can be expressed in the form :

$$k \propto \frac{1}{\sqrt{[\mathrm{HPr}]}}$$

(Table 1), shows that the cupric propionate is dissolved in the organic phase, not as unsolvated molecules but as the propionic acid solvate (I, $R = C_2H_5$, $L = C_2H_5COOH$), thus accounting for the insensitivity of the absorption spectra to changes of the extracting solvent. The partition equilibrium now becomes :

$$2\mathrm{CuPr}^+ + 2\mathrm{Pr}^- + 2\mathrm{HPr} \rightleftharpoons \mathrm{Cu_2Pr_4(HPr)_2}$$

Since the anhydrous cupric alkanoates are insoluble in non-donor solvents, further evidence for solvation by the free acids was sought by determining their solubilities in chloroform in the presence of free acid. Table 2 shows the solubilities (determined iodimetrically) of anhydrous cupric acetate, *iso*butyrate and crotonate in the presence of the corresponding acids.

Table 2. SOLUBILITY AND FREE ACID CONCENTRATION (AT 25° C.)

Acetate			*iso*Butyrate			Crotonate		
[HA] mole/l.	[Cu] mole/l.	$\frac{[\mathrm{Cu}]}{[\mathrm{HA}]}$	[HA] mole/l.	[Cu] mole/l.	$\frac{[\mathrm{Cu}]}{[\mathrm{HA}]}$	[HA] mole/l.	[Cu] mole/l.	$\frac{[\mathrm{Cu}]}{[\mathrm{HA}]}$
0·091	0·0047	0·052	0·099	0·0040	0·040	0·093	0·0069	0·074
0·180	0·0100	0·055	0·183	0·0085	0·046	0·174	0·0128	0·074
0·364	0·0180	0·049	0·367	0·0166	0·045	0·352	0·0239	0·068
0·731	0·0343	0·047	0·725	0·0375	0·052	0·713	0·0433	0·061
1·83	0·0858	0·047	1·86	0·0722	0·039			

As the free acids are known to be mainly dimeric in chloroform solution, the linear relationship between solubility and free-acid concentration shows that the dissolved species is the solvated dimer in accordance with the equilibrium :

$$\mathrm{Cu_2}A_4 + (\mathrm{H}A)_2 \rightleftharpoons \mathrm{Cu_2}A_4(\mathrm{H}A)_2$$

All these solutions have absorption bands at 675 mμ (ε ~ 200 per atom of copper) and 375 mμ (ε ~ 60 per atom of copper). The band at 675 mμ is sensitive to changes of solvate, addition of pyridine causing a shift to 710 mμ and of dioxane to 655 mμ (as found by Martin and Waterman in dioxane solution). The wide occurrence of the solvated dimeric structure in solution is shown by the observation of this pattern of absorption by the cupric compounds of the following acids : acetic, propionic, butyric, *iso*butyric, *n*- and *iso*-valeric, pivalic, caproic, octoic, lauric, stearic, β-chloropropionic, β-phenylpropionic, phenylacetic and crotonic.

The resistance of cupric formate to the formation of the dimeric structure has been studied by Martin and Waterman[7], who observed the characteristic absorption pattern in 90 per cent aqueous formic acid solution and in formic acid/acetone, the absorption bands being at 360 mμ, 745 mμ and 375 mμ, 675 mμ respectively. It now seems probable that the latter solution contains the formic acid solvate (I, R = H, L = HCOOH) and not, as they suggest, the acetone solvate and that the former contains a mixture of this with hydrated monomeric species.

D. P. GRADDON

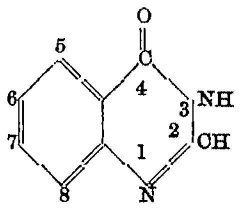
Inorganic Chemistry Department,
University of New South Wales,
Sydney.

---

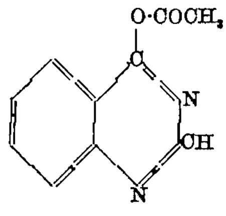
[1] van Niekerk, J. N., and Schoening, F. R. L., *Nature*, 171, 36 (1953).
[2] Martin, R. L., and Waterman, H., *J. Chem. Soc.*, 3545 (1957).
[3] Tsuchida, R., and Yamada, S., *Nature*, 176, 1171 (1955).
[4] Tsuchida, R., Yamada, S., and Nakamura, H., *Nature*, 181, 479 (1958).
[5] Martin, R. L., and Waterman, H., *J. Chem. Soc.*, 1394 (1958).
[6] Graddon, D. P., *J. Inorg. Nuc. Chem.*, 11, 337 (1959).
[7] Martin, R. L., and Waterman, H., *J. Chem. Soc.*, 1359, 2960 (1959).

Acetylation of 4-Quinazolone

THE sodium salt of 4-quinazolone[1] is known to give 3-substituted derivatives on alkylation[1]. In the hope of preparing 3-acetyl-4-quinazolone, the sodium salt of 4-quinazolone was subjected to acetylation. When carefully dried sodium salt of 4-quinazolone was made to react with acetyl chloride in dry dioxane, a colourless crystalline compound $C_{10}H_8O_2N_2$, was isolated. The same derivative was obtained by refluxing 4-quinazolone with large excess of acetic anhydride. Extreme care was necessary in excluding water during the preparation and purification of this compound.



I



II

The new compound has high lability towards water. Slight trace of water in the solvent or exposures to moist air decomposed it into 1 mole of 4-quinazolone and 1 mole of acetic acid even at room temperature.

The reduction of this labile compound with lithium aluminium hydride gave 4-quinazolone in good yield. As an N-acetyl group would be expected to give an

N-ethyl group and an O-acetyl group would be de-acetylated, the results of the lithium aluminium hydride reduction imply that the labile derivative is 4-acetoxyquinazoline (II).

R. Mirza

Akers Research Laboratories,
Imperial Chemical Industries, Ltd.,
Welwyn, Hertfordshire.
April 19.

---

[1] Elderfield, R. C., "Heterocyclic Chemistry", 6 (Wiley, 1958).

BIOCHEMISTRY

Development of 5-Hydroxytryptophan Decarboxylase Activity in Rat Kidney

The studies of Udenfriend and his co-workers[1] indicate that tryptophan is first oxidized to 5-hydroxytryptophan and then decarboxylated, resulting in the formation of 5-hydroxytryptamine. The latter reaction requires the presence of a specific enzyme, 5-hydroxytryptophan decarboxylase[2]. The purpose of the present communication is to describe the development of this enzyme system in the kidneys of fœtal, new-born, and adult rats.

In these experiments, albino rats of the Sprague–Dawley strain were used. All animals were killed by a sharp blow on the head and bled from the neck. The kidneys were removed and homogenized in 4 ml. of distilled water with a Potter–Elvehjem tissue grinder. Enzyme activity of kidney and adult rats was determined individually. In the case of rats younger than 21 days of age, the kidneys from litter mates were pooled and homogenized in 3 ml. of distilled water. The incubation mixture, consisting of 10 μmoles of 5-hydroxy-DL-tryptophan (Sigma Chemical Company) in 2·7 ml. of 0·1 *N* sodium pyrophosphate buffer, *p*H 8·0, was first gassed with nitrogen for 5 min. After agitation with nitrogen for 10 min., 0·3 ml. of rat kidney homogenate was added and the mixture was shaken in a nitrogen atmosphere at 38° C. in a Dubnoff metabolic incubator for a period of 2 hr. The reaction was stopped by the addition of 3·0 ml. of 10 per cent trichloracetic acid. After centrifugation, 3·0 ml. of the supernatant was removed, and the 5-hydroxytryptamine formed was determined by the colorimetric method of Udenfriend *et al.*[3]. All the experiments were carried out in duplicate. The results were expressed as μmoles of 5-hydroxytryptamine formed per 100 mgm. dry weight of kidney per hr.

Table 1 shows the 5-hydroxytryptophan decarboxylase activity of kidneys of rats of various ages. The results indicate that the enzyme was inactive in the fœtus and shortly after birth, and gradually increased to adult-levels over a period of several weeks.

Table 1. Kidney 5-Hydroxytryptophan Decarboxylase Activity in Rats of Different Ages

Age	No. of exp.	No. of animals	5-Hydroxytryptophan decarboxylase activity*
Fœtal†	3	45	0
1 day	3	23	0
2–5 days	4	24	0 21 ± 0 21
7–12 days	5	26	0·38 ± 0·10
21–23 days	7	21	0·66 ± 0·13
33 days	4	8	1 19 ± 0·47
Adults	14	14	1·34 ± 0·58

* Mean values expressed as μmoles 5-hydroxytryptamine formed per 100 mgm. of dry weight of kidneys per hr.
† 1–3 days before term.

Buzard and Nytch[4] have shown that pyridoxal phosphate is a co-factor for rat kidney 5-hydroxytryptophan decarboxylase. The possibility that the low activity of this enzyme in fœtal and new-born rat kidneys may be caused by a deficiency of this co-factor was tested by adding 0·1 and 0·8 μmole pyridoxal phosphate to the incubation mixture. Table 2 shows that although excess amounts of pyridoxal phosphate increased the formation of 5-hydroxytryptamine two- to three-fold in the older and adult rat kidney homogenates, as has previously been reported[4], the addition had only a minimal effect in the fœtal and new-born homogenates. This was also tested *in vivo* by the intraperitoneal injection of 50 mgm. of pyridoxine hydrochloride to a pregnant rat three days prior to delivery. Assay of 5-hydroxytryptophan decarboxylase in the new-born rat kidney homogenate in this litter failed to show any demonstrable enzyme activity.

Table 2. Effect of Pyridoxal Phosphate Supplementation upon 5-Hydroxytryptophan Decarboxylase Activity

Age	5-Hydroxytryptophan decarboxylase activity*		
	Without supplementation	0 1 μM PP added	0 8 μM PP added
Fœtal	0	0 09	0 15
1 day	0	0	—
2 days	0	0·19	0·19
3 days	0·40	0·43	0 62
11 days	0 44	0 62	0·71
21 days	0·83	3·10	—
21 days	0 78	2 85	—
23 days	0·65	1·56	1 77
Adult	1·34	3 01	—
Adult	0·82	2·38	—
Adult	0 65	1 84	—
Adult	0·69	1·62	1 57

* Mean values expressed as μmoles of 5-hydroxytryptamine formed per 100 mgm. dry weight of kidneys per hr.

Finally, reports have appeared showing the inhibition of 5-hydroxytryptophan decarboxylase by carbonyl reagents, metal chelating agents, cupric ions, phenylalanine derivatives, substituted indoles and norepinephrine. Because of this possibility, mixture experiments using rat kidney homogenates were carried out with the following results, expressed in terms of 5-hydroxytryptamine formed: 0·3 ml. fœtal homogenate, 0; 0·15 ml. fœtal and 0·15 ml. adult mixed, 0·40 μmole; and 0·3 ml. adult, 1·06 μmoles. In order to rule out the possibility of non-protein inhibitors, rat kidney homogenate from a young animal was boiled at 100° C. for 3 min. The supernatant had no effect on the 5-hydroxytryptophan decarboxylase activity in adult rat kidney. While this does not positively rule out the possibility of an inhibitor, the evidence would seem to suggest that the low activity of 5-hydroxytryptophan decarboxylase activity in fœtal and new-born rat kidney probably represents a low inherent activity of the enzyme itself[4].

A deficiency of 5-hydroxytryptophan decarboxylase in the fœtal rat kidney is of interest because of the part the enzyme plays in the central nervous system. For example, Amin *et al.*[5] have shown the synthesis of 5-hydroxytryptamine from its immediate precursor 5-hydroxytryptophan and that it is stored in particular regions of the grey matter of the brain[5]. In animal experiments, Feldberg and Sherwood[6] have described characteristic changes in behaviour following the injection of 5-hydroxytryptamine into the cerebral ventricles. The inhibition of 5-hydroxytryptophan decarboxylase by phenylalanine metabolites has also been demonstrated *in vitro*[7]. This may in part account for the lowered levels of circulating 5-hydroxytryptamine and urinary 5-hydroxyindoleacetic acid in patients with phenylketonuria. The pattern of development of this enzyme system in the fœtal brain and the part this may play in the central nervous system in phenylketonuria is being explored.

In any event, the decreased activity of 5-hydroxytryptophan decarboxylase in fœtal and new-born rat kidney can now be added to the growing list of enzyme deficiencies in the new-born period[8], which now includes glucose-6-phosphatase, glucuronyl transferase, histidase, and the hepatic tyrosine oxidation and phenylalanine *p*-hydroxylase system.

Acknowledgment is made of grants by the U.S. Public Health Service *M*-2630, and the Illinois Mental Health Fund.

IRENE HUANG
SHEILA TANNENBAUM
DAVID YI-YUNG HSIA

Genetic Clinic, Children's Memorial Hospital,
and Department of Pediatrics,
Northwestern University Medical School,
Chicago, Illinois.

[1] Udenfriend, S., Weissbach, H., and Bogdanski, D. F., *J. Biol. Chem.*, **224**, 803 (1957).

[2] Buxton, J., and Sinclair, H. M., *Biochem. J.*, **62**, 27*P* (1956).

[3] Udenfriend, S., Weissbach, H., and Clark, C. T., *J. Biol. Chem.*, **215**, 337 (1955).

[4] Buzard, J. A., and Nytch, P. D., *J. Biol. Chem.*, **229**, 409 (1957).

[5] Amin, A. H., Crawford, T. B., and Gaddum, J. H., *J. Physiol.*, **126**, 596 (1954).

[6] Feldberg, W., and Sherwood, S. L., *J. Physiol.*, **123**, 148 (1954).

[7] Davison, A. N., and Sandler, M., *Nature*, **181**, 186 (1958).

[8] Driscoll, S. G., and Hsia, D. Y.-Y., *Pediatrics*, **22**, 785 (1958).

Non-Enzymic Reactions of Indoles with Coenzyme I

IN the course of studies of possible enzymically catalysed reactions of coenzyme I (diphosphopyridine nucleotide) with 5-OH-tryptamine (serotonin), tryptamine and tryptophan[1], it was observed that these indoles react non-enzymically with coenzyme I. Thus, when 5-OH-tryptamine was added to a solution of coenzyme I, an intense yellow coloration appeared. Tryptamine and tryptophan also reacted in the same manner, but larger concentrations of the latter substances were required in order to give the same intensity of colour. Spectral characteristics of the coloured materials are shown in Fig. 1.

The intensity of the colour developed (in the region 450–310 mμ) depended on the *p*H, the concentration of coenzyme I and the concentration of the indoles. At very low *p*H values, interaction occurred only to a very limited extent, as judged from the intensity of the colour. In the *p*H range 4–8, differences in the colour intensity of equally concentrated reaction mixtures were very small. At higher *p*H values, and with serotonin as a reactant, the intensity of the colour developed increased rapidly. Although formation of the coenzyme I–tryptamine complex rendered this base soluble even at *p*H values above the *pK'* (about 9·7) for the protonation of its aliphatic amine, it was difficult to carry out quantitative work with tryptamine in this *p*H range (that is, above *p*H 9·0). With respect to the dependence of the colour intensity on the concentration of the reactants, Beer's law was followed within a wide range of variation of the concentration of either reactant. N-methylnicotinamide was found to react in a similar manner as coenzyme I with the indoles.

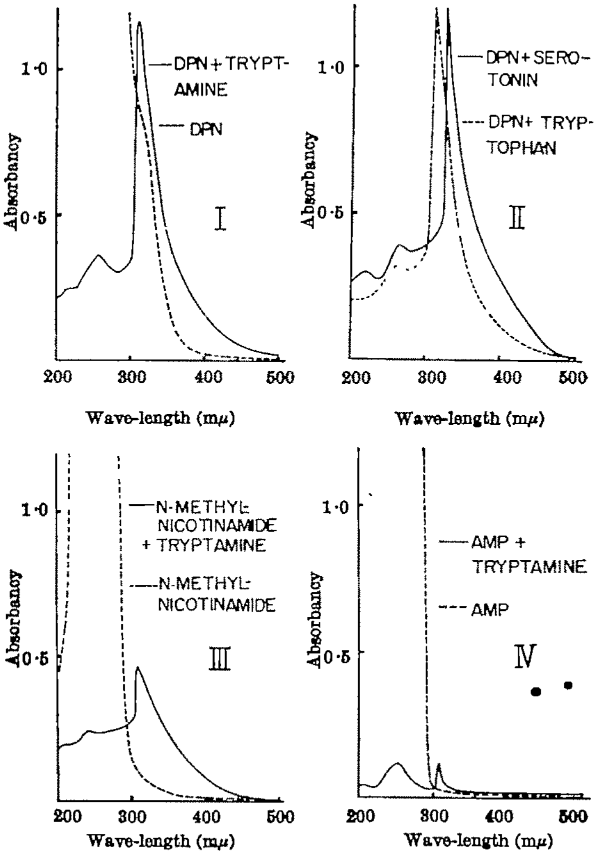


Fig. 1. Interactions of indoles with coenzyme I (DPN) (I and II); N-methyl-nicotinamide (III); and adenosine-5'-phosphate (AMP) (IV). These three compounds were used at concentrations of 5 μmoles per ml. Spectral lines in the absence of indoles correspond to differences (absorbancies) between the absorbance of buffered solutions of the three compounds (experimentals) and the absorbance of the buffer alone (blank). The various indoles were used at concentrations of 20 μmoles per ml. Spectral lines in their presence represent differences (absorbancies) between the absorbance of buffered indole-containing solutions of the three compounds (experimentals) and the absorbance of the respective buffered indole solutions (blanks). All systems were buffered with *tris*-hydroxymethylaminomethane/hydrochloric acid at *p*H 7·8 (400 μmoles per ml.). Absorbancies were taken with a DK_1 Beckman recording spectrophotometer

The experimental evidence indicates that a probable site of reaction of the indole nucleus is the pyrrolic nitrogen in its deprotonated form. The rise of the reactivity of the indoles with increasing *p*H (see above) further supports this view. Apparently, the pyrrolic nitrogen of the indoles acts as a nucleophilic agent, attacking an electrophilic centre in coenzyme I. The participation of the pyridine moiety of coenzyme I in the reaction is indicated by the similar reaction observed with N-methylnicotinamide. In analogy to known reactions of pyridinium structures (for example, coenzyme I) with a number of nucleophilic agents like cyanide[2,3], carbonyl compounds[4], imidazoles[5], etc., the reacting site of the nicotinamide moiety of coenzyme I is probably C4. However, in addition to changes in the visible and near ultra-violet region, the reaction mixtures exhibited also profound changes in the far ultra-violet region of the spectrum. For example, the theoretical absorbancy of a coenzyme I solution containing 5 μmoles per ml. at 260 mμ would be about 90·000 (ref. 6). As shown in Fig. 1, I, the value obtained when a coenzyme I–tryptamine solution was read against an equally concentrated solution of tryptamine was about 0·370, corresponding to a decrease of approximately 243 times. The theoretical absorbance of a tryptamine solution containing 20 µmoles per ml. at 260 mµ would be about 65·000. This creates difficulties in explaining the drop of absorbancy solely on the basis of changes of the indole in the coenzyme I–tryptamine mixture. Since similar changes in the far ultra-violet spectrum are also observed in adenosine-5′-phosphate–tryptamine mixtures (Fig. 1, IV), the adenine moiety of coenzyme I seems to be involved in these interactions.

Attempts to isolate the products (complexes) of these interactions and study their properties are now in progress.

This work was supported in part by Grant No. *E*-2436 from the National Institute of Allergy and Infectious Diseases, National Institutes of Health, United States Public Health Service, Grant No. *G*-7644 from the National Science Foundation, Washington, D.C., and Grant No. *P*-241 from the American Cancer Society, Inc.

S. G. A. ALIVISATOS
G. A. MOURKIDES
A. JIBRIL

Mount Sinai Medical Research Foundation
and Hospital, the Chicago Medical School,
Chicago, Illinois. Dec. 22.

[1] Alivisatos, S. G. A., in "Mechanisms of Hypersensitivity" edit. by Shaffer, J. H., LoGrippo, G. A., and Chase, M. W., 259 (Little, Brown and Co., Boston, 1959).
[2] Meyerhof, O., Ohlmeyer, P., and Mohle, W., *Biochem. Z.*, **297**, 113 (1938).
[3] Colowick, S. P., Kaplan, N. O., and Ciotti, M. M., *J. Biol Chem.*, **191**, 447 (1951).
[4] Burton, R. M., San Pietro, A., and Kaplan, N. O., *Arch. Biochem, Biophys.*, **70**, 87 (1957).
[5] Van Eys, J., *J. Biol. Chem.*, **233**, 1203 (1958).
[6] Kornberg, A., and Horecker, B. L., in "Biochemical Preparations", **3**, 23, edit. by Snell, E. E. (J. Wiley and Sons, New York, 1953).

Nonulosaminic Acid (Sialic Acid) in Protists

NONULOSAMINIC ACID[1], a group of simple and substituted 9-carbon sugars containing nitrogen, was thought restricted to mammals until it was found in the supernates of *Escherichia coli* and *Citrobacter freundii* cultures, but not in the supernates of *Salmonella*, *Shigella*, *Pneumococcus* or *Bacillus* cultures[2]. Nonulosaminic acid has now been found in the cells of *E. coli*[3], *Neisseria meningitidis*, *Salmonella dahlem*, and *S. djkarta*[4].

We have examined thirty species of protists for nonulosaminic acid. A minimum of 100 mgm. of cells, dried at 60° C., were hydrolysed in 1 *N* sulphuric acid for 1 hr. at 100° C. and at a concentration of 10 per cent (w/v) : 0·2 ml. of the hydrolysate was analysed for nonulosaminic acid by the Warren method[5]. Presence of nonulosaminic acid was confirmed by descending paper chromatography of the Warren chromophore with 10 per cent ethanol in water as solvent. The interfering deoxyribose chromophore remains at the starting line and fluoresces white with a Wood's lamp ; the nonulosaminic acid chromophore, R_F 0·11, fluoresces pink.

Nonulosaminic acid was found only among the Gram-negative bacteria (Table 1).

From the meagre information available nonulosaminic acid is limited to Gram-negative bacteria.

Table 1. PRESENCE OF NONULOSAMINIC ACID IN PROTISTS

Schizomycetes	Gram reaction	Acid content
Pseudomonadales		
Pseudomonas salinaria	–	–
Thiobacillus thioxidans	–	–
" *thioparus*	–	–
Rhodopseudomonas palustria	–	+
" *spheroides*	–	++
Chlorobium limicola	–	+
Eubacteriales		
Escherichia coli	–	++
Aerobacter aerogenes	–	++
Proteus vulgaris	–	+
Klebsiella pneumoniae	–	++
Lactobacillus leichmannii	+	–
Bacillus stearothermophilus	+	–
" *subtilis* (four strains)	+	–
" *megaterium*	+	–
" sp. (three strains)	+	–
Sarcina lutea	+	–
Myxobacteriales		
Cytophaga sp.	–	+
Beggiotales		
Leucothrix mucor		–
Ascomycetes		
Brewers' yeast		–
Saccharomyces carlsbergensis		–
Algae		
Cyanidium calidarum		–
Anacystis nidulans		–
Synechococcus sp.		–
Protozoa		
Euglena gracilis		–
Ochromonas malhamensis		–
" *danica*		–
" *minuta*		–
Crithidia fasciculata (two strains)		–
Tetrahymena pyriformis		–

++, More than 2 per cent nonulosaminic acid ; +, 1–2 per cent ; –, acid not detected.

Gram-negative bacteria share common features besides the Gram reaction ; they elaborate endotoxins causing hæmorrhage in mouse tumours[6] and substances which inhibit agglutination of human blood groups[7]. Should nonulosaminic acid be generally distributed among Gram-negative but not Gram-positive bacteria it would be useful as a phylogenetic marker, especially if it should prove to have a very restricted distribution among Gram-positive bacteria. This is under study.

We thank the U.S. Public Health Service for financial support, Dr. Donald Watson of the Rackham Arthritis Unit, University of Michigan, for a sample of pure nonulosaminic acid, and Drs. K. Eimhjellen, J. Gibson, C. Van Baalen, and W. Vishniac for generous samples of some of the protists studied.

S. AARONSON*
T. LESSIE

Biology Department,
Queens College, Flushing 67, New York,
and Haskins Laboratories, Inc.,
305 East 43rd Street,
New York 17.

* National Science Foundation, Science Faculty Fellow.

[1] Stacey, M., *Endeavour*, **19**, 43 (1960).
[2] Barry, G. T., *Nature*, **183**, 117 (1959).
[3] De Witt, C. W., and Row, J. A., *Nature*, **184**, 381 (1959).
[4] Barry, G. T., Tsai, T., and Chen, F. P., *Nature*, **185**, 597 (1960).
[5] Warren, L., *J. Biol. Chem.*, **234**, 1971 (1959).
[6] Hutner, S. H., and Zahl, P. A., *Proc. Soc. Exp. Biol. Med.*, **52**, 364 (1943).
[7] Springer, G. F., *J. Immunol.*, **76**, 399 (1956).

Changes in the Levels of Adenosine Triphosphate and Glycogen in the Liver caused by Protein Administration

DURING a study of the influence of diet on adenosine nucleotide metabolism in the liver of the rat, we have observed that the concentration of adenosine triphosphate in the livers of well-fed animals falls rapidly when they are given a meal of protein. This change

Table 1. Effect of Previous Level of Energy Intake and of Protein Administration on the Concentration of Adenosine Triphosphate and of Glycogen in the Liver of the Rat

Preceding diet	State when killed	Adenosine nucleotides (μmoles/gm. liver)			Glycogen (gm./100 gm. liver)
		Adenosine triphosphate	Adenosine diphosphate	Adenosine monophosphate	
Low energy	Fasting 10 hr.	0·57 ± 0·07	0·92 ± 0·08	2·16 ± 0·07	—
High energy	Fasting 10 hr.	1·65 ± 0·16	0·91 ± 0·08	1·45 ± 0·12	2·3 ± 0·3
High energy	Fed casein 2 hr. before killing	0·45 ± 0·06	0·94 ± 0·16	1·68 ± 0·11	0·6 ± 0·2

On the day of killing, the rats were fed meals of low or high energy content at 9 a.m. and were killed at 7 p.m. Some of the animals on the high energy intake were also fed 2·5 gm. casein at 5 p.m. The adenosine nucleotide data are the means (± *S.E.*) of three experiments, and the glycogen data are the means (± *S.E.*) of six experiments. The adenosine triphosphate concentration for the high energy fasting group was significantly greater than that of the other two groups ($P < 0·01$) and the adenosine monophosphate concentration was significantly lower than that of the low energy group ($P < 0·01$), when analysed by the '*t*' test for differences between groups. The glycogen content of the liver was significantly reduced by protein administration ($P < 0·01$). All other differences were not statistically significant ($P > 0·05$).

is associated with a reduction in liver glycogen content.

Female albino rats weighing approximately 180 gm. were fed twice daily on synthetic diets similar to those used by us in previous experiments[1]. At 9 a.m. they ate 1 gm. of a vitamin–mineral–roughage mixture and 5 gm. of carbohydrate. At 5 p.m. they received 4·2 gm. of a protein–carbohydrate–fat mixture. The total diet of these animals provided 41 kcal./day and in Table 1 they are referred to as the high-energy group. Some animals were fed on the same diet without the carbohydrate in the morning meal. These rats received a total energy intake of 21 kcal./day and are referred to as the low-energy group. The rats rapidly learned to eat these meals promptly and, after a few days, the evening meal was omitted and animals from each group were killed at 7 p.m. in the fasting state, that is, 10 hr. after they had eaten a morning meal which either provided abundant energy as carbohydrate or else contained very little energy. In addition, some of the group on the high-energy intake were given 2·5 gm. of casein (Glaxo), which was made into a paste with 0·1 gm. sodium bicarbonate and was fed 2 hr. before killing. In this way, livers were obtained from three groups of animals: (*a*) a group fasting after a meal low in energy content; (*b*) a group fasting after a meal rich in energy content; (*c*) a group on the higher level of energy intake which were actively absorbing amino-acids from the gut at the time of death.

The livers were analysed for adenosine nucleotides (adenosine tri-, di- and mono-phosphates) by methods described previously[1]. The results (Table 1) confirm our earlier observation[1] that the energy content of the diet has a decisive influence on the concentrations of adenosine nucleotides in the liver. Comparison of the data for the two fasting groups shows that, even although 10 hr. had elapsed since consumption of the last meal, the livers of the rats receiving the higher energy intake had a considerably greater concentration of adenosine triphosphate and a smaller concentration of adenosine monophosphate. However, casein administration 2 hr. before death caused the adenosine triphosphate concentration in the livers of this group to fall to the level observed among animals on the low-energy intake. This was accompanied by a slight increase in adenosine monophosphate concentration which was not statistically significant.

In a separate series of experiments, we observed the effect of these dietary conditions on the glycogen content of the liver. Glycogen was extracted from the liver with 30 per cent potassium hydroxide, precipitated with ethanol and estimated by the anthrone procedure[2]. This showed (Table 1) that rats fasting 10 hr. after receiving the high-energy diet still had a considerable amount of glycogen in their livers, but when animals on this diet received casein 2 hr. before death, a large reduction in liver glycogen content occurred.

Thus the absorption of products of protein digestion causes a marked decrease in the concentration of certain constituents involved in energy metabolism in the liver. These changes occur at an early stage in the absorption process, since it was observed in these experiments that the bulk of the ingested casein was still present in the stomach at the time of killing.

Catherine M. Clark*
G. A. J. Goodlad

Department of Biochemistry,
University of St. Andrews.

J. Chisholm
H. N. Munro

Department of Biochemistry,
University of Glasgow.

[1] Goodlad, G. A. J., and Munro, H. N., *Biochem. J.*, 73, 343 (1959).
[2] Trevelyan, W. E., and Harrison, J. S., *Biochem. J.*, 50, 298 (1952).

Reversible Transformation of Gelatin to the Collagen Structure

The conversion of soluble collagen (tropocollagen, procollagen, acid-extract collagen) to gelatin has been shown to involve the separation of the three-chain coiled-coil structure of the collagen molecule into single peptide chains[1,2] each having the disordered random-coil configuration. The universal experience with gelatins has been that these disordered chains could not be returned to the complete native collagen structure, although optical rotation, polarized infrared, and wide-angle X-ray diffraction studies of cooled gelatin solutions or gels showed that partial ordering and helical folding of the chains could occur in localized regions[3,4]. The principal factor ruling against the complete reversibility of the collagen–gelatin transition was the requirement for the proper juxtaposition and recoiling of the three complex peptide chains.

Recent studies of the collagen degradation process[5,6] and the structure of high molecular weight gelatins[7,8] gave indirect evidence that some features of the structure, and particularly the interchain cross-linkages present in native insoluble collagen, might be retained in the soluble degradation products. This suggested to us that if the relative peptide chain alignments were retained near the cross-linkage sites, treatments which induced the collagen fold might give rise to ordered collagen-like fibres. We have carried out such experiments and have produced ordered collagen-like fibres.

Our standard for judging whether we had achieved recovery of the long-range collagen structure from gelatin solutions was the preparation of fibrous precipitates that exhibited the cross-striated pattern typical of native collagen fibres when viewed in the electron microscope. The only possibility for the misinterpretation of such observations was that some collagen fibres might have been peptized by the gelatin and carried through the extraction and recovery procedures. We believe that the sequence of experimental steps outlined below eliminated this possibility of misinterpretation of the electron micrographs.

Native bull-hide corium collagen, purified as described previously[9], was extracted in an isoionic suspension (pH ~ 6·0) at 60° for 1 hr. The contraction temperature of this collagen preparation was 55·8–60·6° for individual fibres[6]. The solution of solubilized gelatin (~ 7 per cent)[5] was filtered through sintered glass and then fractionated by an ethanol–sodium chloride coacervation technique[6] into six successive fractions. Any suspended collagen carried along through the filter was precipitated with the first fraction. The remaining fractions were collected and the coacervates were dissolved in warm water (40–45°). The gelatin was recovered from these solutions by precipitation with acetone. These precipitates were washed with cold water, then redissolved at 40°, and reprecipitated with acetone. The third fraction, which contained neither the lowest nor the highest molecular weight material, was chosen for the following recovery experiments.

The dried acetone precipitate was dissolved in 0·1 M potassium chloride at 40° by shaking for 1 hr. The solution, $[\alpha]_D^{40} = -136°$, was clarified by centrifugation in a Spinco preparative ultracentrifuge for 1½ hr. at 144,000g and room temperature. A small, translucent gelatinous sediment was discarded. The clear solution was transferred immediately to a cold room at 4° and was kept there for 20 hr. The solution set to a firm clear gel. The gel was placed in a 40° bath and held there without shaking. Within 12 min., as the gel melted, a fine turbidity developed and within 1 hr. floccules appeared. These were collected by low-speed centrifugation at room temperature. The precipitate was white and fibrous in contrast to the translucent gel obtained in the earlier higher-speed centrifugation. The clear supernatant gelled when cooled to 4° but remained clear when rewarmed.

The fibrous precipitate was examined in an electron microscope and clearly showed (Fig. 1) the typical collagen cross-striations. The fibre width, however, was variable, and the characteristic periodicity averaged about 610 Å. The fibres were readily soluble in 6·0 M urea at room temperature but could be held indefinitely at 40° in water or in dilute salt solution. This behaviour of the heat-precipitable gelatins resembles that of neutral salt-soluble collagen.

The fibres represented about 10 per cent of the protein content of the fraction III solution that remained after the initial high-speed centrifugation. The low negative optical rotation of this solution indicated the absence of the collagen helical structure in the dissolved gelatin molecules.

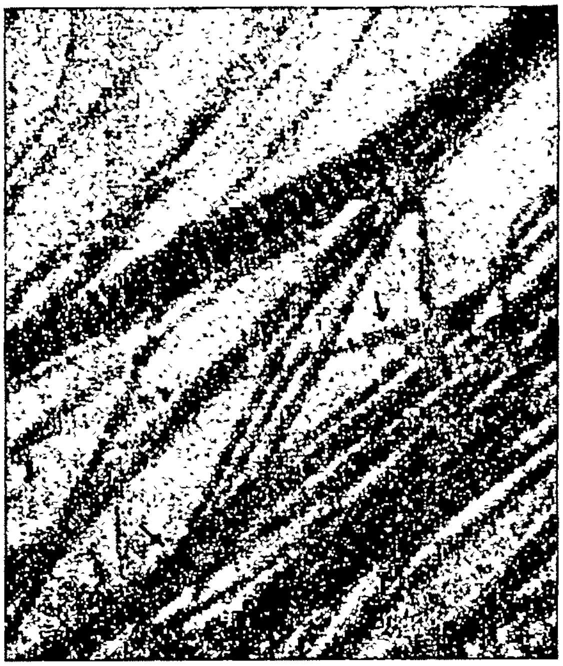


Fig. 1. Electron micrograph of fibres obtained from Fraction III gelatin. Chromium shadowed (× 38,700). The main periodicity is 610 Å., but there is also clearly visible a definite sub-periodicity (arrows) of ~ 210 Å. in the thinner fibrils

Attempts have been made to prepare fibrous precipitates by this and similar procedures with both commercial and other specially prepared gelatins. Only those shown by characterization studies to have the multi-chain structure, and therefore to contain strong interchain cross-linkages, yielded fibrous precipitates. These observations are interpreted as verification of our earlier suggestion that high-molecular weight gelatins are cross-linked networks rather than completely random coils[5,6,8]. Since the chains are held in the proper register whereby they can be re-ordered to the native configuration, the cross-linkages must be inherent in the insoluble collagen and not randomly induced by the degradative treatment.

The quantitative aspects of these experiments are being examined. These, and the necessary characterization studies, will be described in more detail elsewhere.

We are indebted to Dr. L. S. Fosdick of the Northwestern University Dental School for so generously allowing us to use his electron microscope facilities.

Arthur Veis
Jerome Cohen

Central Research Laboratories,
Research Division,
Armour and Co.,
Chicago 9.

[1] Gallop, P. M., *Arch. Biochem. Biophys.*, **54**, 486, 501 (1955).

[2] Boedtker, H., and Doty, P., *J. Amer. Chem. Soc.*, **78**, 4267 (1956).

[3] Robinson, C. H., "Nature and Structure of Collagen", 96 (Academic Press, New York, 1953).

[4] Bear, R. S., "Adv. in Protein Chemistry", **7**, 69 (1952).

[5] Veis, A., and Cohen, J., *J. Amer. Chem. Soc.*, **78**, 6238 (1956).

[6] Veis, A., and Cohen, J., *J. Phys. Chem.*, **62**, 459 (1958).

[7] Courts, A., and Stainsby, G., "Recent Advances in Gelatine and Glue Research", 100 (Pergamon Press, 1957).

[8] Veis, A., Anesey, J., and Cohen, J., "Recent Advances in Gelatine and Glue Research", 155 (Pergamon Press, 1957).

[9] Veis, A., and Cohen, J., *J. Amer. Chem. Soc.*, **77**, 2364 (1955).

PHARMACOLOGY

Milk-ejecting Action of Ergot

It is known that adrenalin inhibits milk ejection[1]. In an attempt to determine whether this inhibition is central or peripheral a series of experiments were performed on rats. The effect of prior administration of ergotamine on the adrenalin-induced black was studied. In the course of this investigation it appeared that ergotamine and ergometrine also had a milk-ejecting action of their own. This property of ergot causing milk ejection does not appear to have been described before.

Milk ejection has been assessed by the increase in weight after suckling of the young rats (8–10 days after birth) separated overnight. Adrenalin as well as atropine and alcohol block the ejection of milk in rats by preventing the release of oxytocin (personal observation). Adrenalin in doses of 1 μgm. and more when administered intraperitoneally always inhibits the milk-ejecting reflex, but when ergotamine ('Gynergen' Sandoz, Ltd.) or ergometrine (Sandoz, Ltd.) is administered to the mother (200–250 gm.) in doses of 50–100 μgm. intraperitoneally half an hour before the administration of adrenalin there is no inhibition of milk ejection. When the lactating mothers were injected with an ergot preparation just prior to suckling the litters gained more weight after suckling than they did normally. The fact that ergometrine also, in addition to ergotamine, has this property of causing milk ejection indicates that ergot does so, not by specifically reversing the action of adrenalin but by itself causing milk ejection. When adrenalin and ergotamine are administered simultaneously to the mother just before suckling there is no inhibition of milk ejection. The action of ergometrine and ergotamine was then studied on six litters where the milk ejection reflex had been blocked by prior administration of atropine (60–120 μgm. intraperitoneally immediately before suckling) and 7·5 per cent alcohol (5 ml./100 gm. body-weight orally 30 min. prior to suckling). It was found that when ergotamine or ergometrine was administered to the mother just prior to suckling neither alcohol nor atropine caused any inhibition of milk ejection. Normally a dose of 3–10 μgm. atropine causes a complete inhibition of milk ejection which can only be reversed by oxytocin. Fig. 1 shows the increase in weight of a litter after suckling when no drug was administered as compared to the increase in weight of the same litter on another day when adrenalin (1 μgm.) and, on another day, adrenalin and ergometrine (50 μgm.) were administered just prior to suckling.

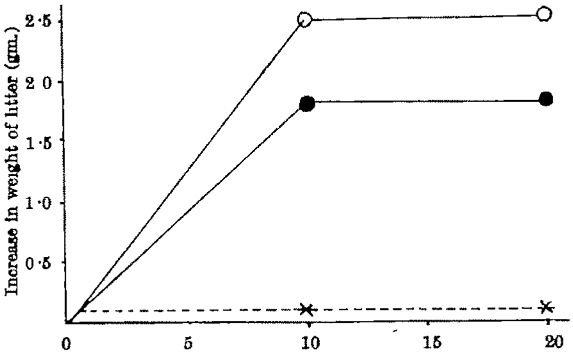


Fig. 1. Milk ejection in unanæsthetized rats. ○, No drug administered; ●, adrenalin (1 μgm.) and ergometrine (50 μgm.) intraperitoneally; ×, adrenalin (1 μgm.) intraperitoneally

The results described in brief indicate that ergot, in addition to its many actions, also causes milk ejection. It is unlikely that ergot causes milk ejection by releasing oxytocin, and we suggest that ergot, when administered to rats, has a direct action on the lactating myoepithelium and causes its contraction. Ergot has for long been known to possess an oxytocic action on the uterus, and it appears to possess another oxytocin-like action causing milk ejection.

Ranjit Roy Chaudhury
Mandakini B. Dikshit

Department of Pharmacology,
All India Institute of Medical Sciences,
Safdarjang,
New Delhi, 16.

---

[1] Cross, B. A., *J. Endocrinol.*, 9, 7 (1953).

Indian Substitutes of Male Fern in Pharmacognosy

Dryopteris filix-mas (L.) Schott, commonly known as the male fern, is a good tænicide and is included in the pharmacopœias of all countries and also in the International Pharmacopœia. India, with her vast resources of drug plants, has many indigenous species of *Dryopteris* growing in the Himalayas, although the true male fern is not indigenous. With the view of finding suitable Indian substitutes of the official drug, phytochemical and pharmacognostical investigations on the following 18 members of the family Aspidiaceae were carried out. *Dryopteris hirtipes* (Bl.) O. Ktze., *D. scotti* (Bedd.) Ching, *D. cochleata* (Don) O. Ktze., *D. barbigera* (Moore) O. Ktze., *D. serratodentata* (Bedd.) Hayata, *D. fibrillosa* (Clarke) Hand-Mzt., *D. rosthernii* (Diels) C. Chr., *D. paleacea* (Don) Hand-Mzt., *D. blanfordii* (Hope) C. Chr., *D. chrysocoma* (Christ) C. Chr., *D. ramosa* (Hope) C. Chr., *D. pulvinulifera* (Bedd.) O. Ktze., *D. splendens* (Hk.) O. Ktze., *D. sparsa* (Don) O. Ktze., *Ctenitis apiciflora* (Wall) Ching, *C. nidus* (Clarke) Ching, *Hypodematium crenatum* (Forsk) Kuhn, *Cyrtomium falcatum* Presl.

Chemical analyses have shown that all the species of *Dryopteris* (with the exception of *D. sparsa*) and both the species of *Ctenitis* contain filicin much above the official requirement (B.P. and U.S.P. require not less than 1·5 per cent of filicin in the crude drug). *Hypodematium* and *Cyrtomium* are practically useless. Of particular interest is the species *D. chrysocoma*, which contains the maximum amount of the active principle (4·3 per cent of filicin in the crude drug). This, together with three other species, namely, *D. ramosa* (3·8 per cent of filicin in the crude drug), *D. barbigera* (2·2 per cent of filicin in the crude drug), and *D. cochleata* (1·8 per cent of filicin in the crude drug), which grow prolifically in a wild state, could be commercially exploited to great advantage.

A valuable field test for species rich in the active principle is found to be a greenish tinge of the cut surface of the rhizome and stipe bases, which colour is retained long after drying. Species poor in this principle either show no colour or turn brown soon after cutting.

An intensive pharmacognostic study has revealed that the species containing oleoresin and filicin invariably show large schizogenously developed cavities within the ground-tissue of the rhizome and the petiole bases. Into these project one to several secretory glands. The species like *D. sparsa*, *Hypodematium crenatum* and *Cyrtomium falcatum* are devoid of these structures, and also the active principle. The secretory glands are of different shapes and sizes in different species but functionally similar. In both species of *Ctenitis* they are elongated cylindrical in contrast to the clavate or pyriform ones in *Dryopteris* species. The former type may probably characterize the genus *Ctenitis* but this requires confirmation by study of more species.

Anatomically, the rhizome and petiole show the usual fern structure. Some species are, however, characterized by the presence of dark patches of sclerenchyma (sclerotic nests) in the ground-tissue of either or both of these structures. These are found to serve as useful criteria for diagnosis. A key based on all the histological characters taken together is being formulated for the differentiation of the species.

P. N. Mehra
T. C. Mittal

Department of Pharmacognosy,
Panjab University,
Amritsar.

PHYSIOLOGY

Korotkov's Sounds: Action of the Heart

Development of work upon Korotkov's sounds, described by me[1], has led to the following explanation of the action of the human heart.

The right and left sides of the heart should each be regarded as the mechanical analogue of a reflex klystron, such as described by Bleaney and Bleaney[2]. The right and left atria on one hand and the pulmonary sinuses and the aortic sinuses on the other constitute cavity resonators wherein contraction and dilatation of the walls and apertures generate force fields through which flows the blood. The action of the left side of the heart will be described in the first instance, although that of the right side is similar.

The function of the left atrium is to set the blood into motion; that of the orifice of the mitral valve is to produce velocity modulation of the stream entering the left ventricle during diastole. The cavity of the ventricle is a drift space in which fast particles of blood travel farther from the mitral valve than slow particles, before being brought to a halt on the completion of ventricular diastole. It is assumed that at the onset of atrial systole, the ring of the mitral valve is of somewhat less diameter than at the end of atrial systole; throughout atrial systole the diameter of the ring increases so that the velocity of the stream decreases.

The blood impinges upon the ventricular wall, by which it is reflected and focused upon the aortic valve. The correct angle of incidence is maintained by the papillary muscles and chordæ tendinæ attached to the mitral valve which guides the flow. At ventricular systole, blood that has travelled farthest is exposed to accelerating force for longer time than blood that has travelled a shorter distance to gain contact with the ventricular wall and, after reflexion, the former is still equivalent to fast particles; the latter to slow. Because of the greater excursion, fast particles are retarded in transit and join slow particles, likewise reflected, which pass through the mitral valve half a period later. This results in alternate attenuation and bunching of the stream flowing through the aortic valve and in the aortic sinuses.

Variations of diameter of the ring of the aortic valve, visible on cardio-angiography, have the effect of accelerating the attenuations and retarding the bunches, this constituting density modulation. In an ordinary fluid, of which the bulk modulus of elasticity is high, very slight variations of density would occur in these circumstances. With blood, however, it is probable that gas bubbles form inside the envelope of the red blood corpuscles, permitting an appreciable 'compressibility'. The pressure, of course, will rise with increase of density and conversely.

More power is taken from the stream during the retardations than is lost during the accelerations, with a gain which is utilized to maintain resonance in the aortic sinuses and a pulsatile flow in the coronary arteries. In addition, there is a shock wave, transmitted by the aorta and coronary arteries, arising from the forces of cavitation in the aortic sinuses.

By analogy from the klystron, the mitral and aortic valves will be out of phase by $(n + \frac{3}{4})$, where n is an integer or zero. Closure of the mitral valve does not coincide with the state of smallest diameter of its orifice, the peculiar structure of the valve making this possible. The aortic valve, on the other hand, closes when the diameter of the ring of the valve is least, accounting for the differing arrangement of the cusps.

It will be seen that the mitral valve is acting as a buncher, the aortic valve and sinuses as a catcher, corresponding to the resonators of the klystron, which are so named. More generally, these functions would appear to be subserved, respectively, by the sinospiral and bulbospiral embryological systems of the heart. The tubular heart, from which the 'reflex heart' develops, is presumably analogous to a straight-through klystron.

The iron-containing substance in cardiac muscle is probably of the nature of a Berthillode compound, for an explanation of which term reference may be made to Partington[3]. On the flow of oxygenated blood through the coronary system, following systole, the lattice-work of the compound increases in diameter as it takes up oxygen, thus increasing the volume of the cavity of the ventricle in an active manner. The shock wave of the second heart sound overcomes thyxotropism in the cardiac musculature, so facilitating ventricular diastole.

Energy from the main blood stream is fed back into this mechanism through the coronary arteries, which also supply the wall of the atrium and the musculature of the mitral orifice, whereby the resonators are coupled.

The two systems will now be assumed to be over-coupled so that the heart is regarded not only as an oscillator but as possessing also the property of self-oscillation. Regeneration is effected through the oxidation of carbohydrate, a process which provides energy to drive the ventricles, or repellors, removing oxygen from the lattice-work which shrinks during systole.

A function of the autonomic nervous supply to the heart is that of tuning the resonators, which is assisted by the apposition of the aortic and mitral valves. In a klystron, separate resonators are difficult to tune: correct phasing is essential in such a device and more easily achieved by the reflex principle.

The right atrium and ventricle behave in a manner similar to the left with the exception that power, taken from the stream, is transmitted solely as a pressure wave by the pulmonary artery. The tricuspid valve acts as a buncher while the pulmonary valve and sinuses act as a catcher, each being in phase and paired to form a set with the corresponding valve of the left side. On each side, the shock wave of the first heart sound overcomes thyxotropism of the atrium.

The wave-mode of the oscillator is stabilized by the conducting system of the heart, which is comparable to the strapping of a magnetron. Mode jumps occur in extrasystole, differing values of n explain the varying grades of heart block but variation of each element of the $(n + \frac{1}{2})$ phase rule is also physiological.

J. E. MALCOLM

Royal Air Force Hospital,
Ely.

[1] Malcolm, J. E., "The Blood Pressure Sounds and their Meanings" (William Heinemann Medical Books, Ltd., London, 1957 and 1959).

[2] Bleaney, B. I., and Bleaney, B., "Electricity and Magnetism" (Clarendon Press, Oxford, 1957).

[3] Partington, J. R., "General and Inorganic Chemistry" (Macmillan and Co., Ltd., London, 1958).

Potential Oscillations in the Lower Olfactory Pathway of the Toad

IN the olfactory bulb of the hedgehog and the rabbit, Adrian[1,2] found that the potential waves evoked by olfactory stimulation take shapes of potential oscillation. It was presumed that the waves were developed by synchronized activity in the dendritic region of the bulb. Later, he[3] recorded the similar potential in the olfactory epithelium of the rabbit, and found that the potential pattern in the epithelium has all the features of that appearing in the bulb. In the experiment, Adrian[3] did not record the potentials in the epithelium and the bulb simultaneously; but from the similarity he presumed that the mechanism which produces the potential oscillation in the bulb originates in the olfactory epithelium. In the olfactory epithelium of the frog, Ottoson[4] found that rhythmic waves sometimes superimpose on the crest of the slow potentials produced by odour stimulation. He presumed that they are identical to the potential oscillations found by Adrian[1–3].

Since the toad (*Bufo vulgaris japonicus*) has long olfactory nerves, potentials can be recorded in the olfactory epithelium, nerve and bulb simultaneously. By olfactory stimulation, potential oscillations appeared in these tissues as well (Fig. 1). Those which appeared in the olfactory nerve and bulb are identical with one another in frequency, phase and shape. Consequently, it is apparent in the toad that the potential oscillations in the bulb originates in, or before, the olfactory nerve. However, the similar potential oscillations have never been found in the olfactory epithelium of the toad. Thus, our finding in the toad partly supports Adrian's assumption. On the other hand, the potential oscillation in the olfactory epithelium of the toad usually appeared superimposed on the slow potential which was reported by Takagi and Shibuya[5–7]. It has higher frequency than the potential oscillations in the nerve and bulb, and is different in shape from the latter ones. Besides, it always began to appear some time after the beginning of the latter ones. It often appeared even after the latter ones had nearly disappeared, when stimulation was very short. In these points, the potential oscillation in the olfactory epithelium of the toad entirely differs from those in the olfactory nerve and bulb. The former oscillation closely resembles the rhythmic wave found by Ottoson[4] in the olfactory epithelium of the frog (*Rana temporaria*). Though we could not find the similar wave in the frog (*Rana nigromaculata*), it is supposed that the rhythmic wave found in *Rana temporaria* is identical to that in the olfactory epithelium of the toad. From these findings in the toad, it is concluded that there are two kinds of potential oscillations in the lower olfactory nervous system, and that they are mutually of indifferent origin and nature.

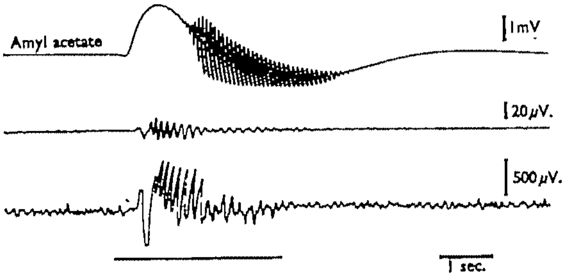


Fig. 1. Two types of potential oscillations. Top, a potential oscillation appearing on the falling phase of the slow potential; middle, a potential oscillation recorded in the olfactory nerve; bottom, a potential oscillation recorded in the olfactory bulb. It is noted that the first half of the potential in the olfactory bulb is identical in frequency, phase and shape with the one in the olfactory nerve, but is entirely different from the one in the olfactory epithelium. The horizontal line on the left below indicates olfactory stimulation

Full details of this work will be published elsewhere.

S. F. TAKAGI
T. SHIBUYA

Department of Physiology,
School of Medicine,
Gunma University,
Maebashi, Japan.
Dec. 22.

[1] Adrian, E. D., *J. Physiol.*, 100, 459 (1942).

[2] Adrian, E. D., *Electroenceph. Clin. Neurophysiol.*, 11, 377 (1950).

[3] Adrian, E. D., *J. Physiol.*, 128, 21,P (1955).

[4] Ottoson, D., *Acta Physiol. Scand.*, 35, Supp. 122 (1956).

[5] Takagi, S. F., and Shibuya, T., *Nature*, 184, 60 (1959).

[6] Takagi, S. F., and Shibuya, T., *Jap. J. Physiol.*, 10 (in the press).

[7] Takagi, S. F., and Shibuya, T., *Jap. J. Physiol.*, 10 (in the press).

Saliva-Serum Ratios of Tritium after the Administration of Tritiated Water

Taggart and Hytten[1] reported results which indicated that the salivary glands can concentrate deuterium oxide above the level in serum of human subjects. They had administered deuterium oxide orally to normal pregnant women and found, 3 hr. later, saliva–serum ratios ranging from 1·05 to 1·34, and in one subject after 24 hr. they found a ratio of 1·39.

These results have considerable importance as they suggest that human salivary glands can differentiate between deuterium and hydrogen, and it would therefore be of interest to know if a similar effect occurs with tritium. In view of the paucity of information readily available[2] on this subject we decided to estimate the saliva–serum ratios of tritium 3 hr. after the administration of tritiated water in human subjects. The test was performed on 6 physically healthy subjects. 10 ml. of tritiated water containing 500 μc. tritium were given orally immediately before breakfast. 3 hr. later, samples of venous blood and saliva were collected. Water was obtained from serum and saliva by the technique described by Cooper *et al.*[3] and the tritium was estimated in a liquid scintillation counter.

Table 1

Sex	Age	Saliva water (c.p.s.)	Serum water (c.p.s.)	Ratio saliva–serum
F	38	68·6	68·0	1·01
F	45	67·7	67·5	1·00
F	35	54·4	55·6	0·98
M	32	53·8	52·6	1·02
M	36	63·5	64·2	0·99
M	34	59·5	59·3	1·00
Mean		61·25	61·20	1·00

Table 1 shows the results. The saliva–serum ratio at 3 hr. ranged from 0·98 to 1·02 with a mean of 1·00. Thus 3 hr. after its oral administration the tritium in the salivary gland has reached equilibrium with the water in the serum and there is no evidence that the salivary gland is able to concentrate tritium. If the differential concentration of deuterium oxide is related to the atomic weight of deuterium it would seem that this effect should be at least as equally marked with tritium.

Taggart and Hytten raised the possibility that some substance in saliva had distilled across with the water and affected the density of the distillate and thus the estimation of deuterium oxide by the falling drop method. In view of our findings, therefore, it would be useful to have the results of saliva–serum ratios of deuterium oxide estimated by mass spectrometry.

A. J. COPPEN
J. L. GIBBONS

Institute of Psychiatry,
Maudsley Hospital,
Denmark Hill,
London, S.E.5.

[1] Taggart, N., and Hytten, F. E., *Nature*, **184**, 457 (1959).

[2] Pinson, E. A., *Physiol. Rev.*, **32**, 123 (1952).

[3] Cooper, J. A. D., Radin, N. S., and Borden, C., *J. Lab. Clin. Med.*, **52**, 129 (1958).

Effect of Thyroxine and 2,4-Dinitrophenol on Levels of Ubiquinone and Ubichromenol in the Rat

THE observation by Aiyar *et al.*[1] that thyrotoxicosis in the rat is accompanied by an increase in liver ubiquinone prompts us to record our own related findings. We have investigated the effect of thyroxine and 2,4-dinitrophenol on both ubiquinone and ubichromenol-levels in the rat, using animals from a stock colony and also from a vitamin-E deficient colony. Female rats were used, aged 3–4 months in one experiment and aged 15 months in another. The animals were divided into groups of six, and test groups received thyroxine, thyroxine and α-tocopheryl acetate, or 2,4-dinitrophenol. After three weeks on test, the rats were killed, and their hearts and livers (each organ pooled with others from the same group) were analysed for ubiquinone and ubichromenol by the method of Diplock *et al.*[2].

Table 1. FEMALE RATS OF THE NORWEGIAN HOODED STRAIN WERE USED IN GROUPS OF SIX

In Exp. 1, the rats were 3–4 months old; in Exp. 2, 15 months old. The supplements were: Exp. 1, thyroxine, 2,4-dinitrophenol and α-tocopheryl acetate all at 25 μgm./gm. of diet; Exp. 2, thyroxine 5 mgm. and 2,4-dinitrophenol 1·25 mgm. divided into bi-weekly doses intraperitoneally

Exp.	Group treatment	Ubiquinone (μgm./gm.)		Ubichromenol (μgm./gm.)	
		Heart	Liver	Heart	Liver
1	Adequate vit. E control	205	127	4·4	80·6
	Adequate vit. E + thyroxine	179	342	8·4	119
	E-def. control	149	162	4·0	46·8
	E-def. + thyroxine	180	227	9·4	83·0
	E-def. + thyroxine + α-tocopheryl acetate	199	235	9·9	82·0
	E-def. + 2,4-dinitrophenol	241	182	25·5	69·5
2	E.-def. control	159	96	15·7	34·1
	E-def. + thyroxine	141	482	14·3	148
	E-def. + 2,4-dinitrophenol	143	114	14·4	47·4

The results are given in Table 1, the figures for ubiquinone and ubichromenol representing the total isoprenologue content[3] in each case.

In both rats receiving adequate vitamin E and those deficient in this vitamin, thyroxine produced large increases in the ubiquinone- and ubichromenol-levels in the liver, these increases being particularly marked in the older group of vitamin-E deficient rats. Indeed, the levels in the livers of the latter animals are considerably higher than any others so far observed by us in the course of several hundred tissue analyses. The effects of thyroxine on levels in the heart were less marked generally. The further supplementation of the thyroxine group with α-tocopheryl acetate produced no noticeable effects in these experiments. When 2,4-dinitrophenol was given to vitamin-E deficient rats in an amount equivalent to thyroxine on a molecular basis, little effect was observed; but, when larger, nearly toxic doses of 2,4-dinitrophenol were given, a sharp increase in ubiquinone and ubichromenol occurred in the heart, although the liver was relatively unaffected.

Although 2,4-dinitrophenol and thyroxine are both agents that uncouple oxidative phosphorylation, their mode of action is different. It is possible that the above effects on ubiquinone- and ubichromenol-levels *in vivo* may be related to this uncoupling activity and that the differences observed may reflect the difference in mode of action; alternatively, they may be caused simply by a differing uptake of thyroxine and 2,4-dinitrophenol by the heart and the liver. Whether the increases in ubiquinone and ubichromenol are due to enhanced synthesis or to less-efficient utilization of these lipids cannot be deduced from these experiments, but the results here are qualitatively different from those of other experiments on the specific influence of vitamin-E on the levels of ubiquinone in the rat, in which a direct effect on synthesis is more clearly indicated.

E. E. EDWIN
J. GREEN
A. T. DIPLOCK
J. BUNYAN

Walton Oaks Experimental Station,
Research Laboratories of Vitamins, Ltd.,
Dorking Road,
Tadworth, Surrey.

[1] Aiyar, A. S., Sulebele, G. A., Rege, D. V., and Sreenivasan, A., *Nature*, **184**, 1867 (1959).

[2] Diplock, A. T., Green, J., Edwin, E. E., and Bunyan, J., *Biochem. J.* (in the press).

[3] Diplock, A. T., Edwin, E. E., Green, J., Bunyan, J., and Marcinkiewicz, S., *Nature*, **186**, 554 (1960).

Influence of Temperature upon Blood Coagulation in a Cold- and a Warm-blooded Animal

THE influence of change of temperature upon the speed of blood clotting in warm-blooded animals is well recognized. Indeed, the fact that human plasma at 0° C. does not clot for several hours is utilized in some investigations in coagulation research.

If a similar depression of blood coagulation at low temperatures occurred in cold-blooded animals this would tend to make them unusually vulnerable to trauma during some part of their lives. This consideration led us to compare the influence of temperature on the clotting mechanism of a warm- and a cold-blooded animal.

Because of its ready availability, human blood was compared with that of the South African clawed toad *Xenopus laevis*. Human blood was collected by venepuncture and toad blood was obtained from the heart after the animal had been anæsthetized with ether. Considerable difficulty was at first experienced in obtaining adequate unclotted samples by methods involving direct cardiac puncture. To overcome this, the heart was exposed by a central skin excision, division of the pectoral girdle and opening of the pericardium. The animal was then placed on a wire netting (approximately 1 cm.^{2} network) with the heart dependent between the wires. In this way approximately 3 ml. could be collected into an underlying vessel within a few seconds of a deep scalpel incision into the ventricle. The contamination by tissue juices, although present, is probably minimal under these conditions and the sample appears preferable to that obtained after a lengthy and technically difficult cardiac puncture technique. The blood from three toads was pooled to make a single specimen.

All samples were collected in graduated siliconed centrifuge tubes with 3·8 per cent of sodium citrate in a proportion of nine parts of blood to one part of citrate solution.

The thromboplastin preparations were made from emulsified human brain and emulsified toad brain and spinal cord. The dilutions were adjusted to give a satisfactory one-stage prothrombin time with human and toad plasma respectively. The thromboplastin time (one-stage 'prothrombin' time) and the calcium clotting time estimations were performed as recommended by Biggs and Macfarlane[1], but in the latter test citrated whole blood was substituted for citrated plasma.

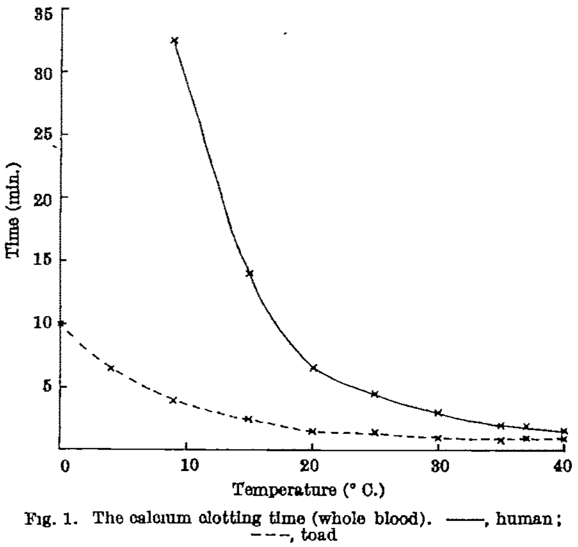


Fig. 1. The calcium clotting time (whole blood). ——, human; – – –, toad

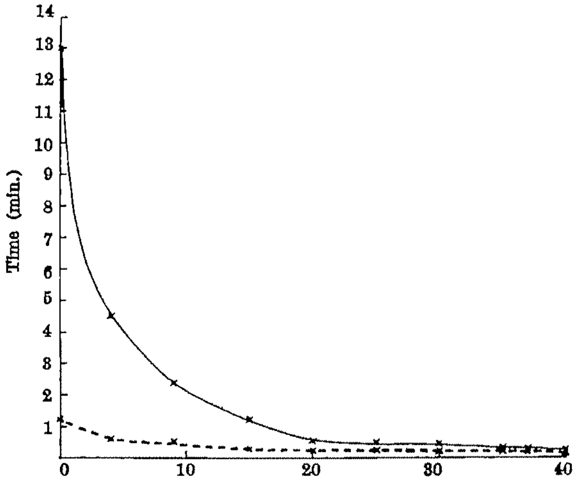


Fig. 2. Thromboplastin time (one-stage 'prothrombin' time). ——, human; – – –, toad

The results are shown in Figs. 1 and 2.

A determination of calcium clotting time was used in preference to one of whole-blood clotting time, because the latter would have required several fresh samples of blood, needing more than a single animal to cover the complete range of temperature being investigated. It therefore appeared desirable to test the clotting time of a single pooled citrated sample obtained from three animals after recalcifying at various temperatures.

In order to keep the platelet activity of the specimens as close to physiological conditions as possible, citrated whole blood rather than plasma was used in the estimations of the clotting time.

Quick[2] showed that tissue thromboplastin of a reptile (turtle) showed species specificity, when mixed with the plasma of warm-blooded animals. This specificity has been demonstrated with the amphibian used in this investigation. The thromboplastin times of human or toad plasma were therefore compared using human and toad brain emulsions respectively. Owing to the small size of the toad brain, the spinal cord was also included in the preparations.

From a comparison of the two curves in Fig. 1 it can be seen that the toad-clotting mechanism appears well adapted for functioning at low temperatures. Fig. 2 shows the influence of temperature on the thromboplastin time, which does not involve certain clotting factors, such as hæmophilic globulin, which are needed for active intrinsic thromboplastin formation. As with the recalcified whole blood clotting time the thromboplastin time in the cold-blooded animal appears comparatively unaffected by a temperature lowered below 10° C.

H. B. ANSTALL
Massachusetts General Hospital,
Boston, Massachusetts.

R. G. HUNTSMAN
Department of Clinical Pathology,
Guy's Hospital, London, S.E.1.

---

[1] Biggs, R., and Macfarlane, R. G., "Human Blood Coagulation and its Disorders" (Blackwell Scientific Publications, Oxford, 1953).

[2] Quick, A. J., *J. Biol. Chem.*, 123, xcix (1938).

Blood Glucose in Crayfishes in Relation to Moult and Handling

DURING a recent investigation of the physiology of excretion in the crayfish[1], it was discovered that significant differences in blood glucose-levels existed between intermoult (stage *C*) and premoult (stage *D*) specimens of *Pacifastacus leniusculus* (Dana) (Table 1). The moult stage was determined by a modification of the method of Drach[2]. The crayfishes were kept in a water-bath at 16° C. in which they had been unsegregated and unfed for periods of one to two weeks. Blood glucose was determined by the glucose oxidase (enzymatic) method of Saifer and Gerstenfeld[3] (for details of experimental procedure, see Riegel and Kirschner, ref. 1).

Table 1. BLOOD GLUCOSE-LEVELS OF INTERMOULT (*C*) AND PREMOULT (*D*) MALE *Pacifastacus leniusculus*. DIFFERENCES ARE STATISTICALLY VERY SIGNIFICANT ($t = 3{\cdot}06$; $P = < 1$ PER CENT)

Moult stage	*C*	*D*
Number	10	9
Average blood glucose (mgm. per cent)	21	48
Range	(5–39)	(18–91)
Standard error	3·3	7·7

Glucose proved to be a highly mobile substance in crayfish blood ; injected glucose disappeared rapidly. Handling of crayfishes (for example, injection of materials, and especially withdrawal of blood samples at frequent intervals) commonly resulted in a spontaneous rise in blood glucose-levels, a prolonged cessation or marked decrease in urine production, and in many cases the abnormal appearance of glucose in the urine.

The results of determinations of normal blood glucose-levels of *C*- and *D*-stage crayfishes agree with those of Renaud[4], who measured the reducing value of the blood of *Cancer pagurus*. However, Scheer[5] found no difference in blood carbohydrate-level between late *C*- and early *D*-stage *Carcinides* (= *Carcinus*) *maenas*. Similarly, McWhinnie and Scheer[6] found that the blood glucose-levels of *Hemigrapsus nudus* reached their maximum during the intermoult (*C*) stage of the moult-cycle and actually declined during the premoult (*D*) stage. McWhinnie and Scheer determined glucose by a method similar in most respects to that used in the present work. They found that glucose comprised less than 20 per cent of the total 'blood sugar' value determined by other less-specific methods.

The reasons for the spontaneous rise in blood glucose of handled crayfishes are obscure. It seems reasonable to assume that handling placed the crayfishes under stress. Since an elevation of blood glucose-levels is a common stress phenomenon seen in vertebrates, it is possible that a similar stress–blood glucose relationship exists in the crayfish. This explanation would fail, if the view of Scheer[7], that glucose is not utilized as a substrate for oxidative metabolism in Crustacea, is accepted. However, more recent evidence (ref. 8 and Scheer, B. T., personal communication) indicates that glucose is, in fact, utilized for oxidative metabolism in crustaceans ; at least, according to Scheer[7], in those crustaceans that undergo a period of dormancy during their moult cycle (anecdysis). The crayfish is an anecdytic form, as are the crabs, *Hemigrapsus nudus* and *Carcinides maenas*.

The complete cessation or marked decrease in urine production and the glucosuria of crayfishes that were handled[1] is suggestive of a hormonal effect. For example, the stoppage or decrease in urine production commonly was maintained for 20 hr. or more during the experimental periods—long after handling had ceased. Further, it was only after 20 hr. that glucosuria occurred. It is well known that the sinus glands of Crustacea contain a diabetogenic hormone, which is reported to be responsible for most of the hyperglycæmic effects seen in those animals[9]. The diabetogenic hormone conceivably could be responsible for the hyperglycæmia and possibly the glucosuria of handled crayfishes. Further, it is possible that it, or some as yet unknown hormone fraction, has an antidiuretic effect in the crayfish.

This work was supported by funds provided for medical and biological research by the State of Washington Initiative No. 171, and by a grant (*G*4925) to L. B. Kirschner from the National Science Foundation.

J. A. RIEGEL*

Department of Zoology,
Washington State University,
Pullman, Washington.

---

* Postdoctoral Research Fellow of the National Heart Institute, National Institutes of Health.

[1] Riegel, J. A., and Kirschner, L. B., *Biol. Bull.* (in the press).
[2] Drach, P., *Ann. Inst. Océanog. Monaco*, **19**, 103 (1939).
[3] Saifer, A., and Gerstenfeld, S., *J. Lab. and Clin. Med.*, **51**, 448 (1958).
[4] Renaud, L., *Ann. Inst. Océanog. Monaco*, **24**, 259 (1949).
[5] Scheer, B. T., *Biol. Bull.*, **116**, 175 (1959).
[6] McWhinnie, M. A., and Scheer, B. T., *Science*, **128**, 90 (1958).
[7] Scheer, B. T., "Recent Advances in Invertebrate Physiology", 213 (University of Oregon Pub., 1957).
[8] Hu, A. S. L., *Arch. Biochem. Biophys.*, **75**, 387 (1958).
[9] Kleinholz, L. H., Havel, V. J., and Reichart, R., *Biol. Bull.*, **99**, 454 (1950).

Membrane Potential Changes associated with Stimulation of Smooth Muscle by Adrenalin

THE smooth muscle of the taenia coli of the guinea pig is contracted by acetylcholine and is relaxed by adrenalin. It has been shown that acetylcholine contraction is associated with depolarization of the muscle membrane and initiation or increase in spike activity[1,2]. Adrenalin relaxation is associated with hyperpolarization of the membrane and inhibition of spike activity[1,3].

The smooth muscle of the muscularis mucosæ (dog) is contracted by both acetylcholine and adrenalin[4]. It was of interest, therefore, to observe whether adrenalin contraction of this muscle was associated with hyperpolarization or depolarization.

Membrane potential changes of muscularis mucosæ (pig œsophagus) in the presence of adrenalin and acetylcholine were measured by the sucrose gap technique[5]. Fig. 1 shows that contraction by adrenalin as well as by acetylcholine was associated with depolarization and initiation of spike activity.

This result supports the view that drugs act via a membrane system, where depolarization and initiation of spike activity result in contraction, and hyperpolarization in relaxation. It is unlikely that adrenalin acts in two completely different ways on the muscle membranes of the taenia coli and muscularis mucosæ. It is more likely that adrenalin acts in the same way on two muscles which differ in internal/external ion distribution and/or in membrane permeability properties. Comparison of the morphological features

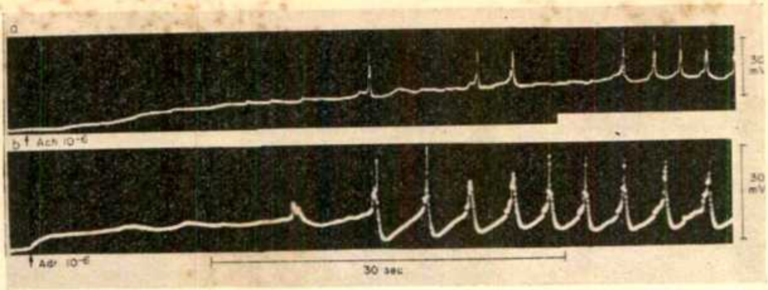


Fig. 1 Membrane potential changes and spike activity in the presence of: (*a*) acetylcholine (Ach) 10^{-6}; (*b*) adrenalin (Adr) 10^{-6}. Pig œsophagus muscularis mucosæ. Sucrose gap technique. Temp., 35° C.

and electrical properties of these two muscles revealed no qualitative differences[6,7]. Experiments designed to detect differences in ion distribution, permeability and electrogenic sodium pump activity[3] are in progress.

Some of this work was done in the Department of Physiology, University of Illinois.

G. BURNSTOCK

Department of Zoology,
University of Melbourne.

---

[1] Bülbring, E., *J. Physiol.*, **135**, 412 (1957).

[2] Burnstock, G., *J. Physiol.*, **143**, 165 (1958*a*).

[3] Burnstock, G., *J. Physiol.*, **143**, 183 (1958*b*).

[4] King, C. E., and Robinson, M. H., *Amer. J. Physiol.*, **143**, 325 (1945).

[5] Burnstock, G., and Straub, R. W., *J. Physiol.*, **140**, 156 (1958).

[6] Burnstock, G., and Prosser, C. L., *Amer. J. Physiol.* (in the press).

[7] Prosser, C. L., and Burnstock, G., *Amer. J. Physiol.* (in the press).

Accumulation of Substrate by Isolated Rat Diaphragm: a Possible Mechanism for the Anti-Inflammatory Action of Corticosteroids

ADRENALECTOMY enhances, and adrenal cortical hormone depresses, the incorporation of carbon-14 from amino-acids, and from amino-acid precursors, into the protein of isolated rat diaphragm[1,2]. These changes are, at least in part, the result of a direct effect on protein biosynthesis[1,3]. Whether corticosteroids also effect protein synthesis indirectly by influencing amino-acid transport and accumulation is not known. The possibility was tested by measuring the penetration and accumulation of [1-^{14}C-]-amino*iso*butyric acid[4], a non-utilizable amino-acid analogue, and of the utilizable amino-acids [U-^{14}C] L-phenylalanine and [U-^{14}C] L-lysine, by 'intact' diaphragms[5] isolated from normal, adrenalectomized, and cortisone-treated rats.

Table 1. EFFECT OF ADRENALECTOMY AND CORTISONE ON THE ACCUMULATION OF CARBON-14 LABELLED SUBSTRATE BY ISOLATED 'INTACT' RAT DIAPHRAGM

Substrate added to the medium	Counts/min./ml. intracellular water / Counts/min./ml. incubation medium		
	Normal	Adrenal-ectomized	Cortisone
[1-^{14}C]-amino*iso*-butyric acid	1·41 ± 0·061 (6)*	1·35 ± 0·046 (6)	0·72 ± 0·021 (6) (P < 0·001)
[U-^{14}C]-L-phenyl-alanine	2·51 ± 0·120 (6)	2·41 ± 0·149 (6)	1·79 ± 0·052 (6) (P < 0·001)
[U-^{14}C]-L-lysine	1·95 ± 0·059 (6)	1·88 ± 0·055 (6)	0·92 ± 0·030 (6) (P < 0·001)
[2-Ring-^{14}C] histamine dihydro-chloride	3·88 ± 0·125 (6)	3·69 ± 0·375 (6)	2·83 ± 0·096 (6) (P < 0·001)

Diaphragms from normal, adrenalectomized (4 days) and cortisone-treated (2 mgm./day for 4 days) rats were incubated with shaking for 2 hr. at 37° in 5 ml. Krebs–Henseleit bicarbonate buffer. Concentration of substances used were: [1-^{14}C]-amino*iso*butyric acid, $1·37 \times 10^{-4}$ M; L-phenylalanine, $4·9 \times 10^{-5}$ M; L-lysine, $6·55 \times 10^{-5}$ M; histamine, 1×10^{-4} M. The radioactivity added was, in each experiment, 0·5 μc./ml. Accumulation of soluble radioactivity was determined by extracting diaphragm with 10 ml. of 1 per cent trichloracetic acid at 100° for 5 min. Aliquots of the soluble extract and of the incubation medium were diluted, plated and assayed with a gas-flow Geiger counter. The results are expressed as the ratio of counts/min./ml. intracellular water (assumed to be 75 per cent of wet weight) to counts/min./ml. incubation medium; a ratio greater than one indicates intracellular concentration against a gradient. The value of P for a difference which is significant is given in brackets.

* Mean ± *S.E.* of mean; number of observations in parenthesis.

Cortisone significantly depressed accumulation in skeletal muscle of [1-^{14}C]-amino*iso*butyric acid and of L-phenylalanine and L-lysine; adrenalectomy was without effect on this process (Table 1). It is concluded that increased protein biosynthesis after adrenalectomy is not due to stimulation of amino-acid penetration; decreased accumulation could contribute to the depression in protein synthesis after cortisone.

The decrease in amino-acid penetration after cortisone has another and possibly more important implication, namely, that the mechanism of corticosteroid protection against inflammation and allergy may involve exclusion from cells of inciting humoral substances, similar in structure to the amino-acids, as for example histamine. This possibility was tested. Cortisone decreased accumulation of carbon-14 histamine by isolated muscle (Table 1). The biochemical basis of the anti-inflammatory and anti-allergic action of corticosteroids may be a decrease in the penetration into cells of a local humoral substance (histamine or like histamine) which in turn serves as the stimulus for tissue changes in inflammation and allergy.

This investigation was aided in part by a grant (*A*–1653) from the National Institutes of Health, and by the Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago.

IRA G. WOOL

Department of Physiology,
University of Chicago.

---

[1] Wool, I. G., and Weinshelbaum, E. I., *Amer. J. Physiol.*, **197**, 1089 (1959).

[2] Wool, I. G., and Weinshelbaum, E. I., *Amer. J. Physiol.*, **198**, 360 (1960).

[3] Wool, I. G., and Weinshelbaum, E. I., *Amer. J. Physiol.*, **198**(5), (1960).

[4] Kipnis, D. M., and Noall, M. W., *Biochim. Biophys. Acta*, **28**, 226 (1958).

[5] Kipnis, D. M., and Cori, C. F., *J. Biol. Chem.*, **224**, 681 (1957).

IMMUNOLOGY

A Possible Basis for Immunological Tolerance

THE following hypothesis is based on the possibility that, although the mechanism for the entrance of macromolecules into the cell may be the relatively non-specific phenomenon of pinocytosis, the mechanisms for secreting materials out of the cell may be specific. These unknown (probably active) transport mechanisms will, for ease in referring to them, be called 'secretases', by analogy to the bacterial permeases, which are concerned with entry rather than exit mechanisms[1]. Simple diffusion would account for only a small part of the macromolecular traffic in either direction across the membrane, since most of the 'pores' or holes in the cell membrane would be too small to allow passage of the large protein molecules.

The very young or embryonic animal is generally incapable of giving an immune response or forming antibodies ; at what particular stage it does acquire the ability to respond depends upon the species of animal. The degree of relationship of the antigen to native components of the animal may also be important. In the developing animal the cells of the future globulin- and antibody-synthesizing system are in the process of rapid division and differentiation. In some unknown manner cells acquire the ability to produce globulins of many different configurations. It is suggested here that a mechanism (the 'secretase') is induced in these cells to secrete the synthesized serum protein into the serum. Secretases would also be induced to act on the materials produced by the other cells, and brought into any given cell by non-selective processes.

The number of different secretases need not be impossibly large ; there may well be, for example, a few relatively unchanging regions common to many different globulin molecules. Other regions of the globulin molecules would be more variable[2] and would account for the many different antibody specificities. Porter[3] has evidence that the γ-globulin molecule consists of three parts : fraction III is apparently identical in all gamma-globulin molecules, and fractions I and II contain the antibody-combining sites. The types of secretases inducible would be under genetic control, and only those secretases for which there were genetic information available would be inducible. The inducibility of un-induced secretases would be lost or inhibited in the mature animal, although the fact that X-irradiation[4] or treatment with 6-mercaptopurine[5] can restore the ability to acquire tolerance suggests that this type of differentiation is not irreversible for the organism as a whole.

According to this hypothesis, antigen injected into the normal animal would be collected in cells by non-specific mechanisms, and, not being able to get out, would be metabolized. Humphrey[6] has suggested that foreign materials in the circulation are removed from the tissue fluids by the mechanisms that deal with similar native materials. In those cells where molecules with a configuration complementary to the antigen (antibodies, usually γ-globulins) were being produced, combination between the two would occur intracellularly. The resulting complex would then be broken down, and the increase in metabolites might be the stimulus that causes these cells to grow, accelerate their production of antibodies, and proliferate. Talmage's observation[7] that the greater the binding of the antigen to the antibody, the greater the degree of stimulation of antibody synthesis, would be explained by a facilitated breakdown of the antigen–antibody complex in those cells where the affinity of the antigen for the antibody was strongest. Cinader and Pearce[8] observe that "the difference between the half life of H.A. [human albumin] in normal and in tolerant animals may indicate the possible existence of a specific process of elimination which acts before the final rapid elimination of antigen by antibody begins. This process may be abolished by injection of antigen immediately after birth".

Presence of the antigen during the critical induction period would result in the induction of a secretase for the antigen, if the genetic information were available. Continued presence of the antigen in the tissues would be required to maintain the secretase ; if antigen were lost from the tissues the secretase would gradually be diluted out and the animal would lose its tolerance. The tolerant animal could not form antibody against the tolerated antigen, or against its own serum proteins, because the secretase would prevent these molecules from accumulating in the cells in amount sufficient to stimulate detectable antibody production.

Humphrey[6] has shown that in at least one case homologous protein persists intact within katabolizing cells for only a very short period of time. One might predict, on the basis of this hypothesis, that antigen would be eliminated from the *serum* of non-tolerant animals, prior to their immune response, at a faster rate than it would be eliminated from the serum of tolerant animals. Cinader and Pearce[8] found that non-tolerant animals could eliminate antigen from the serum at a faster rate than tolerant animals ; however, work by Denhardt and Owen[9] with a small number of rabbits indicated that tolerant animals could eliminate antigen from their sera at a greater rate than non-tolerant animals. Further study of this problem is highly desirable.

In conclusion, it is realized that tolerance may be equally well accounted for in terms of induction of a specific enzyme katabolizing the antigen ; perhaps what is required is a synthesis of these two points of view. The 'secretase' may be considered as the hypothetical 'recognition unit' postulated by Burnet and Fenner[10].

The encouragement and expert guidance of Dr. Ray Owen and the helpful suggestions of Prof. Peter Medawar are gratefully acknowledged.

D. T. DENHARDT

Swarthmore College,
Swarthmore, Pennsylvania.

[1] Cohen, G., and Monod, J., *Bact. Rev.*, **21**, 169 (1957).
[2] Cf. Haurowitz, F., *J. Cell. Comp. Physiol.*, **47**, Supp. 1, 1 (1956).
[3] Porter, R. R., *Nature*, **182**, 670 (1958).
[4] Dixon, F. J., and Maurer, F. H., *J. Exp. Med.*, **101**, 245 (1955).
[5] Schwartz, R., and Dameshek, W., *Nature*, **183**, 1682 (1959).
[6] Humphrey, J. H., *Proc. Roy. Soc.*, B, **146**, 34 (1956).
[7] Talmage, D. W., in "Symposium on Molecular Biology", edit. by Zirkle (Chicago, 1959).
[8] Cinader, B., and Pearce, J. H., *Brit. J. Exp. Path.*, **39**, 8 (1958).
[9] Denhardt, D. T., and Owen, R. D., *Transplantation Bull.* (in the press).
[10] Burnet, F. M., and Fenner, F., "The Production of Antibodies" (Macmillan, Melbourne, 1949).

HÆMATOLOGY

A New Electrophoretic Medium and its Application to the Resolution of Human Hæmoglobin Variants

SEVERAL techniques for the analysis of protein mixtures by either zone electrophoresis on inert media[1] or chromatography on ion-exchange cellulose derivatives have been described[2,3]. Greater scope and versatility should result if the supporting medium used for zone electrophoresis itself ionizes. In standard gel-electrophoresis techniques, ion transport takes place almost exclusively through the interstitial solution. The incorporation of ion-exchange groups into a gel superimposes a selectivity effect, the migration of the ions being retarded to a varying extent depending on their affinity for the exchanger. Attempts to use ion-exchange cellulose papers in this way have so far been unsuccessful. It is, however, also possible to prepare these cellulose derivatives in gel form. Electrophoresis on such a continuous-phase ion-exchange medium has not been reported hitherto. This communication is a preliminary report on the combination of electrophoretic and ion-exchange techniques applied to the separation of human hæmoglobin variants, using carboxymethyl cellulose gel as the supporting medium.

The sodium counter-ion form of the weakly acidic cation exchanger, carboxymethyl cellulose, is soluble in water at degrees of substitution above about 0·3, while below 0·15 the exchanger is fibrous though swollen. Between these limits it is in gel form, and by suitably modifying the standard preparative technique a range of gels can be made (Jakubovic, A. O., unpublished results). Certain aspects of the fibrous exchanger have been described[2,5], and it has also been applied to the chromatographic separation of hæmoglobins by Huisman and his colleagues[3].

One batch of gel (supplied by W. and R. Balston, Ltd.), carboxymethyl cellulose of 0·18 substitution, having a cation-exchange capacity of 1·05 m.equiv./gm. dry, and swollen to 90 per cent water content, was used throughout the experiments. After purification by dialysis in de-ionized water, the gel was dialysed with the appropriate buffer—sodium phosphate of 0·17–0·04 M sodium ion concentration—and placed in a suitable 'Perspex' boat. The final pH in the gel was 6·7. Electrophoresis was carried out overnight. The naturally occurring hæmoglobin combinations used in the experiments described were hæmoglobins A, SC, AS, AF (thalassæmia major, HbF = 75 per cent) and AJ.

The hæmoglobins invariably migrated to the cathode, the rate of migration increasing with the sodium ion concentration. At the highest concentrations used, the hæmoglobins moved through the gel rapidly, showing only slight separation (Fig. 1a). On lowering the sodium concentration they moved more slowly, migrating at various rates, but always in the order hæmoglobin A followed by hæmoglobin S and F close together and then C; at the lowest sodium concentration used they remained close to the origin (Fig. 1b). By varying the sodium ion concentration, either the hæmoglobin S to C or the hæmoglobin A to S gap could be magnified (Fig. 2a and b). The best overall separation was achieved with a sodium ion concentration of 0·07 M (Fig. 2c). This figure also shows clear separation of hæmoglobin A from F.

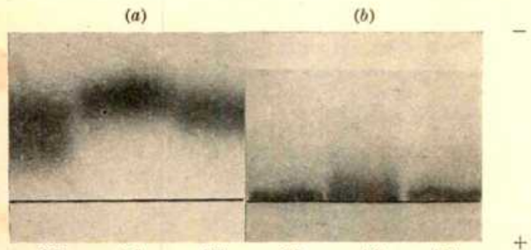


Fig. 1. Electrophoresis of human hæmoglobin variants on carboxymethyl cellulose gel at the extremes of sodium concentrations used: (a) 0·17 M; (b) 0·04 M

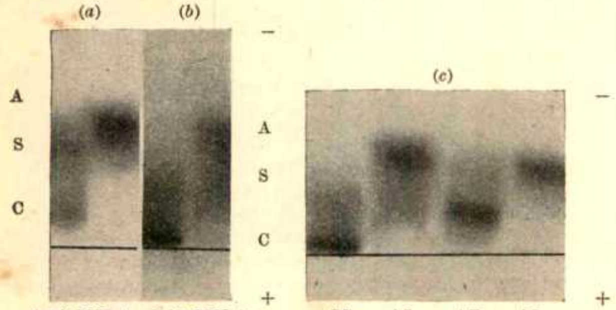


Fig. 2. Electrophoresis of human hæmoglobin variants on carboxymethyl cellulose gel. (a and b) Effect of variation of the sodium ion concentration on the separation of hæmoglobins A, S and C. (c) Overall separation achieved at 0·07 M sodium concentration, including separation of hæmoglobins A and F

Table 1

Starch-gel electrophoresis (sodium phosphate pH 6·8)*	Carboxymethyl cellulose gel electrophoresis (pH 6·7)	Carboxymethyl cellulose chromatography (pH 7–8) (ref. 3)
In sequence of increasing migration to the cathode		In order of retention on column
HbJ	HbC	HbC
HbA HbF HbS KbC close together	HbS HbF very close together	HbS
	HbA and J	HbF
		HbA
		HbJ

* Huehns, E. R., Flynn, F. V., Butler, E. A., and Shooter, E. M. (unpublished work).

In Table 1 the order of migration in starch-gel electrophoresis, carboxymethyl cellulose gel electrophoresis and chromatographic elution from fibrous carboxymethyl cellulose are compared. Under the carboxymethyl cellulose gel electrophoretic conditions used, the ion-exchange effect was predominant. From Table 1 it can be seen that hæmoglobins C, S and F are strongly held by the gel, but in the case of hæmoglobin J the ion-exchange and electrophoretic effects seem to be balanced and therefore hæmoglobins A and J did not separate.

It would, however, be possible to change the pH of electrophoresis in such a way that the charge on the protein was reversed, and the migration would then be unaffected by the exchange groups of the gel. The influence of the latter depends on the concentration and ionization of the carboxyl groups. The concentration can be varied by changes in degree of substitution of the cellulose and swelling, the ionization by varying the pH and ionic concentration of the ambient electrolyte. Only the last has been utilized here. The effect of varying the capacity and swelling of the exchanger gel and the pH of electrophoresis, as well as the wider utilization of this new method of gel-phase ion-exchange electrophoresis, is being investigated.

We wish to thank Dr. E. M. Shooter for helpful advice and discussion. The work was carried out during the tenure by one of us (E. R. H.) of a Beit Memorial Fellowship.

E. R. HUEHNS

Department of Biochemistry,
University College, London.

A. O. JAKUBOVIC

Whatman Research Laboratory,
W. and R. Balston, Ltd.,
Maidstone, Kent.

[1] Kunkel, H. G., and Trautman, R., in Bier, M., "Electrophoresis; Theory, Methods and Application" (Academic Press, 1959).

[2] Peterson, E. A., and Sober, H. A., *J. Amer. Chem. Soc.*, **78**, 751 (1956). Sober, H. A., Gutter, F. J., Wyckoff, M. M., and Peterson, E. A., *J. Amer. Chem. Soc.*, **78**, 756 (1956).

[3] Huisman, T. H. J., Martis, E. A., and Dozy, A., *J. Lab. and Clin. Med.*, **52**, 312 (1958).

[4] Jakubovic, A. O., Hills, G. J., and Kitchener, J. A., *Trans. Farad Soc.*, **55**, 1570 (1959).

[5] Hoffpauir, C. L., and Guthrie, J. D., *Text. Res. J.*, **20**, 617 (1950). Jakubovic, A. O., and Knight, C. S., in Smith, I., "Chromatographic Techniques", 2nd edit. (Heinemann, 1960).

PATHOLOGY

Chronic Aortitis in the California Sea-lion, *Zalophus californianus*

During a long-term study on the general biology of the California sea-lion, *Zalophus californianus* (Lesson), it became evident that degenerative diseases associated with ageing are very common in this species. Therefore, a study of the heart and aorta was undertaken.

Circulatory disease in captive pinnipeds has been extensively studied by Fox[1] over a number of years. His findings included arteriosclerosis with typical medial involvement as well as myocarditis. Of the ten pathological specimens he found during this work, no indication was given of the genus and species involved; all animals were grouped under the order Pinnipedia.

The present study deals with lesions in the aorta of three mature bull sea-lions and is the first report of such pathology in this species to be found in a wild population. The hearts of seventy animals of both sexes were taken at random for study from a total collection of some two hundred specimens; these were obtained over the past two and a half years from islands off the coast of Baja California, Mexico. The collection area ranged from Los Coronados Islands (lat., 32° 26′ N.; long., 117° 16′ W.) to Cabo San Lucas, the extreme southern tip of Baja California (lat. 22° 45′ N.; long. 110° 00′ W.). All three of the abnormal individuals were secured on Los Coronados Islands, where most of the males were collected.

As soon as possible after killing, the hearts were removed leaving several inches of aorta attached: after rinsing in water, the tissue was preserved in 10 per cent formalin for later examination. The aortas were screened for visible lesions. Of the three specimens exhibiting gross pathology, two were sent to two separate laboratories for section and independent histopathological study; the third was retained and examined by us. The three diagnoses were identical. The sections were stained with hæmatoxylin and eosin. No gross myocardial disease was evident in any case.

Using the Lieberman–Burchard reaction on ether extracts of the finely ground material, samples from the pathological areas revealed a considerably higher cholesterol content than samples of the tissue from apparently normal adjacent regions.

Grossly, the intimal surface of the arteries contained numerous punctate elevations which, in the most extreme case, resembled tree bark. Approximately 10 per cent of the intimal surface was involved and the affected areas ranged in width from 0·1 to 1·5 cm.

Microscopically, the sections of aorta revealed extensive active aortitis, while other areas showed healing. The intima itself was not involved; rather there was, in the foci of the active areas, an extensive inflammatory reaction in the media, extending from the subintima to the adventitia. The disease process involved destruction of elastic tissue about the blood vessels and an infiltration of plasma cells, macrophages and lymphocytes. A secondary fibrosis in the subintimal areas overlaid the zones of aortitis. The healed areas contained abnormally large blood vessels surrounded by small amounts of scar tissue.

In many respects the condition found in these sea-lions resembles the aortic lesions found in chronic human syphilis, although the etiology of the disease in these animals is unknown.

The work was accomplished while the senior author served as a research assistant of the Institute of Marine Resources at the University of California and while the junior author held a fellowship-grant from the San Diego County Heart Association, to which grateful acknowledgment is made. The work was made possible by the effective co-operation of the Mexican Government.

Our sincere thanks are due to Dr. Lewis A. Palmer, La Jolla Clinical Laboratory, and Dr. Findlay E. Russell, College of Medical Evangelists, Los Angeles, for their kindness in the preparation and diagnosis of the sections.

Arthur L. Kelly
David Jensen
Scripps Institution of Oceanography,
La Jolla,
California.

---

[1] Fox, H., *Amer. J. Med. Sci.*, **159**, 821 (1920); *Trans. Coll. Phys., Philadelphia*, 3rd Ser., **43**, 130 (1921); "Diseases in Captive Wild Animals and Birds", 70 (J. B. Lippincott Co., Philadelphia, 1923).

BIOLOGY

Inactivation by Visible Light of Yeast sensitized by a Nucleic Acid Fluorochrome

Precise and reproducible survival curves have previously been obtained for haploid and diploid yeast irradiated with X-rays and with ultra-violet light[1,2]. Similar curves have now been obtained for the inactivation by visible light of yeast cells sensitized with the fluorescent diaminoacridine dye, acridine orange (3,6-*bis*-dimethylaminoacridine).

Cells of a haploid (*SC*–7) and a diploid (*SC*–6) strain of the yeast, *Saccharomyces cerevisiae*, were used in resting condition following seven days growth on potato dextrose agar at room temperature. Survival was measured by colony count on agar plates after three days incubation at 30° C. in the dark. The light source was a General Electric *R*–52 750-watt flood-lamp filtered to remove wave-lengths greater than 6000 Å. and less than 4100 Å.; the incident flux at the level of the samples was approximately 10^5 erg/cm.^{2}/sec. 20 min. before irradiation, highly purified acridine orange was added to a suspension of 10^6 cells/ml. in *p*H 7 phosphate buffer to make a final dye concentration of 1 : 200,000 or $1{\cdot}8 \times 10^{-5}$ *M*. Details of the dye purification process and of experimental technique will be given elsewhere. All operations were performed under red light. Neither visible irradiation in the absence of dye nor the presence of dye without irradiation produced inactivation.

Typical visible light inactivation curves for haploid and diploid yeast are shown in Fig. 1. These curves exhibit high reproducibility except for the resistant 'tail' appearing at low diploid survival. (Such variable tails are also found for X-ray and ultra-violet inactivation.) These curves are similar to those obtained for ultra-violet inactivation[2] in that they are multi-component types of low 'hitness' and that the diploid is more resistant than the haploid.

These similarities between the visible and the ultra-violet inactivation curves tempt one to conclude that visible light inactivates some of the same

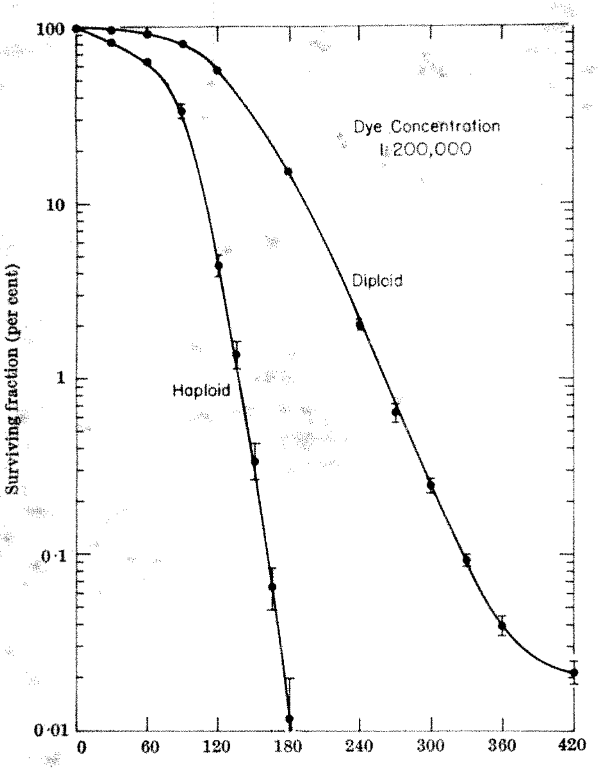


Fig. 1

sites that are sensitive to ultra-violet and that at least part of the damage can be explained by the replica diploid model[3,4] which has been invoked to account, in part, for the well-known difference in sensitivity between haploid and diploid yeast for ultra-violet and for X-rays. However, the equality of the limiting slopes of the haploid and diploid curves, which would be required if all the damage resulted from a replica diploid mechanism, is lacking. To examine further the nature of the visible light inactivation, perhaps the best approach (made feasible by the reproducibility of the survival curves) is that of additivity experiments in which doses of X-rays, ultra-violet and visible light are combined. From a series of such experiments, we have concluded that there is indeed considerable overlap among the targets and sites sensitive to these different radiations and that the difference in visible light sensitivity between the haploid and diploid strains can be explained, in part, on the basis of the replica diploid model. These experiments will be reported elsewhere.

These curves are of interest for several reasons. There has recently been much interest in the application of diaminoacridine dyes, particularly acridine orange, as stains in fluorescence microscopy[5]. These dyes allow one, on the basis of the different colours of the emitted light, to localize and distinguish structures containing ribonucleic and deoxyribonucleic acids within a cell. Most of this work has been done on fixed preparations with impure dye. Although the dyes will also stain the living cell, there are reports of deleterious effects on populations of micro-organisms and on cells in tissue culture[6-9]. It is likely, especially in view of the strong fluorescence of these dyes, that much of the damage reported in living preparations is caused by photodynamic action or other photoinactivation resulting from light absorbed by the bound dye, as is the case with the yeast inactivation reported above. Indeed, regeneration of liver tissue within the living rat has been shown to occur in the presence of proflavin[10]. It is then possible that under appropriate conditions these dyes can be used for non-injurious staining of many kinds of living cells. We have found that this is in fact the case for low concentrations of dye and that if suitable precautions are taken against the action of visible light (that is, by growing cultures in the dark and working by red light), such diverse materials as yeast, *Escherichia coli* and human liver cells in culture not only withstand exposure to acridine orange while in the resting state but also multiply indefinitely in concentrations of dye sufficient to permit observation of actively dividing cells with a sensitive fluorescence microscope (unpublished work).

By detailed analysis of inactivation curves, it may be possible to identify the specific intracellular sites to which the dye molecules are actually bound *in vivo*. Further, if most of the dye contained in the cell is bound specifically to nucleic acid and if the photodamage results from action upon these molecules alone, then there may be available a method for destroying part or all of a nucleic acid molecule without the concomitant effects upon protein which result when ultra-violet radiation is used for this purpose.

This investigation was aided by research grant *C*–2739 from the National Cancer Institute of the United States Public Health Service. One of us (D. F.) was supported by a National Science Foundation Predoctoral Fellowship.

David Freifelder*
Robert B. Uretz

Committee on Biophysics,
University of Chicago,
Chicago 37.

* Present address: Department of Biology, Massachusetts Institute of Technology.

[1] Wood, T. H., *Proc. Soc. Exp. Biol. Med.*, **84**, 446 (1953).
[2] Uretz, R. B., *Radiation Res.*, **2**, 240 (1955).
[3] Latarjet, R., and Ephrussi, B., *C.R. Acad. Sci.*, *Paris*, **229**, 306 (1949).
[4] Zirkle, R. E., and Tobias, C. A., *Arch. Biochem. Biophys.*, **47**, 282 (1953).
[5] Anderson, E. C., Armstrong, J. A., and Niven, J. S. F., *Symp. Soc. Gen. Microbiol.*, **9**, 224 (1959).
[6] Albert, A., "The Acridines" (Arnold, London, 1951).
[7] Jacoby, F., Medawar, P. B., and Willmer, E. N., *Brit. Med. J.*, ii, 149 (1941).
[8] Lasnitzki, I., and Wilkinson, J. H., *Brit. J. Cancer*, **2**, 369 (1948).
[9] Lettré, H., *Angew. Chemie*, **63**, 421 (1951).
[10] De Bruyn, P. P. H., Robertson, R. C., and Farr, R. S., *Anat. Rec.*, **108**, 279 (1950).

Pure Culture of the Trichomycete, *Amoebidium parasiticum*

The Trichomycetes as defined by Duboscq *et al.*[1] include four orders of little-known fungi. Common characteristics of this class include a polarized thallus of limited growth, a basal holdfast, and association with various arthropods, usually as endocommensals in the digestive tract.

Previous work on the Trichomycetes has raised some interesting problems for both the botanist and zoologist. There are repeated suggestions in the literature that the resistant stages of the Trichomycetes are induced by host moulting. If this should be the case, it immediately brings to mind the close relation existing between the wood-roach flagellates and their host during the moulting period[2]. Numerous questions on host specificity, host relations and nutrition await further investigation. A possible answer to some of these questions can be obtained through experimental approaches utilizing pure (axenic) cultures. Previous investigators have failed to isolate any member of the Trichomycetes in pure culture. Lichtwardt[3] and I (unpublished work), utilizing varied methods and conditions, failed to culture members of the Eccrinales.

The discovery of a large population of various *Cladocera* infected with *Amoebidium parasiticum* (see Fig. 1, left) has made possible cultural attempts with this Trichomycete. Heavily infected animals were dissected in sterile diluted pond water. This dissection resulted in the release of numerous endospores into the water. The endospores were retrieved with a fine capillary pipette and carried through three washes of sterile water. The spores were then transferred in a drop of water to dilute (0·1 per cent) tryptone agar plates and streaked with a sterile glass rod. Colonies of *Amoebidium parasiticum*, which were free from bacteria, were observed after three days (see Fig. 1*b*). They were then transferred to 1 ml. of water at the base of a tryptone agar slant and to a tryptone–glucose broth. Good growth occurred on both of these media and purity was maintained. (Composition of broth: 5 gm. tryptone, 3 gm. glucose per litre. Total phosphate, 0·003 *M*; inorganic constituents as indicated by Machlis[4].)

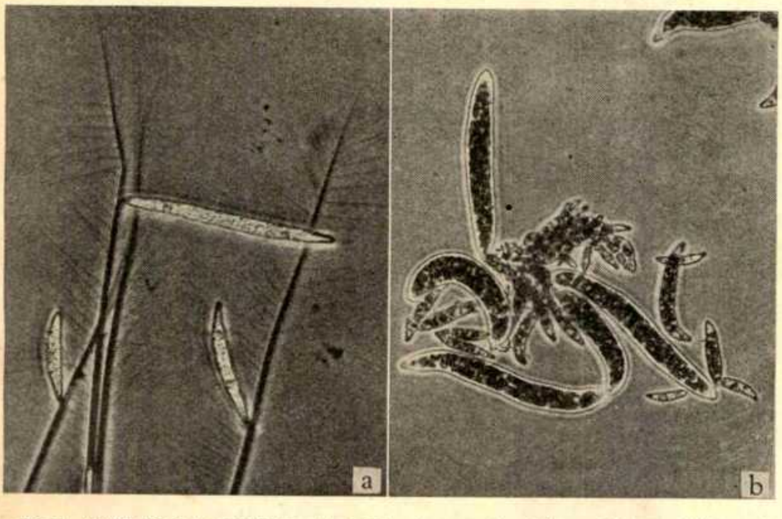


Fig. 1. (*a*) Thalli of *A. parasiticum* attached to plumose setæ of *Simocephalus* sp. (Cladocera). × 350. (*b*) Thalli of *A. parasiticum* grown in tryptone–glucose broth. × 170

Reproduction in pure culture is by endospores and factors causing amœba formation have not yet been determined. As *Amoebidium parasiticum* is usually an ectocommensal and exhibits a rather low host specificity it is perhaps not surprising that it was obtained in pure culture. The techniques utilized are fairly standard[5] and have been used by Emerson in culturing *Oedogoniomyces lymnaeae* and by me in culturing *Harpochytrium hedenii*. Both these fungi have unbranched thalli with basal holdfasts. However, their vegetative reproduction is by uniflagellate zoospores and they are not associated with animal hosts. It is believed that a comparative study using pure cultures of *Amoebidium*, *Oedogoniomyces* and *Harpochytrium* will yield information on the biology and relations of these interesting organisms.

HOWARD C. WHISLER

Department of Botany,
University of California.

[1] Duboscq, O., Leger, L., and Tuzet, O., *Arch. Zool. Exp.*, **86**, 29 (1948).
[2] Cleveland, L. R., *Proc. U.S. Nat. Acad. Sci.*, **45**, 747 (1959).
[3] Lichtwardt, R. W., *Mycologia*, **46**, 564 (1954).
[4] Machlis, L., *Amer. J. Bot.*, **40**, 450 (1953).
[5] Emerson, R., "Ann. Rev. Microbiol.", **4**, 169 (1950).

Furunculosis in Salmon Kelts

According to the report of the Furunculosis Committee[1], this disease is most common among salmonids during the summer, when river-levels are low and when the water temperature lies within the range 55–66° F. The final report of this Committee[1] does, however, mention the occurrence of this disease in spawning or spawned salmon "in at least two districts in Scotland", but no further details are given.

Large numbers of salmon die in the rivers each year after spawning. The cause of this mortality, which is heavier among males than among females, is unknown, but it is commonly supposed to be the outcome of a period in fresh water without food and of the strain imposed by movement upstream followed by spawning.

During the autumn of 1958, salmon were impounded in the upper reaches of a Scottish river for stripping. Three of these fish died before stripping, and it was later found that they had died from furunculosis; more of the fish died after stripping, again, as was afterwards learned, from furunculosis. These results suggested either that these fish had become infected during their period of impoundment or that furunculosis was a more common cause of death in kelts than had been supposed. To examine the latter possibility, dead or dying kelts were collected from the lower reaches of the river in question and from three other Scottish rivers. In all, 96 kelts were examined and, of these, 85 had furunculosis.

River-levels were very low during November and December 1958, and these unusual conditions may have contributed to this result, in that fish were more closely congregated than usual, offering favourable conditions for the spread of disease, and dead fish were more easily seen and removed. Observations on the occurrence of furunculosis in kelts were therefore again made in 1959. Most of the rivers were in spate during the spawning season of that year, so that recovery of dead kelts was more difficult. To date, 24 kelts have been received from 5 rivers, and 9 of the kelts had furunculosis. This incidence of furunculosis in kelts was not confined to Scottish rivers, as during 1959, 14 salmon kelts were examined in England and Wales. I am indebted to Mr. F. T. K. Pentelow, chief salmon and fresh-water fisheries officer, for the information that 11 of these were suffering from furunculosis.

Whether or not the incidence of furunculosis among kelts in the Scottish rivers in 1958 was unusually high, the two sets of results suggest that the normal incidence of this disease in kelts is high enough to warrant further investigation. As this might be an important factor in the spread of the disease, these observations will be continued.

ISABEL W. SMITH

Marine Laboratory (Department of Agriculture
and Fisheries for Scotland),
Aberdeen.

[1] Final Report of the Furunculosis Committee (H.M. Stationery Office, 1935).

Genetical and Biochemical Studies of the Immobilization Antigens of *Paramecium aurelia*

HIGHLY purified preparations of the immobilization antigens of *Paramecium aurelia*, about which extensive genetic studies have been described previously[1], are now known to consist largely of protein (ref. 2 and unpublished work by J. O. B.). With the aim of obtaining information on genetically controlled protein variations, we have made a preliminary study of the physicochemical properties of some of these antigens, using various stocks of *P. aurelia* (variety 1). The antigens studied are denoted 60D, 90D, 103D, 33D, 60G, 60T. Formation of the first four is governed by a series of alleles denoted D^{60}, D^{90}, etc., and of the fifth by a non-allelic gene G^{60} in conjunction with a different cytoplasmic state. The type 60T is produced in conjunction with a third cytoplasmic state; but the genic basis of this type has not been investigated.

The immunological relationships between the different types of antigen appeared to vary according to the kind of test which was performed. By the immobilization test very little cross-reaction was found when any heterologous combination of the above-mentioned antigens and the various antisera was made. Other tests, however (absorption of immobilizing antibodies by whole *Paramecia* or migration of precipitin bands in agar-gel diffusion experiments), showed that the four D antigens are immunologically related to each other, and are unrelated to the 60G type (J. O. B., unpublished work).

Electrophoretic behaviour of the antigens was studied on starch-gel at *p*H 9·6 by a modification of the method of Smithies[4]. A gradient of 30–40 V. per cm. was found to be necessary to get appreciable movement of the antigens and the runs usually lasted 6–8 hr. After this time a slice of the gel was removed and stained with nigrosin, showing the presence of a single band of protein near the origin on the anode side. All other mobile proteins had passed into the anodic buffer vessel by this time. Correspondence of the stained band with antigen was shown by taking a parallel slice of gel and testing the eluate obtained from it for specific serum-blocking activity.

In this way the electrophoretic mobilities of the antigens were compared and it was found that type 60G moved toward the anode significantly more slowly than any of the D types (see Fig. 1), and type 60T was the fastest. All four (allelic) D types were apparently identical in mobility under these conditions.

Some of the antigens were also compared in regard to their adsorption–desorption behaviour on a column of calcium phosphate, using the technique of Tiselius *et al.*[5]. Partially purified preparations of various antigens were applied to the column and elution was then carried out with phosphate buffer at *p*H 6·8, starting with an ionic strength of 0·001 *M* and increasing stepwise to 0·05 *M*. Protein in the samples of eluate was measured spectrophotometrically by ultra-violet absorption at 280 mμ and antigenic activity assayed by serum-blocking. It was found that antigen 60G was eluted by buffer at an ionic strength of 0·005 *M*, 60D and 60T at 0·01 *M* and 90D at 0·05 *M*. When two antigens (60D and 90D) were mixed together and chromatographed on calcium phosphate, two peaks of protein—each containing only one antigen—were obtained at positions on the elution diagram corresponding exactly to those found when the two antigens were chromatographed separately.

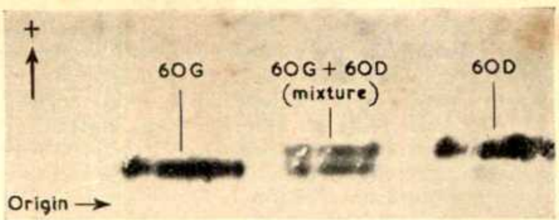


Fig. 1. Photograph of starch-gel slice containing three samples of antigen, stained with nigrosin after 4 hr. electrophoresis at 30 V. per cm., *p*H 9·6

We therefore conclude that the electrophoretic comparisons of the different antigens studied to some extent parallel the immunological and genetical relationships: antigens which are unrelated immunologically and controlled by genes at different loci (for example, the G and D types) differ electrophoretically; antigens which are immunologically closely related and controlled by allelic genes at a single locus do not show electrophoretic differences under the conditions chosen, but do differ in regard to their adsorption–desorption behaviour on calcium phosphate.

More detailed accounts of the work referred to here will be published elsewhere. Thanks are due to the Medical Research Council for a grant supporting this work.

J. O. BISHOP
G. H. BEALE

Department of Animal Genetics,
University of Edinburgh.

[1] Beale, G. H., *Int. Rev. Cyt.*, **6**, 1 (1957); "The Genetics of *Paramecium aurelia*" (Cambridge, 1954); *Proc. Roy. Soc.*, B, **148**, 308 (1958).

[2] Preer, J. R., *J. Immunol.*, **83**, 276, 378, 385 (1959); *Genetics*, **44**, 805 (1959).

[3] Oudin, J., *Meth. Med. Res.*, **5**, 335 (1952).

[4] Smithies, O., *Biochem. J.*, **61**, 629 (1955).

[5] Tiselius, A., Hjerten, S., and Levin, O., *Arch. Biochem. Biophys.*, **65**, 132 (1956).

BACTERIOLOGY

Mechanism of Immunity in Hæmorrhagic Septicæmia

HÆMORRHAGIC septicæmia of cattle and buffaloes caused by *Pasteurella multocida* type I kills many thousands of animals in Asia each year. It is possible to immunize against the disease effectively with improved vaccines, and in addition 5–10 per cent of animals possess a naturally acquired immunity. Both kinds of immune animals have in their sera circulating antibodies which are detectable by the passive mouse protection test. Hitherto, it has been difficult to find whether these protective antibodies operated by a bactericidal or an opsonizing mechanism. Experiments using cultured bacteria, even those from primary plates sown with infected blood, showed no significant differences between known positive and negative sera in the bactericidal test of Muschel and Treffers[1], or in phagocytosis tests in roller tubes using heparinized or citrated blood.

Recent experiments in Australia and Thailand using pasteurellas grown *in vivo* in cattle and buffaloes give clear results in both bactericidal and phagocytosis tests. In 25 buffaloes and 6 cattle, complete correlation was obtained in mouse protection, serum bactericidal, opsonizing tests and direct challenge of the donor animals by subcutaneous injection of 1000 *LD* of the pasteurella. Twenty-six were positive to all tests and survived; five were negative to all tests and succumbed. In the latter group an occasional leucocyte was found containing a single pasteurella, whereas in the positives nearly every polymorphonuclear cell in the smears from roller tubes contained several pasteurellas. The bactericidal effect was measured by the ability of fresh sera in dilution of 1 ml. in 10 ml. broth to prolong the lag phase of the inoculum of pasteurellas introduced in 0·01 ml. infected serum. When growth occurred after the period of inhibition there was no agglutination except in the very strongly reacting sera. Mice inoculated with 0·1-ml. samples withdrawn 30 min. after the positive tests were set up survived, whereas those inoculated from negative tests died. This indicates a bactericidal effect on the inoculum rather than a temporary agglutinating action; the amount of serum in the inoculum was only one-tenth of a mouse protective dose in a conventional passive immunizing test. Parallel tests conducted with cultured pasteurellas were uniformly negative for bactericidal action, and phagocytosis was approximately equal in both immune and control bloods.

Extraction by 2·5 per cent aqueous solution of sodium chloride of dried cultivated pasteurellas yielded 0·5 per cent by weight of a ketose-containing polysaccharide which is disposed mostly at the surface of the small capsules. This substance was not detectable in pasteurellas grown *in vivo*[2]. This is the only difference known at present between the two kinds of bacteria which might account for their different reaction in the bactericidal tests.

R. V. S. BAIN

Department of Veterinary Pathology,
University of Sydney.

---

[1] Muschel, L. H., and Treffers, N. P., *J. Immunol.*, **76**, 1 (1956).

[2] Knox, K. W., and Bain, R. V. S., *Immunology* (in the press).

Nitrogen Fixation in Extracts of *Azotobacter vinelandii*

IT is well established that soil micro-organisms, including species of *Azotobacter* and *Clostridia*, fix atmospheric nitrogen. Although several attempts have been made to demonstrate the incorporation of nitrogen-15 into extracts of these micro-organisms the results at best have been variable and of doubtful significance[1]. Protoplasts, prepared from *Azotobacter* by careful lysis of the cells with lysozyme, incorporated only small amounts of nitrogen-15, namely, an enrichment of 0·04 atom per cent excess[2]. We have recently succeeded in preparing cell-free extracts from *Azotobacter vinelandii*, either by treating the cells with lysozyme or with the ultrasonic probe, which will incorporate nitrogen-15 at a measurable rate. The cells must, however, be disrupted in the culture medium in which they were grown.

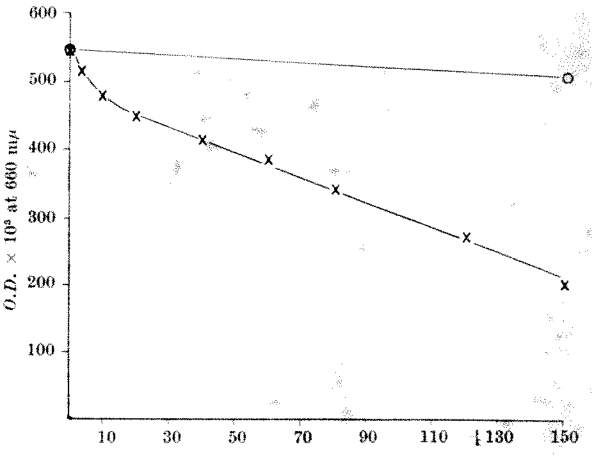


Fig. 1. Effect of lysozyme on the disruption of cells of *Azotobacter vinelandii* measured in 1-cm. cells at 660 mμ in a spectrophotometer. Assay system given in text. ○—○, No lysozyme; ×—×, lysozyme added

Azotobacter vinelandii (*O* strain) was kindly supplied by Dr. R. Burris and Dr. P. Wilson, Wisconsin University, Madison. The bacteria grown in 500 ml. of Burk's nitrogen-free medium[3] (*p*H 7·2) in litre flasks were well aerated in shake culture with sterile air. After 24-hr. growth, when the optical density readings of 3 ml. aliquots of the medium in 1 cm. cells were between 0·5 and 0·8, the cells were disrupted either with lysozyme or, alternatively, with an ultrasonic probe. The lysozyme treatment was a modification of Repaske's method[4] for lysing Gram-negative bacteria—50 ml. culture solution containing the cells was put in a 100 ml. conical flask, the *p*H adjusted to 8·0 with 0·01 *N* sodium hydroxide and the following reagents added; 5 ml. 0·1 *M* sodium pyrophosphate (*p*H 8·0), 5 ml. disodium versenate (0·16 mgm./ml.) and 5 ml. egg-white lysozyme (0·2 mgm./ml.). The decrease in optical density of the suspension was followed at 660 mμ in a 1-cm. spectrophotometer cell. The results in Fig. 1 show that at *p*H 8·0 almost complete lysis of the cells was achieved within 2 hr. The *p*H of the lysate was then adjusted to 7·2 with 0·01 *N* hydrochloric acid since nitrogen fixation in whole cells is maximal at this value.

The ultrasonic treatment with the Mullard probe (20 kc./s.) was as follows: 30 ml. culture medium containing the cells was put into a double-wall glass vessel (40 ml. capacity) which was kept cool by circulating iced water through the jacket. The contents were agitated with a magnetic stirrer and the cells were subjected to ultrasonic treatment for 15 min.

Cell-free extracts from either treatment were prepared by centrifuging at 25,000*g* for 30 min. in a refrigerated centrifuge at 4° C. Microscopic examination confirmed the complete absence of whole cells from these extracts.

Whole cells or extracts of *Azotobacter* were exposed to nitrogen-15 in 25 ml. sterilized Erlenmeyer flasks fitted with Thunberg type stoppers so that the contents, usually 10 ml., could be evacuated to 0·1 mm. mercury before introducing the following gas mixture : 30 per cent nitrogen : 30 per cent oxygen : 40 per cent helium. The nitrogen was 30 per cent enriched with nitrogen-15. The vessels were sealed and put on a reciprocator for 18 hr. (80 oscillations/min.) at 30° C. The samples were digested with 3-ml. sulphuric acid (analytical reagent) s.g. 1·84, 0·5 gm. catalyst mixture (4 gm. mercuric oxide : 50 gm. potassium sulphate) in micro-Kjeldahl flasks for 6 hr. A suitable aliquot containing between 30 and 400 μgm. total nitrogen, as determined in the Markham apparatus, was distilled into 5 ml. 0·07 *N* sulphuric acid (analytical reagent) and the volume reduced to approximately 1 ml. in a boiling-tube before transferring it into one arm of a Rittenberg tube. The enrichment of nitrogen-15 in the samples was determined by the method of Sims and Cocking[5].

Table 1. FIXATION OF NITROGEN-15 IN EXTRACTS OF *Azotobacter vinelandii*

Atom percentage nitrogen-15 excess

A. Extracts prepared by lysozyme treatment

	(1) Whole cells	(2) Lysis of cells with lysozyme. Supernatant solution used after centrifuging at 25,000*g* for 30 min.	(3) Boiled supernatant solution from (2)	(4) Supernatant solution from (2) treated with 10 per cent w/v trichloracetic acid
Exp. 1	4·00	0·22	0	0
Exp. 2	3·54	0·54	0	0

B. Extracts prepared by ultrasonic treatment

(1) Whole cells	(2) Ultrasonic treatment of cells (15 min.)	(3) Supernatant solution after centrifuging at 25,000*g* for 30 min.	(4) Boiled supernatant solution from (2)
2·73	2·54	0·385	0

The results in Table 1 show that the cell-free extracts of *Azotobacter* prepared by either method incorporate appreciable amounts of the stable isotope. The ultrasonic treatment of the cells did not appear to affect the nitrogen-fixing mechanism since enrichment of the isotope in the homogenate was similar to that of whole cells. Even after high-speed centrifugation the incorporation of the tracer into the cell-free extracts, although reduced, was quite substantial. Work is now in progress to determine the mechanism of nitrogen fixation in the cell-free preparations and, in particular, the nature of the contributory factors in the culture medium in which the organism was grown.

The mass spectrometer measurements were made for us at the Physical Chemistry Department of this University through the courtesy of Dr. W. J. Dunning and later by Dr. D. H. Tomlin, Physics Department, University of Reading. We acknowledge with thanks the help received from the two Departments.

D. J. D. NICHOLAS*
D. J. FISHER

Long Ashton Research Station,
University of Bristol.
Jan. 8.

---

* Member of the Scientific Staff of the Agricultural Research Council seconded to the Long Ashton Research Station.

[1] Burris, R. H., in "Inorganic Nitrogen Metabolism", edit. by McElroy, W. D., and Glass, B., 361 (Johns Hopkins Univ. Press, Baltimore, 1956).

[2] Jose, A. G., and Pengram, R. M., *Bact. Proc.*, **157**, 132 (1957).

[3] Burk, D., Linweaver, H., and Horner, C. K., *Soil Sci.*, **33**, 413 (1932).

[4] Repaske, R., *Biochim. Biophys. Acta*, **22**, 189 (1956).

[5] Sims, A. P., and Cocking, E. C., *Nature*, **181**, 474 (1958).

Simplified Bulk Growth of *Vibrio fœtus*

THE cultivation of *Vibrio fœtus* in quantity, for antigen production, is generally regarded as rather difficult and costly. Commonly employed culture media are semi-solid 'Thiol' (Difco) and *Brucella* broth ('Albimi'), both containing 0·1 per cent agar.

A recent paper[1] summarizes much of present knowledge on the subject, and describes the adaptation of a previously published method[2] for *Pasteurella multocida*, using a special liquid medium. Apart from a French reference[3] we have found no mention in the literature of the employment of ordinary (nutrient) agar for the growth of *V. fœtus*, and no mention at all of the use of broth.

The nature of vaginal 'exudates' and other specimens from which we recovered *V. fœtus* led us to suspect that this organism thrived best in the presence of abundant moisture. We found that it grew more readily and luxuriantly on solid media, for example, when the condensation water had not been removed by drying (for example, during prior incubation as a sterility check, which we omit). Serial subculturing on blood-agar plates was usually then successful.

We originally used nutrient agar (equal parts meat extract[4] and Martin's peptone[5] plus 1·5 per cent agar) treated in this way for the production of antigen, setting it in 8 oz. 'medicine' bottles lying flat and distributing over the surface about 20 × 0·08 ml. heaps of young *V. fœtus* culture in semi-solid agar (equal parts meat extract and Martin's peptone + 0·1 per cent agar). After incubation in less than 10 per cent carbon dioxide the growth was harvested by washing with formol–saline, physiological saline or broth. The last two have the advantage that a second crop can be harvested after simply re-incubating the original agar bottles without further sowing.

In semi-solid agar, in which the inoculum remained near the surface, rich growth occurred in tubes down to about 1 cm. below the surface under 10 per cent carbon dioxide and in zones at various depths in air. Increased depth of the growth disks below the surface is associated with reduction in catalase activity, which usually reappears on subculture under 10 per cent carbon dioxide.

For bulk culture, the semi-solid agar was placed in wide, flat-bottomed glass vessels to form a shallow layer the depth of which approximated that to which *V. fœtus* grew in tubes of such agar when incubated under 10 per cent carbon dioxide, namely, 1–2 cm. After incubation at 37° C. for 2–4 days, harvesting was carried out by adding 10 volumes of saline for each volume of medium present.

The agar was separated by centrifugation for 15 min. at 500*g* and the bacteria sedimented by a second centrifugation for 15 min. at 3,000*g* in an angle head. Failure to remove the agar results in difficulties in reading the vaginal mucus agglutination test.

The cells were washed by resuspending and centrifuging three times with formol–saline (physiological saline containing 0·3 per cent formalin), *p*H 7, and then resuspended, in formol–saline containing 0·5 per cent phenol, to the opacity desired for the vaginal mucus agglutination test.

It was then found that *V. fœtus* could be grown in nutrient broth (equal parts meat extract and Martin's peptone) without the addition of agar. In vertical tubes the inoculum sank to the bottom and no growth occurred ; but when the broth was dispensed in a shallow layer (1–2 cm.) in wide, flat-bottomed vessels, as just described for semi-solid agar, good growth resulted. Greater depth of medium could probably be used if mechanical agitation were employed. Harvesting and washing procedures were as for other bacteria grown in broth.

After two days incubation in an atmosphere of 10 per cent carbon dioxide we were usually able to prepare a volume of antigen suspension (of opacity 2 on the Burroughs Wellcome scale) a little greater than that of the broth originally inoculated. Incubation for four days generally yields about double the volume, and even five days incubation does not seem to impair the specificity of the antigen.

To date six strains of *V. fœtus* (the English 'Longsdon' and '1980', and four local field strains isolated at Glenfield) have been found to grow well in both media. Each of the four local strains did so immediately after primary isolation on blood agar plates. At present semi-solid agar is used for stock cultures and broth for antigen production.

We are grateful to Mr. J. C. Keast, director of veterinary research, New South Wales Department of Agriculture, for his encouragement and interest in this work, and to Dr. B. P. Setchell, also of this Station, for helpful advice in the preparation of notes for publication.

DUSAN JAKOVLJEVIC
H. E. R. BEATTIE
Veterinary Research Station,
Glenfield,
New South Wales.

[1] Dennis, S. M., and Jones, R. F., *Aust. Vet. J.*, **35**, 457 (1959).
[2] Bain, R. V. S., and Jones, R. F., *Brit. Vet. J.*, **114**, 215 (1958).
[3] Gallut, J., *Ann. Inst. Pasteur*, **83**, 449 (1952).
[4] Mackie, T. J., and McCartney, J. E., "Handbook of Practical Bacteriology" (Livingstone, Edinburgh, 1953).
[5] Levine, M., and Schoenlein, H. W., "A Compilation of Culture Media" (Baillière, Tindall and Cox, London, 1930).

GENETICS

Inheritance of Asymmetry in a Water-boatman (*Krizousacorixa femorata*)

ASYMMETRY of the abdominal segments in the corixid males is a regular occurrence with the sense of asymmetry, dextral or sinistral, regularly uniform intraspecifically. One finds among the males no intermediate forms, for all the asymmetrical structures of a dextral male are perfect mirror-images of those in a sinistral male and vice versa. More particularly, the sex-limited structures are confined to the body wall, and more precisely, to the last six segments where the exoskeleton and musculature display an asymmetrical pattern, emphasized by an oval black body (the strigil) and a curved genital capsule. In the dextral male the strigil is limited to the right margin of the sixth segment and the genital capsule is directed to the right. These asymmetrical structures are, of course, mirror-images of those in a sinistral male, while in the females bilateral symmetry prevails. Instances of *situs inversus*[1] are rare.

At Lake Zumpango, near Mexico City, I discovered an unusually high frequency of *situs inversus* in a large population of *K. femorata*, or water-boatman. In a sample of 650 males, 475 were dextral and 175 sinistral. Though previous investigators have reported the phenomenon of *situs inversus* in this corixid, I have not found any published account of the inheritance of dextro-sinistral asymmetry in this or any other species of corixid.

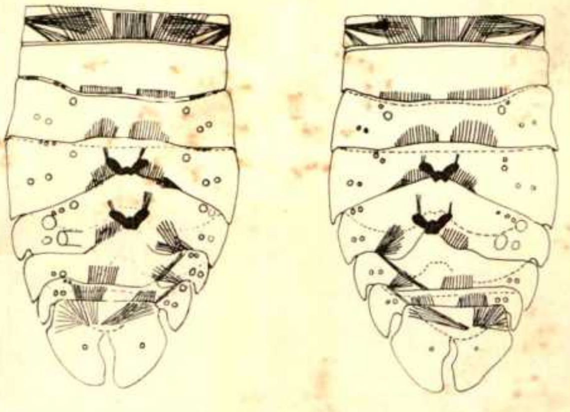


Fig. 1. Ventral view of the abdominal exoskeleton and musculature in asymmetrical males, dextral and sinistral, of *K. femorata*, Guer.

In elucidating the mode of inheritance by means of breeding experiments, single-pair matings in various combinations were made in the laboratory. An all-dextral male line of some ten generations was established. Attempts to produce an all-sinistral line, however, resulted in families containing dextral and sinistral males in different proportions. The results from three single-pair matings of a sinistral male and a virgin female are shown in Table 1, suggesting a 2 : 1, 1 : 1, and 1 : 2 ratio.

Table 1. PROGENIES FROM CROSSES BETWEEN SINISTRAL MALES AND VIRGIN FEMALES

Family 1	52 sinistral ♂♂	49 dextral ♂♂	62♀♀
Family 2	52 sinistral ♂♂	25 dextral ♂♂	90♀♀
Family 3	17 sinistral ♂♂	36 dextral ♂♂	50♀♀

A sequence of experimental matings of dextral and sinistral lines was carried out and the segregation ratios analysed; these will be published in full detail elsewhere. From the results, however, one can conclude *ex hypothesi* that the inheritance of the polymorphic characteristic of asymmetry depends upon an allelomorphic series of three genes, D, D^s, and d, of which D (dextrality) is dominant to D^s (sinistrality), which in turn is dominant to d (dextrality). The intermediate member of the series is lethal as a homozygote.

I am grateful to Sir Ronald Fisher for his direction of this work.

WALTER PETERS*
Department of Genetics,
University of Cambridge.

* Present address: Department of Biology, Loyola University, Chicago.

[1] Peters, W., *J. Morph.*, **84**, 525 (1949).

Triploid Rat Embryos and Other Chromosomal Deviants after Colchicine Treatment and Polyspermy

Austin and Braden[1] have shown in their classic paper on polyspermy in the rat that dispermy leads to a triploid fertilized egg and that such an egg may cleave normally up to at least the eight-cell stage. These conclusions have been confirmed by the recent investigations of one of us[2]. However, Braden and Austin[3] found no instance of triploidy among rats born from delayed mated females in spite of the presence of about 9 per cent dispermic eggs at fertilization stages.

The fate of heteroploid mammalian embryos coming from sources other than polyspermy has mostly been

Table 1. EFFECTS OF INTRAPERITONEAL INJECTIONS OF COLCHICINE ON FERTILIZATION IN THE RAT

Interval mating-injection	Dose (mgm./100 gm. body-weight)	No. of females	Penetrated eggs	Polyspermic eggs	Eggs with suppressed second polar body	Androgenetic eggs	Eggs with subnuclei
2 hr.	0·025–0·05	13	111	7 (6·3%)	42 (38%)	1 (0·9%)	16 (14%)
2½ hr.	0·05	6	45	0	5 (11%)	17* (38%)	8 (18%)

* Includes four possible androgenetic eggs at the 2- to 3-cell stage.

Table 2. CHROMOSOME CLASSES OF 9–15 DAYS OLD RAT EMBRYOS AFTER DIFFERENT TREATMENTS TO INDUCE HETEROPLOIDY

Age of embryos (days)	Group	No. of pregnant females	No. of embryos	Classified as			
				Diploid	Triploid	Mosaic	Without mitoses
8–12	Colchicine	14	63	42	2	13	4
	'polyspermy'	12	130	115	8	6	1
13–15	Colchicine	5	22	14	0	1	7
	'polyspermy'	9	89	84	0	2	3

examined in the mouse[4]. Some spontaneous triploid and mosaic embryos were recovered in 'silver' females up to 9½-days gestation. But triploids were absent in the offspring of 'silver' mice (Beatty, R. A., personal communication). No heteroploid adult was observed either in the offspring of colchicine-treated mice[5]. It would seem, therefore, that most, if not all, heteroploid (triploid) mouse embryos die some time between mid-term and parturition.

In the present communication we report attempts to induce experimentally polyspermy and other types of heteroploidy in the rat. Parallel with this work, the fate of heteroploid rat embryos has been studied by chromosomal examination.

Adult female rats of the Wistar *CF*, Long-Evans, and Sherman strains were used, all mated with Wistar *CF* males towards the end of œstrus. It is known[6] that if mating is not allowed until after ovulation, sperm penetration in the rat begins about 2–4 hr. after copulation and then is completed, in any one rat, in 1–2 hr. The eggs were examined under the phase-contrast microscope in the living state and, in some cases, after acetocarmine staining under the coverslip.

In an attempt to induce polyspermy, eight females of each of the three strains used were subjected to a moderate hyperthermia for 3 hr. after mating. The body-temperatures were maintained at 40–41° C. by keeping the rats in a box heated at 35–36° C. The incidence of polyspermic (dispermic) eggs reached 8–10 per cent in the Sherman and Long-Evans strains but only 3·5 per cent in the Wistar *CF* strain.

In order to inhibit the second polar division, Wistar *CF* females were injected intraperitoneally with colchicine after mating. In earlier work[7], intraperitoneal injections of 0·05–0·1 mgm. colchicine per 100 gm. body-weight, 1–2 hr. after delayed matings, caused suppression of the second polar body in about 70 per cent of the eggs. Other abnormalities were: eggs with a single (presumably male) pronucleus and those with subnuclei in place of the female pronucleus. Our results are shown in Table 1.

It appears that the frequency of the different anomalies depends closely on the time of application. If the drug is applied at 2 hr. after mating, the second polar body is suppressed in many eggs; on the other hand, androgenesis is the principal anomaly at 2½ hr. In the latter case the second 'polar body' is formed

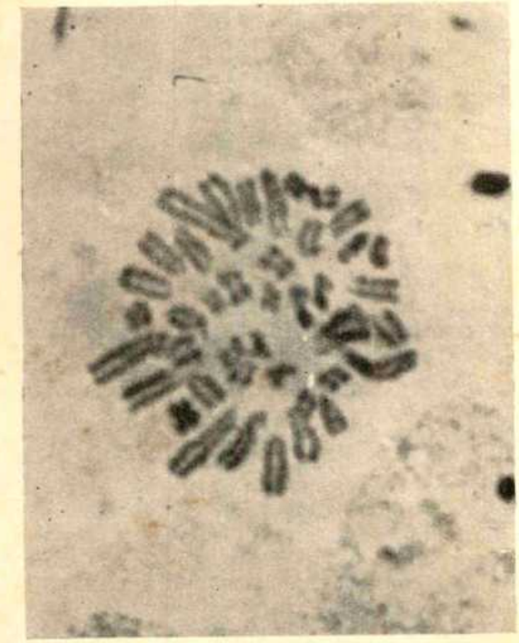


Fig. 1. Diploid metaphase ($2n = 42$; 12-days-old embryo) (×2,500)

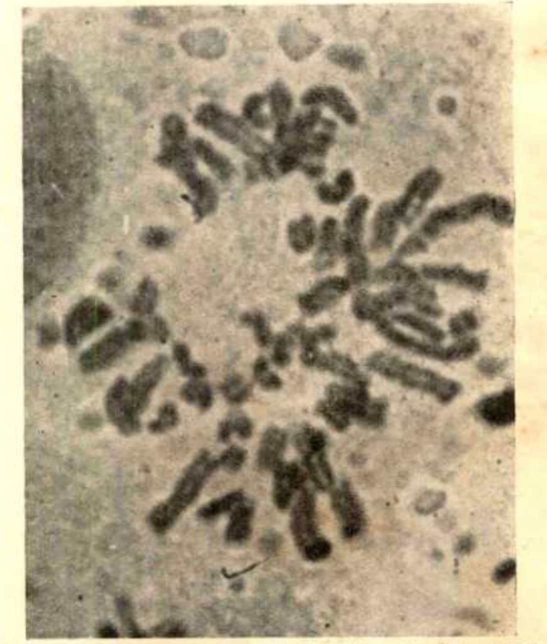


Fig. 2. Triploid metaphase (10-days-old embryo) (× 2,500)

without a spindle mitosis and includes the whole female chromatin. The higher doses of the drug frequently block the development of the pronuclei for up to 24 hr. Some evidence shows that androgenetic eggs may undergo cleavage, but their development stops at an early stage.

Twenty-four colchicine-treated females, and twenty-two females subjected to treatments to induce polyspermy (mostly of the Sherman strain), were killed 8–15 days after copulation. For the chromosomal examination whole embryos or, in later stages, the head were stained by acetic orcein after hypotonic pretreatment and squashed. Eighty-five embryos of the colchicine group and 219 embryos of the 'polyspermy' group were analysed; the results are given in Table 2.

Embryos classified as triploid contained predominantly triploid and near-triploid mitoses. Most of the mosaics contained triploid or near-triploid mitoses as well as other types of mitoses, the diploid number being, in general, the most frequent; these embryos might have come from originally triploid eggs. The remaining mosaics were diplo-aneuploid. There was practically no sign of 'somatic inconstancy' in the embryos classified as diploid. In an earlier study[8] by one of us, no deviation from the normal number was observed either in spermatogonia of adult rats.

Eight triploid embryos were highly retarded and clearly abortive; two triploids, however, both 10 days old and obtained in the 'polyspermy' group, were of normal size and appearance. Eight of the mosaic embryos were abortive while 14 appeared normal although more or less delayed in some cases.

To conclude, our results put forward new evidence that dispermic fertilization is a source of triploid embryos in the rat. It seems that most dispermic triploid embryos can become implanted and their further fate does not differ considerably from that of triploids of other origin.

Colchicine treatment after ovulation is an efficient method to induce heteroploidy in the rat; but few heteroploid embryos survive to mid-term. A large proportion of the heteroploid forms (including most triploids) die before or soon after implantation.

The disappearance of triploids, and the reduction in the number of mosaics, after 12 days gestation show that the chances of these heteroploid forms reaching term, whatever be their origin, are faint. This is in accordance with the failure (refs. 2–4 and Beatty, R. A., personal communication) to produce adult heteroploid (triploid) offspring. In fact, the 12 days old triploid embryos described here are, to our knowledge, the latest stage of triploidy recorded so far in any mammal.

L. Piko
O. Bomsel-Helmreich

Station de Physiologie Animale,
Jouy en Josas
(Seine-et-Oise).

---

[1] Austin, C. R., and Braden, A. W. H., *Aust. J. Biol. Sci.*, 6, 674 (1953).

[2] Piko, L., *C.R. Soc. Biol., Paris*, 152, 1356 (1958) (and unpublished results).

[3] Braden A. W. H., and Austin, C. R., *Science*, 120, 361 (1954).

[4] cf Beatty, R. A., "Parthenogenesis and Polyploidy in Mammalian Development" (Cambridge Univ. Press, 1957).

[5] Edwards, R. G., *J. Exp. Zool.*, 137, 317, 349 (1958)

[6] Austin, C. R., and Braden, A. W. H., *Aust. J Biol. Sci.*, 7, 179 (1954).

[7] Austin, C. R., and Braden, A. W. H., *Aust. J. Biol. Sci.*, 7, 195 (1954).

Bomsel-Helmreich, O., *Ann. Zootech.*, 8, 327 (1959).

Fractionation of Genes

After study of a dwarf tribe of Papuans at Aiome in the mountains of New Guinea in 1958 (not yet published), the conclusion was reached that they originated as a single-gene dwarf mutation from their tall neighbours who live at lower altitudes. This conclusion has since been confirmed by Champness *et al.*[1], who find that the blood groups of the tall and dwarf tribes in this area are essentially the same while the serology of a dwarf tribe in another part of New Guinea was markedly different. This supports the view that in mankind dwarf tribes or races have originated many times independently in different parts of the world, as they are known to have done in animals. In Africa it was concluded[2] that the Congo Pygmies arose long ago as a single-gene achondroplastic dwarf mutation from a tall race probably with mahogany skin colour.

In an extensive study of dwarf tribes in Dutch New Guinea, Bijlmer[3] found records of male stature stretching, perhaps in a step-like series, from 167 cm. (occasionally more) in the talls to 144·9 cm. as the lowest mean stature for a particular dwarf tribe.

Contemplating these and various other facts of dwarfing during a journey in India during October–December 1959, the tentative conclusion was reached that the intermediate heights of some Papuan tribes must have been derived in part from back-crossing of dwarfs to talls, accompanied by fractionation of the original 'large' gene for dwarfing and the production of 'smaller' genes having various intermediate effects. This is in accordance with the view I have always held that some mutations occur with large effects, as well as many with small effects. Having reached the conclusion that fractionation of genes must occur in some dwarf races, it was boldly decided to discuss this principle as soon as opportunity permitted a description of the Aiome dwarf race.

That opportunity has not yet occurred; but in the meantime, through the kindness of Dr. L. T. Ride, vice-chancellor of the University of Hong Kong, I was able in January 1960 to read back-numbers of *Nature*. In the number for December 19, 1959, I found a paper[4] which in one sense forestalled, but in another sense confirmed, the point of view mentioned above.

Briefly stated, the conception of the sub-gene is based[5] on experiments with the *T*4 bacteriophage and later with certain bacteria and lower fungi. From study of small differences in the phenotypic expression of a pair of genes in the *cis–trans* or coupling and repulsion phases it is shown that the cistron is a unit within the gene, and it may contain more than a hundred sensitive points at which a mutant phenotype may occur.

In the work of Fahmy and Fahmy[4], a large number of sex-linked recessive visibles obtained at the *r* locus by irradiation of *Drosophila melanogaster* proved to be a pseudo-allelic series, apparently involving several functional sub-units (cistrons) one or more at a time. That these are all intra-genic point mutations is shown by the absence of any band deficiencies in the *X*-chromosomes. Complementation maps indicate that six cistrons are involved in this series, which can be arranged in a linear sequence with overlapping.

Since the cistron conception is now established for an insect it may be assumed to apply to genes generally, including those of man. If genes contain, or consist of, cistrons then fractionation of the gene can occur, which will reduce the original genic effect. This principle is of wide importance in human genetics. In Eskimo X Nordic[6], the F_1 X Nordic can produce an individual having blue eyes, fair hair and white skin like the original grandfather. Thus the gene for blue eyes, for example, segregates as a complete unit in this racial cross. But in the European population many intergrades between blue and brown iris occur which have never been properly studied but which may be reasonably attributed to fractionation of the original gene.

As regards the blood groups, it is evident that ABO are original or ancestral genes, and that A_1, A_2, etc., are later developments produced by fractioning of the original gene so that its effect is milder in different degrees. Similarly, there is evidence that brachycephaly first appeared in the Upper Palæolithic as a marked departure from the previous dolichocephaly. Later, more extreme forms of brachycephaly as well as intermediate cephalic indices have probably been produced, partly by fractionation of the original gene, through hybridization, or otherwise. Thus in many cases the more extreme form of a gene appears first and its lesser and later forms bridge the gap by means of a series of sub-genes.

R. Ruggles Gates

18 Concord Avenue,
Cambridge 38, Mass.

---

[1] Champness, L. T., Kooptzoff, O., and Walsh, R. J., *Oceania* (in the press).

[2] Gates, R. R., *Acta Genet. Med. et Gemell.*, 7, 159 (1958).

[3] Bijlmer, H. J. T., *Nova Guinea*, N.S., 3, 113 (1939).

[4] Fahmy, C. G., and Fahmy, M. J., *Nature*, 184, 1927 (1959).

[5] Benzer, S., "The Elementary Units of Heredity" in "Chemical Basis of Heredity", 70 (Johns Hopkins Press, 1956).

[6] Gates, R. R., "Heredity in Man", 385 (London, 1929).

GEOLOGY

Geological Reconnaissance of the Sör-Rondane Mountains (Queen Maud Land)

In the course of the summer field parties of the Expedition Antarctique Belge 1957–58, I carried out a geological reconnaissance in the Sor-Rondane ranges, unexplored up to then.

This massif extends over approximately 250 km. east and west (from 23° E. to 28° E.) and has a depth of about 100 km. The foot-hills of the chain lie about 150 km. inland from the coast, at approximately 72° S. latitude. The summits are elevated between 1,200 and 3,500 m. above sea-level and the snow-line lies between 1,000 and 3,000 m.

The present topographical features have resulted from glacial erosion followed by a long stage of post-glacial erosion due mainly to mechanical weathering. The highest peaks investigated show evidence of heavy glaciation.

The region investigated is formed entirely of crystalline rocks, there being no trace of non-metamorphosed sedimentary rocks, nor of epizonal metamorphism.

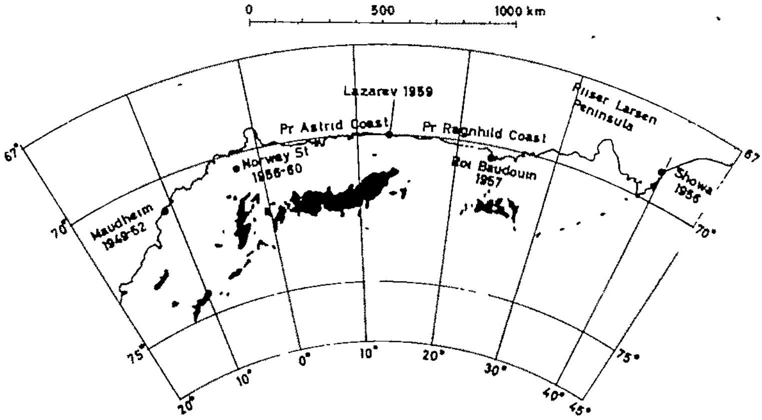


Fig 1. Queen Maud Land

The nunataks to the north of the chain are formed of intrusive igneous rocks (coarse-grained red granite at Roemnesfjell, diorites at Nordtoppen and Småhausane).

The mountain chain itself is formed of migmatites and highly varied, though mainly biotitic and amphibolic, gneiss. In one occurrence (at Austkampane) the gneiss is interspersed with layers of pure crystalline limestone associated with banks of calcium silicate gneiss. Homogeneous massifs of dioritic gneiss are also found. The general direction of the gneiss is east–west; the dip is very variable.

The gneissic complex, at certain points, is transected by a disordered network of pegmatitic and granitic dykes. The intensity and widespread occurrence of this phenomenon are striking characteristics of the region.

The phenomena of anatexy and of migmatization are widespread. This gneissic complex obviously forms part of the eastern Antarctic Pre-cambrian complex. The igneous intrusives to the north of the chain are clearly later than the gneiss but of unknown age.

There is no evidence of mineralization either in the gneiss or in the igneous intrusives.

The following successive stages in the geological history of this region are identifiable: (1) the deposition of a vast and varied sedimentary complex, including limestone deposits, under geosynclinal conditions; (2) the folding and metamorphism of the sedimentary complex in a deep zone (upper catazone), accompanied by dioritic intrusions; (3) the intrusion of granitic and dioritic rocks into the gneiss; (4) the formation of granitic and pegmatic dykes cutting through the intrusive bodies.

The radioactivity dating of the samples at present being carried out will furnish more precise information as to the chronology of these stages.

I wish to thank Dr. Jacques Giot, who led the sled journey into the Sör-Rondane, and Drs. Paul and Jean Michot, who are carrying out the petrographical study of the samples collected.

The geographical names refer to the map of the Sör-Rondane Mountains, published by the Norsk Polarinstitutt, in 1957.

E. E. Picciotto

Laboratoire de Physique Nucléaire,
Université Libre de Bruxelles.

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, May 30

UNIVERSITY OF LONDON (in the Anatomy Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. B. Segre (University of Rome): "Galois Spaces".*

UNIVERSITY OF LONDON (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Sir Aubrey Lewis: "Agents of Cultural Advance" (Hobhouse Memorial Lecture) *

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Sir Mortimer Wheeler: "An Ancient Metropolis of the North-West Frontier; Recent Work at Charsada" (The Dickson Asia Lecture 1960).

Tuesday, May 31

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 5.45 p.m.—Mr. W. E Griffiths: "Recent Excavations at Stone Circles in North Wales".* (Seventh of nine lectures on "Recent Archæological Discovery in Britain". Further lectures on June 7 and 14.)

Wednesday, June 1

GEOLOGICAL SOCIETY OF LONDON (at Burlington House Piccadilly, London, W.1), at 5 p.m.—Prof. E. Sherbon Hills (University of Melbourne). "Morphotectonics and the Geomorphological Sciences, with special reference to Australia" (Fifteenth William Smith Lecture).

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road, London, E.1), at 5.30 p.m.—Prof. S. Chapman, F.R.S. (Geophysical Institute, Alaska): "Electric Currents in the Earth's Ionosphere".*

INSTITUTE OF INFORMATION SCIENTISTS (at the College of Preceptors, 2 Bloomsbury Square, London, W.C.1), at 6.15 p.m.—Annual General Meeting. 7.30 p.m.—Prof. J. D. Bernal, F.R.S.: "Can Communications Science be used in Channelling Scientific Information?"

SOCIETY OF CHEMICAL INDUSTRY, HEAVY ORGANIC CHEMICALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. R. Holroyd: "Cross Fertilization of Petroleum and Chemical Industry Techniques through Heavy Organic Chemicals".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. G. C. Drew: "Alcohol and Skilled Performance".

Thursday, June 2

BRITISH ASSOCIATION FOR COMMERCIAL AND INDUSTRIAL EDUCATION (at the Polytechnic, Regent Street, London, W.1), from 10 a.m. to 4.15 p.m.—Conference and Exhibition on "Visual Aids for Technical Education".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. H. Godwin, F.R.S.: "Radiocarbon Dating and Quaternary History in Britain" (The Croonian Lecture).

MINERALOGICAL SOCIETY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. S. J. Bach: "The Metabolic Fate of Protein-Nitrogen in the Mammal".*

UNIVERSITY OF LONDON (at Guy's Hospital Medical School, St. Thomas's Street, London, S.E.1), at 5.30 p.m.—Prof. O. Liébecq (Liège): "Biochemical Aspects of Glucose Utilization in Muscle Tissue".*

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road, London, E.1), at 5.30 p.m.—Prof. S. Chapman, F.R.S. (Geophysical Institute, Alaska). "Electric Currents Beyond the Ionosphere".*

WORSHIPFUL SOCIETY OF APOTHECARIES OF LONDON, FACULTY OF THE HISTORY OF MEDICINE AND PHARMACY (at Apothecaries Hall, Black Friars Lane, London, E.C.4), at 5.30 p.m.—Mr. K. D. Keele: "William Harvey: Pioneer of Medical Science" (First Annual Students' Lecture).

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. M. Heidelberger: "Chemical Constitution and Immunological Specificity" (Centenary Lecture).

Friday, June 3

INSTITUTION OF CHEMICAL ENGINEERS (at the Imperial College of Science and Technology, Department of Chemical Engineering, Prince Consort Road, London, S.W.7), at 3.30 p.m.—Mr. N. G. Maroudas: "Mass Transfer in Liquid–Liquid Systems: Simultaneous Transfer of Two Solutes between Two Immiscible Solvents".

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road London, E.1), at 5.30 p.m.—Prof. S. Chapman, F.R.S. (Geophysical Institute, Alaska): "The Solar Corona and the Earth's Outermost Atmosphere".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

MAY AND BAKER RESEARCH FELLOW (honours graduate in chemistry)—The Registrar, Wye College (University of London), Wye, Kent (June 1).

ASSISTANT LECTURER, Grade "B", IN BIOLOGY; and an ASSISTANT LECTURER, Grade "B", IN CHEMISTRY—The Principal, Peel Park Technical College, Salford 5 (June 2).

ASSISTANT LECTURER IN GENETICS; and a LECTURER or ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, The University, Leicester (June 4).

LECTURER (graduate in pharmacology, physiology, biochemistry or veterinary medicine) IN THE DEPARTMENT OF VETERINARY PHARMACOLOGY—The Secretary, The University, Edinburgh (June 4).

ASSISTANTS (2) IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (June 6).

UNIVERSITY DEMONSTRATOR (with an honours degree in chemistry or agricultural chemistry) IN SOIL SCIENCE—The Secretary, School of Agriculture, The University, Cambridge (June 8).

LECTURER or ASSISTANT LECTURER (qualified in pure or applied mathematics) IN MATHEMATICS—The Registrar, University College of North Staffordshire, Keele, Staffs (June 9).

DEMONSTRATOR IN THE DEPARTMENT OF PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (June 10).

LECTURER IN STATISTICS IN THE DEPARTMENT OF PURE MATHEMATICS; a LECTURER IN THE DEPARTMENT OF MATHEMATICAL PHYSICS; LECTURERS (2) IN THE DEPARTMENT OF PHYSICS; LECTURERS (2) IN THE DEPARTMENT OF CHEMISTRY; a LECTURER (preferably MYCOLOGIST) IN THE DEPARTMENT OF BOTANY; a LECTURER IN THE DEPARTMENT OF MECHANICAL ENGINEERING; a LECTURER IN THE DEPARTMENT OF ENGINEERING PRODUCTION; LECTURERS (3) IN THE DEPARTMENT OF CIVIL ENGINEERING; LECTURERS (2) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING; a LECTURER IN THE DEPARTMENT OF CHEMICAL ENGINEERING; a LECTURER IN THE DEPARTMENT OF PHYSICAL METALLURGY; and a LECTURER IN THE DEPARTMENT OF INDUSTRIAL METALLURGY—The Deputy Registrar, The University, Edgbaston, Birmingham 15 (June 11).

TUTORIAL ASSISTANTS (2) IN THE DEPARTMENT OF GEOLOGY—The Registrar, University College of Wales, Aberystwyth (June 11).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or five subjects at G.C.E. "O" level and at least two at "A" level) IN THE DEPARTMENT OF POTATO GENETICS, to assist in routine tests and pathological investigations—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts (June 15).

LECTURER (with a degree in textile industries, followed by research experience; or chemistry, followed by specialization in textile chemistry) IN TEXTILE CHEMISTRY at the Home Science School, University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or The Registrar, University of Otago (New Zealand and London, June 15)

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, The University, Leicester (June 18).

LECTURER or an ASSISTANT LECTURER (veterinary surgeon, or possessing a degree in an appropriate biological subject) IN VETERINARY PATHOLOGY—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (June 18).

LECTURER or SENIOR LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Sheffield (June 18).

SENIOR LECTURER IN SOLID STATE PHYSICS—The Registrar, The University, Sheffield (June 18).

LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Leeds 2 (June 24).

CHAIR OF MECHANICAL ENGINEERING AND HEAD OF THE DEPARTMENT—The Registrar, The University, Nottingham (June 30).

LECTURER (with a thorough knowledge of the physics of materials, and industrial or research experience involving semiconductors, polymers, magnetic materials, etc.) IN MATERIALS TECHNOLOGY IN THE DEPARTMENT OF ELECTRONIC ENGINEERING—The Registrar, University College of North Wales, Bangor, North Wales (June 30).

LECTURERS (2) IN PSYCHOLOGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

LECTURERS or ASSISTANT LECTURERS (with at least a good honours degree in mathematics and experience in teaching and research) IN MATHEMATICS at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Malaya and London, June 30).

POSTDOCTORAL RESEARCH FELLOWS (with previous experience either in the chemical investigations of the structure of proteins or in the synthesis of peptides)—Dr. G. T. Young, The Dyson Perrins Laboratory, The University, South Parks Road, Oxford (June 30).

WAYNFLETE PROFESSOR OF PURE MATHEMATICS—The Registrar, University Registry, Oxford (June 30).

ASSISTANT DIRECTOR OF THE SOLAR PHYSICS OBSERVATORY, for research in solar or stellar physics, with some lecturing and light administration—The Director, Observatories, The University, Madingley Road, Cambridge (July 1).

SENIOR LECTURER and a LECTURER IN PHYSICS at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 1).

CHAIR OF PHARMACOLOGY in the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong and London, July 15).

PROFESSOR, and a READER IN THE DEPARTMENT OF MATHEMATICS, University of Rajshahi, East Pakistan—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (August 31).

ASSISTANT EXPERIMENTAL OFFICER (CHEMISTRY) (male or female, with a university pass degree in chemistry or agricultural chemistry)—The Secretary, Welsh Plant Breeding Station, Plas Gogerddan, near Aberystwyth.

ASSISTANT, Grade "B" (with a good honours degree, and preferably industrial or research experience), FOR MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham, Essex.

ASSISTANT PROFESSOR (medically qualified or with a science degree of appropriate quality) IN THE DEPARTMENT OF MEDICAL BACTERIOLOGY—The Dean, Faculty of Medicine, The University of Alberta, Edmonton, Alberta, Canada.

CHEMISTRY MASTER, to teach throughout the school to "A" and "S" level G.C.E.—The Headmaster, The Perse School, Cambridge.

Computer to work in a small team concerned with plasma research—Prof. D. Gabor, F.R.S., Electrical Engineering Department, Imperial College of Science and Technology, London, S.W.7.

Experimentalist (with G.C.E. at "A" level, H.N.C. or equivalent and appropriate experience), to work in the Proton Physics Group of the Nuclear Physics Division engaged in the investigation of various methods, such as plating and vacuum evaporation, for producing thin targets for exposure in the Proton Linear Accelerator and also to work on nuclear detectors and to participate in the experimental work of the group which is using the P.L.A. for studying nuclear structure—The Senior Recruitment Officer (1672/34), U.K A.E A., A.E.R.E., Harwell, Didcot, Berks.

Junior Lecturer (Ph.D. standard in chemistry or biochemistry, and interested in pursuing research in microbiological chemistry) in the Department of Biochemistry—The Dean, London School of Hygiene and Tropical Medicine (University of London), Keppel Street, London, W.C 1.

Lecturer (graduate, with teaching and/or industrial experience in electronic and control technology, or a related branch of applied physics) in the School of Physics and Applied Science—The Registrar, College of Technology and Commerce, Leicester.

Lecturer (honours graduate, or with an equivalent qualification, preferably with industrial and/or teaching experience in statistics) in Statistics and Mathematics—The Principal, Medway College of Technology, Horsted, Maidstone Road, Chatham, Kent.

Lecturers, Grade "B" (2) (graduates of a British university, one with qualifications and experience in electronics, and the other with qualifications and experience in theoretical and nuclear physics)—Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

Professor (with a background of university teaching and significant research accomplishment, with relevant professional experience) of Mechanical Engineering (Chairman of the Department)—The Dean of Engineering, University of Waterloo, Waterloo, Ontario, Canada.

Research Assistant (with a degree in botany, and preferably an interest in mycology) in Botany—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1.

Research Assistant (with a degree in science or graduate member of the Royal Institute of Chemistry, or graduating this summer and qualified to work for a higher degree or research diploma) in Organic Chemistry—The Principal, Bolton Technical College, Bolton, Lancs.

Research Assistants (honours graduates in physics or students in the present graduation class), for work on problems concerned with counting techniques and high energy physics, gas discharges, spectroscopy or electronics—The Clerk to the Governors, Northern Polytechnic, Holloway Road, London, N.7.

Research Biochemist (Ph.D., preferably with a knowledge or research experience in the fields of pharmacology or pharmacological chemistry, clinical biochemistry or spectrophotometry), for investigations into the biochemical actions of drugs currently used in the treatment of mental illness, proceeding in conjunction with clinical studies on therapeutic action—The Director of Clinical Research, Crichton Royal, Dumfries.

Research Officer, Biochemist (with a good honours degree in chemistry or biochemistry, with postgraduate experience in biochemistry, preferably of animal nutrition and/or animal physiology) in the Animal Husbandry Division, East African Agriculture and Forestry Research Organization, Kenya—Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/151/C.1.

Senior Lecturer (with a good honours degree in mathematics) in Pure Mathematics—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

National Institute of Industrial Psychology Annual Report and Statement of Accounts for the year ended 30th September, 1959 Pp 12. (London National Institute of Industrial Psychology, 1960) [73

Colonial Office Colonial Research 1958–1959 Reports of the Colonial Research Council; Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Economic Research Committee; Colonial Fisheries Advisory Committee; Colonial Medical Research Committee; Colonial Pesticides Research Committee; Colonial Products Council, Colonial Road Research Committee; Colonial Social Sciences Research Council; Tsetse Fly and Trypanosomiasis Committee; Director, Anti-Locust Research Center; and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. Pp. 419. (Cmnd. 938.) (London H.M. Stationery Office, 1959.) 18*s*. net. [73

Time Measurement in Dynamic Geometry. By S. Ryzewski. Part 1. Pp. 16. Part 2: Pp. 8. (Southampton S. Ryzewski, 15 Landguard Road, 1959 and 1960.) [73

The British Gelatine and Glue Research Association. Eleventh Annual Report for the year October 1958 to September 1959. Pp. 16. (London The British Gelatine and Glue Research Association, 1960.) [73

Defective Molecules as a Cause of Disease: an Inaugural Lecture. By Prof. G. H. Lathe. Pp. i+24. (Leeds. Leeds University Press, 1960.) 2*s* 6*d*. [73

Carnegie Trust for the Universities of Scotland Fifty-eighth Annual Report for the year 1958–59. Pp. iii+73. (Edinburgh. Carnegie Trust for the Universities of Scotland, 1960.) [73

Ciba (A.R.L.), Ltd. Technical Notes No. 206 (February, 1960): Model-making with 'Araldite.' Pp. 12. (Duxford: Ciba (A.R.L.), Ltd, 1960.) [73

Urwick Management Centre: Current Courses. Pp. 8. (Slough Urwick Management Centre, 1960.) [73

The Coil Spring Federation Research Organisation. Spring Research for Industry. Pp. 16. (Sheffield: Coil Spring Federation Research Organization, 1960.) [73

British Broadcasting Corporation. B.B.C. Engineering Monograph No. 28: Programme Switching, Control, and Monitoring in Sound Broadcasting. By R. D Petrie and J. C. Taylor. Pp. 32. (London: British Broadcasting Corporation, 1960.) 5*s*. [73

Society of Glass Technology. *Glass Technology*, Vol. 1, No. 1 (February, 1960). Pp. xl+68. Published bi-monthly. 25*s*. per issue or £6 15*s* per volume. *Physics and Chemistry of Glasses*, Vol. 1, No. 1 (February, 1960). Pp. 54. Published bi-monthly 25*s*. per issue or £6 15*s*. per volume. Joint annual subscription £10 (Sheffield. Society of Glass Technology, 1960.) [73

Commission for Technical Co-operation in Africa South of the Sahara. CSA/CCTA. Publication No. 30, Joint Project No. 4: Inventory of Economic Studies Concerning Africa South of the Sahara—an Annotated Reading List of Books, Articles and Official Publications. Pp. xi+301. (London: Commission for Technical Co-operation in Africa South of the Sahara, 1960.) [73

Campaign for Nuclear Disarmament. *CND. Scientists Bulletin*, No 1, 1960 Pp. 4. (London. Campaign for Nuclear Disarmament, 1960) [83

Other Countries

Institut Royal Météorologique de Belgique. Publications, Serie B, No. 27 Équation Générale des Transformations Pseudoadiabatiques dans l'Atmosphère. Par Dr. L. Dufour. Pp. 10. (Bruxelles: Institut Royal Météorologique de Belgique, 1959.) [73

Bulletin of the American Museum of Natural History. Vol. 119, Article 1: The Vegetation of Micronesia. 1. General Descriptions, The Vegetation of the Marianas Islands, and a Detailed Consideration of the Vegetation of Guam. By F. Raymond Fosberg. Pp. 1–76+plates 1–40. (New York: American Museum of Natural History, 1960.) 2.50 dollars [73

Smithsonian Institution Bureau of American Ethnology. Bulletin No. 172: The Story of a Tlingit Community—a Problem in the Relationship Between Archaeological, Ethnological, and Historical Methods. By Frederica de Laguna. Pp. x+254+11 plates. (Washington, D.C.: Government Printing Office, 1960.) 2 dollars. [73

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Bulletin No. 50. A Glacial Study of Central Quebec-Labrador. By E. P. Henderson. Pp. viii+94 (24 plates). (Ottawa Queen's Printer, 1959.) 1 dollar. [73

Le Problème de Fermat et la Formule du Binome. Aide-Mémoire des Principaux Résultats Obtenus par F. Henri-A. Beauvois. Pp. 7. (Pessac Gironde F. Henri-A. Beauvois, 1960.) [83

Bulletin of the Astronomical Institutes of the Netherlands, Vol. 15, No. 494 (1960 February 8): The Component of the Galactic Gravitational Field Perpendicular to the Galactic Plane, *Kz*. By E. R. Hill. Note on the Determination of *Kz* and on the Mass Density Near the Sun. By J. H. Oort. Pp. 1–53. Vol. 15, No. 495 (1960 February 10). The Computation of Partition Functions in a Stellar Atmosphere. By C. de Jager and L. Neven. Pp. 55–66 (Leiden: Astronomical Institutes of the Netherlands, 1960.) [83

United States Department of the Interior. Fish and Wildlife Service. Fishery Bulletin No. 166. Relation Between Fish Condition and Population Size in the Sardine (*Sardinops caerulea*). By John S. MacGregor. Pp. iv+215–230. (Washington, D.C.: Government Printing Office, 1959.) 20 cents [83

Union of South Africa: Department of Commerce and Industries. Division of Fisheries Investigational Report No. 39: The Biology of Guano-Producing Sea-Birds. The Distribution, Abundance and Breeding Habits of the Cape Ganet, *Morus capensis*, off the South-Western Coast of the Cape Province. By R. W. Rand. Pp. 36. (Reprint from *Commerce and Industry*.) (Pretoria: Government Printer, 1959.) [83

Government of Bombay. Haffkine Institute Annual Report for the year 1958. Pp. iii+56. (Bombay: Government Book Depot; London: High Commissioner for India, 1959.) Rs. 0 62; 1*s*. 1*d*. [83

Texas Instruments, Inc. Annual Report, 1959. Pp. 20. (Dallas Texas Instruments, Inc., 1960.) [83

United States Department of the Interior Fish and Wildlife Service. Fishery Bulletin No. 165: Distribution and Abundance of Eggs of the Pacific Sardine, 1952–1956. By E. H Ahlstrom. Pp. iv+185–213. 30 cents. Fish and Wildlife Circular No. 58. Public Fish Culture in the United States, 1958: a Statistical Summary. By William Hagen. Pp. iv+44. 35 cents. (Washington, D.C.: Government Printing Office, 1959.) [83

Bibliography of Plasma Physics and Magnetohydrodynamics and their Applications to Controlled Thermonuclear Reactions. Compiled by James D. Ramer, with the assistance of Chong Kook Lewe and Maurice Barkley. Pp. ii+105. (College Park, Maryland: Engineering and Physical Sciences Library, University of Maryland, 1959.) [83

Rensselaer Polytechnic Institute, Troy, New York. Annual Report, 1958–1959. Pp. 54. (Troy, New York: Rensselaer Polytechnic Institute, 1960.) [83

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

MANAGEMENT, EDUCATION AND BUSINESS STUDIES

In a circular issued to local education authorities on March 28, 1960*, the Minister of Education gave details of the radical changes which are to be made in schemes of management studies and commercial education in Britain. Due to take effect in the autumn of 1961, the changes will affect both the existing courses leading to the Intermediate Certificate and Diploma in Management, which are administered jointly by the Ministry of Education, the British Institute of Management and other professional management bodies, and the Ordinary National and Higher National Certificates in Commerce, which are administered by a joint committee of professional bodies, local education authorities and the Ministry of Education.

The changes in management education and commercial studies have been announced jointly because, to some extent, future arrangements will lead to amalgamation of existing courses and to much more simplified administrative arrangements for the control of the new courses which have been devised.

The development of education for management in England and Wales is described in the Report of a Working Party which is issued as an appendix to Circular 1/60. Following the report of the Committee on Education for Management appointed by the Minister of Education in 1945 under the chairmanship of Colonel L. F. Urwick, a scheme of management studies was begun in senior technical colleges about nine years ago. The courses recommended were of five years duration and led to examinations for the Common Intermediate Certificate in Management Studies at the end of three years and a Diploma in Management Studies which was taken at the end of five years. Over the nine years the Urwick courses have led to considerably increased interest in management education, and industry in Great Britain owes a considerable debt of gratitude to Urwick and his committee for devising practical schemes of management studies which at long last the country is beginning to take seriously.

Inevitably the pioneering courses have met with criticisms and these have been considered by the Working Party which began its work in October 1955. The need to reconcile conflicting views of numerous professional management bodies, industrial and commercial organizations, educational institutions and local education authorities has caused the Working Party to tread a tortuous path and to take an unconscionable time in producing its report. This was submitted to the Minister in October 1958, and the changes now announced represent another triumph in producing an agreed scheme which should do much to put management education at a level where it can no longer be ignored by the purists or by those practical men who came up the so-called hard way.

At present there is a lack of adequate provision for extended management courses of an advanced nature suitable for men and women who are already professionally qualified, and there are relatively few colleges with a nucleus of full-time staff able to develop such courses and to engage in research. So far, too, management education has been conditioned by its history in that it has usually been closely associated with economics and commerce, and has left in relative neglect the social sciences, particularly psychology and sociology. The Minister is convinced that there is both an educational and also a pressing economic need for a major advance, and proposes to set up a course leading to a Diploma in Management Studies. This course may not, in general, be taken by people unless they already possess graduate or equivalent professional qualifications and have had a measure of relevant practical experience in employment. If taken part-time, the courses will last three years, with a minimum entry age of twenty-three. No diplomas will be awarded before the age of twenty-six.

Entry to courses will normally be permitted only to students who hold a degree, a diploma in technology, a final professional qualification approved for the purpose, or a higher national diploma, or people in managerial positions whose education has been interrupted since leaving school and who do not have the necessary academic entry qualifications. For those with appropriate experience exceptional admission will be available.

Experience in management studies has shown the advantage of full-time, and especially full-time residential, courses over part-time courses. Those advantages are especially apparent for students of mature age and experience and of proved academic ability. The Minister indicates that full-time residential courses will increasingly be found to constitute the most satisfactory way of meeting the needs of the students for whom the Diploma scheme is designed.

In the existing courses many of the students are young, inexperienced youths who seek to obtain managerial positions by long and arduous studies spread over at least five years of often badly taught evening classes; others are frustrated clerks and some of middle age who have been passed over for promotion, and who turn to management evening classes to prove themselves and restore their fortunes. Much misery has resulted from this system, and the Minister now roundly calls upon employers to remedy this unsatisfactory position by supporting part-time or full-time day or, even more desirable, full-time residential courses.

In principle, postgraduate courses of the type envisaged should be conducted only in colleges which are well equipped and staffed for the purpose and which offer courses in other subjects at postgraduate level as well as advanced courses in the separate aspects and techniques of management. So far as full-time and sandwich courses are concerned, the Minister recommends that provision should be restricted to the Colleges of Advanced Technology and those Regional Colleges which are already conducting well-established courses at the level of the Diploma in Management Studies. Only by such concentration will it be possible to build up the nucleus of full-time staff well qualified in the economic, physical and social sciences and able to conduct the research and consultancy work which are the essential bases of a lively postgraduate course. This long-overdue step will do much to improve the quality of management education.

---

* Ministry of Education. Circular 1/60 (28th March, 1960): The Future Development of Management Education and of Business Studies—Revision of Joint Examination Schemes. Pp. 3. Appendix to Circular 1/60: Report of the Working Party appointed to examine the Scheme of Management Studies. Pp. 1+57. (London: Ministry of Education, 1960.)

Students of management would have been much happier with the Circular, however, if greater emphasis had been placed on the maintenance of adequate teaching standards at senior technical colleges by means of regular inspection. The Minister's statement would also have been improved if it had contained some reference to the well-known passage in the Urwick Report that "Theoretical Training alone does not make a Manager".

Besides the Diploma in Management Studies, Circular 1/60 also describes the setting up of two new National Certificates in Business Studies—an Ordinary and a Higher. These will replace the existing Common Intermediate Certificate in Management Studies as well as the Ordinary and Higher National Certificates in Commerce. Unlike the proposal to develop a new Diploma in Management Studies, which is likely to meet with the warmest support from thinking management in industry, the proposal to introduce Ordinary and Higher National Certificates in Business Studies may not meet with much enthusiasm. Ordinary and Higher National Certificates have acquired significance as qualifications pursued by enterprising youths and young men who attend part-time day and evening classes. The Ordinary and Higher National Certificates in Commerce have never acquired respectability, and to dissolve these into the new Ordinary and Higher National Certificates in Business Studies will give the latter emotional overtones which may take them a long time to throw off before becoming accepted as a genuine first step in management studies. An Ordinary National Certificate for genuine students of commerce should have been preserved. The Higher National Certificate in Commerce could well have been dropped, and a new certificate, similar to that proposed both by the Minister and the Working Party, should have been introduced. It should have no direct connexions with the Ordinary National Certificate in Commerce, the name "National" should not figure in it, and it should, as the Minister proposes, be available to all those students who at present take the Common Intermediate Certificate in Management Studies as well as students who hold Ordinary National Certificates in metallurgy, engineering, physics, commerce or any other discipline. The new Higher National Certificate in Business Studies will inevitably be regarded as the natural development from the Ordinary National Certificate in Business Studies. Its name may lead to its demise.

The third proposal contained in the Minister's circular is that an Advisory Council on Education for Management should be set up. Unlike the new diploma and certificates, which only apply to England and Wales, the proposed Council will be established by the Minister of Education, Secretary of State for Scotland and the Minister of Education for Northern Ireland, and will be concerned with management education in the United Kingdom. Such a Council is badly needed; it was one of the major recommendations in the Urwick Report. The three Ministers concerned are to be commended for its establishment, for its proposed composition, and its wide terms of reference. The Council will consist not only of representatives of appropriate educational institutions and of the major professional bodies concerned with management education but also representatives of those scientific and technological institutions which are themselves much interested in management education, together with representatives of both sides of industry and a number of other members with knowledge of management education generally, including management education in the universities. It will be concerned not only with the development of management education at levels beyond the equivalent of a university degree but also with the encouragement of research in management studies.

The new proposals should lead to a silent revolution in British industry. Despite all our success stories, those familiar with industrial undertakings are only too aware that the general picture is still one of muddle, mis-management and the rule of the thumb. Real work-study is little applied; budgeting is unknown; marketing is regarded as hocus-pocus: stock control using operational research techniques is regarded as unsuitable for 'practical' men. A significant difference between American and British industry is that the Americans have long believed in the value of management education; the consequences are well known. Top management in British industry should now grasp the opportunities provided by the Minister to spread the scientific mode of thought along the lines advocated by Urwick and other pioneers many years ago. Now that the Minister has come down so heavily on the side of residential courses for management studies, perhaps he may soon announce what the Government proposes to do to fulfil its election promise of setting up an Advanced Centre for Management Education with university status. He should also ask his newly appointed Advisory Council to examine the existing facilities for management education to see if some order may not be built up from the existing confusion. The diversified activities at the Administrative Staff College, management consultant training centres, university and technical college management courses should be brought together to fit into a unified pattern of education for management. Existing residential courses of the requisite standard should be accepted in part for the new Diploma in Management Studies.

RUSSIAN APPROACH TO MINERAL PARAGENESIS

Physiochemical Basis of the Analysis of the Paragenesis of Minerals

By D. S. Korzhinskii. Translated from the Russian. Pp. 142. (New York: Consultants Bureau, Inc.; London: Chapman and Hall, Ltd., 1959.) 7.50 dollars; 63s. net.

THIS book, which was originally published in Russian in 1957, is an excellent, clearly written, introductory discussion of the application of thermodynamics and the principles of projective geometry to the analysis of the paragenesis of minerals in multi-component heterogeneous natural silicate systems.

The first chapter discusses the thermodynamic principles governing mineral paragenesis and is especially notable in two respects. First, by its consideration of the extensive parameters, that is to say, those such as mass, volume, entropy and enthalpy, the magnitudes of which depend on the size of a system or phase as distinct from the intensive parameters such as temperature, pressure and concentration. These extensive parameters have long been neglected even in classical thermodynamics and this neglect has been carried over into most of the thermodynamic discussions of natural silicate systems. Secondly, and equally notable, is the extension of the phase rule to cover open systems and not just isolated and closed systems, which are now generally recognized to be extremely rare in geological conditions. Apart from his memorable studies of the basement rocks of eastern Siberia, the author is perhaps best known for his views on metasomatism and the significance of 'perfectly mobile' components the chemical potentials, activities and concentrations (not masses) in one of the phases or partial vapour pressures of which are factors of equilibrium of a system. Without such a concept of 'perfectly mobile' components the thermodynamic approach to open systems is impossible. The author is careful to restrict his consideration of components to independent components, but we must hope he will eventually extend his treatment.

The second chapter deals with methods of representing the chemical composition of various systems, especially multi-component ones, with emphasis on the use of projective geometry in graphical methods. Of particular interest is the use of vectors to represent many (for example, seven) component compounds, following Lodochnikov's earlier work. All the constructions are clearly explained and fully illustrated with admirably labelled diagrams.

Chapter 3 concerns the relation between the chemical and mineralogical composition of rocks under constant external conditions, and includes examples of the paragenetic analysis of minerals in multi-component systems, while Chapter 4 considers the dependence of mineralogical composition on external conditions. In this section more examples are given, which include the use of determinants in calculations of reactions in multi-component systems. A short explanation of the routine in using determinants is given.

In the brief final chapter a few general comments emphasize that in most naturally occurring mineral assemblages the problem is to find the conditions under which the minerals crystallized, using the observed or deduced paragenesis, and that the determination of the stable assemblage in each of numerous different, but associated, rocks is important, but frequently difficult to achieve. No mention is made of the vital importance of synthetic laboratory studies.

Examples of the application of the author's approach to particular systems such as the five-component system, CaO-MgO-SiO_2-CO_2-H_2O, and the paragenetic analysis of granitic rocks in relation to the chemical potentials of sodium and potassium, both of which are fully examined, are particularly interesting, and more examples would have been generally welcomed. It is unfortunate that some of the examples do not use co-existing minerals actually analysed and that in the last-mentioned example average chemical compositions of biotites and hornblendes in rather different rocks, and rather poor averages at that, should have been used as the basis for the calculations. Integration of some of the experimentally determined laboratory results available with the natural parageneses could have been profitably included.

Perhaps most important of all, this book directs our attention to the woefully inadequate training in physical chemistry and mathematics of, unfortunately, nearly all geologists. The prevailing emphasis in most universities on laboratory and field studies, to the almost complete exclusion of theoretical geology, especially thermodynamics, has resulted in most geological research becoming a distressingly empirical subject of unco-ordinated fact-finding, and we must welcome this new and fundamental, even if introductory, synthesis. BERNARD E. LEAKE

STEROLS AND TERPENES

Cholesterol

By Prof. David Kritchevsky. Pp. xi+291. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 78s. net.

Ciba Foundation Symposium on the Biosynthesis of Terpenes and Sterols

Edited by G. E. W. Wolstenholme and Maeve O'Connor. Pp. xii+311. (London: J. and A. Churchill, Ltd., 1959.) 45s. net.

ACCORDING to a note on the dust cover, Dr. Kritchevsky's book "provides a centralized source of information on the biological function and significance of cholesterol. It covers cholesterol chemistry, biochemistry, and physiology". One must undoubtedly admire the courage of an author who is willing to undertake such a herculean task, especially when a rival work, which appeared almost simultaneously, required 15 co-authors. As a guide to the literature, it is of considerable value, for reference is made to approximately 2,000 publications.

The first chapter, which deals with the chemistry of cholesterol and its derivatives, is only partially successful. In the space of about 50 pages, the reader is led from the first studies of gallstones in the first half of the eighteenth century to total syntheses of steroids at the beginning of the second half of the twentieth century. The result of such compression is likely to be difficult for biologists to understand and of little value to the chemist. For example, the Woodward synthesis is covered in eight lines of text and a flow-sheet. Sarrett's original synthesis of 11-ketoprogesterone is mentioned, but subsequent improvements (*J. Amer. Chem. Soc.*, 77, 1026, 3824 (1955)) have not been included. Johnson's synthesis of *epi*androsterone is omitted entirely (*J. Amer. Chem. Soc.*, 75, 2275 (1953)). This chapter closes with a useful account of methods of synthesis of isotopically labelled derivatives of cholesterol.

Knowledge of the biosynthesis of cholesterol has increased so rapidly that already the second chapter, through no fault of the author, is badly out of date. Realization that cholesterol biosynthesis proceeds through phosphomevalonic acid has come since the publication of this book. Details of the rearrangements which occur during the formation of lanosterol from squalene have also been elucidated recently.

During the remainder of the book, the author appears to be more at home with his subject, and there are successive detailed accounts of the absorption, transport, and metabolism of cholesterol, the implication of cholesterol in disease states, cholesterol-levels in the blood, and analytical methods for cholesterol. The overall impression which the reader is likely to gain from this part of the book is one of confusion. The author gives a detailed account of a mass of experimental results which abounds with apparent contradictions. Perhaps a more critical approach would have been better. Generous use of subheadings and tables, however, simplifies the reader's task to a considerable extent.

The book ends with a long and useful appendix, which contains a wealth of physical data on cholesterol, its derivatives, and related sterols. In addition, there are tables giving the cholesterol content of foods, sera, breast milk and tissues of many species. Typographical errors in structural formulæ were found on pp. 32 and 64.

The Ciba Foundation has a happy knack of organizing symposia in which the most eminent workers on biological subjects of great current interest are invited to contribute. The published records of these symposia are valuable both to those directly interested in the subject and to those who gamely continue the struggle to keep abreast of modern advances. The uninhibited discussions, which follow the individual contributions, enable the critical reader to appreciate divergencies of opinion among the experts, regions where hypotheses are ahead of experiment, and hence, the possible directions of future research. The present volume is no exception. The 17 papers, which comprise the symposium, cover most facets of the field of terpenoid and steroid biosynthesis. From acetate to cholesterol and the bile acids through such intermediates as mevalonic acid and its phosphate esters, squalene, and lanosterol, is a long story, but such has been the interest, particularly since the discovery of mevalonic acid, that most of the essential steps are now fairly clearly defined. The importance of acetate and mevalonate in the biosynthesis of triterpenes and carotenoids is clear, but these aspects of the field seem less fashionable than cholesterol, perhaps because of the clinical interest in the link between the biochemistry of cholesterol and atherosclerosis.

It is difficult to select any of the work reported in this volume for particular mention. One must, however, pay tribute to the painstaking work of Folkers' group; their discovery of mevalonic acid has provided a tremendous stimulus to biosynthetic studies in this field. For sheer brilliance of experimental technique, the elucidation, by Cornforth and his colleagues, of the mechanism of the rearrangement of methyl groups, which occurs during the cyclization of squalene to lanosterol, is difficult to surpass. The paper describing the biosynthesis of terpenoid compounds in fungi by Birch and Smith has an originality of ideas which stems from a combination of a wide knowledge of natural product chemistry and the mechanisms of organic chemical reactions. Thus, structures as different as mycophenolic acid, mycelianamide, gibberellic acid, and rosenonolactone are shown to be closely related biogenetically.

During the chairman's opening remarks and several times during the subsequent discussion, Sir Robert Robinson parades his anti-carbonium ion banner without seeming to intimidate all the authors, for a number of structures with integral positive charges on carbon are to be found within these pages. It should be remembered that this symposium deals necessarily with only a part of the story of the biosynthesis of terpenes and sterols, namely the nature of the reactions undergone by the substrates in the enzyme-controlled sequence which starts from acetate. Perhaps one day it will be possible to add the missing chapters and write out detailed reaction mechanisms, which include the parts played by the various enzymes, and then it may well be recognized that Sir Robert's criticisms are justified.

D. T. ELMORE

STATISTICAL METHODS IN BIOLOGICAL AND MEDICAL SCIENCES

Statistical Methods in Biology

By Dr. Norman T. J. Bailey. (Biological Science Texts.) Pp. ix+200. (London: English Universities Press, 1959.) 25*s*. net.

Elementary Statistics with Applications in Medicine and the Biological Sciences

By Prof. Frederick E. Croxton. Pp. vii+380. (New York: Dover Publications, 1959.) 16*s*. net.

THESE books are intended for different audiences. Dr. Bailey's book "is to provide workers in the biological and medical sciences with an elementary account of the chief statistical methods liable to be needed in practice". It does this admirably, in a very readable manner.

One of the features of the book is a separate summary of statistical formulæ, arranged so that the reader may easily find the technique appropriate to his problem. In the main text Dr. Bailey is careful to underline the pitfalls surrounding each method, but for obvious reasons of space these do not reappear in the summary. At the beginning of the summary Dr. Bailey warns: "If there is any doubt as to the application or interpretation of any formula, the reader should refer back to the full discussion". The reader should act on this frequently.

The main part of the book covers the usual field of such a treatise—basic ideas of estimation and significance tests, standard distributions and tests, and first principles of experimental designs. Mathematical symbolism is kept to a minimum. As a result, many formulæ appear without introduction: but this is justified by the book's intentions. Curiosity about mathematical derivations may be satisfied elsewhere.

The biologist will find this book extremely useful, both as a 'field guide' and for an insight into the methods employed in statistics. The statistician also would be advised to study this book, as an example of how lucidly statistical principles and arguments may be presented to non-mathematicians.

Dr. Bailey's book is not intended for undergraduate students as yet unfamiliar with research problems. It is to them that Prof. Croxton's book is directed. But as a whole, although the many excellent worked examples are medical in origin, the book is strongly biased towards methods more important to social scientists than to medical or biology students. The first third of the book is devoted to methods of presentation of data, and calculations of medians, modes, skewness and kurtosis. Thereafter the student is led through linear and non-linear correlation, (the word 'regression' appears only in the index), the normal, binomial and Poisson distributions, the reliability and significance of means and proportions, χ^2 tests, and finally a brief section on analysis of variance and allied procedures. As in Dr. Bailey's book, mathematical symbolism is avoided as much as possible; but replacing e by its numerical value in the normal distribution is surely carrying this 'simplification' too far. Prof. Croxton uses language and notation which is not standard, and some arguments, presented in general terms, are applicable only to the particular example under consideration. Although the book might be useful to a student of social medicine, it is on the whole unsatisfactory as an introduction to statistical methods as applied to experimentation.

Both books are attractively presented, Dr. Bailey's solidly bound, Prof. Croxton's in the well-constructed series of Dover reprints; and both are inexpensive by modern standards.

R. M. Cormack

ADVANCES IN PLANT PHYSIOLOGY

Annual Review of Plant Physiology

Vol. 10. Edited by Leonard Machlis, in association with John G. Torrey. Pp. vii+483. (Palo Alto, Calif.: Annual Reviews, Inc., 1959.) 7 dollars.

The tenth annual review of plant physiology follows the same pattern as previous volumes in that no attempt is made to cover advances made in the whole range of plant physiology, but rather to concentrate on a number of restricted fields so as to give a picture of the present position of knowledge in them resulting from recent developments.

The subjects dealt with in the 19 articles which make up the present volume are diverse. Metabolism is well represented. Respiratory mechanism in higher plants, a subject which has attracted a great deal of attention in recent years, is dealt with by D. P. Hackett, and the closely related topic of the metabolism of carbon compounds by M. Gibbs. P. K. Stumpf and C. Bradbeer report on fat metabolism in higher plants, R. H. Burris on nitrogen nutrition and N. W. Pirie on leaf proteins. Two articles are concerned with chlorophyll-containing bodies, one by J. T. Wolken on the structure of the chloroplast, the other by A. W. Frenkel on reactions of bacterial chromatophores induced by light. Various aspects of mineral nutrition considered by W. H. Chandler, T. C. Broyer and P. R. Stout, and S. H. Wittwer and F. C. Teubner have a special bearing on horticulture and agriculture, while the article by G. G. Laties on active transport of salt into plant tissue deals with a fundamental problem of salt relations of plants.

As regards growth and development, J. Doorenbos and S. J. Wellensiek discuss the influence of photoperiod on floral induction, while two articles are concerned with growth-regulating substances, one on the chemical regulation of growth by a number of substances by F. C. Steward and E. M. Shantz, the other, by H. E. Gruen, on auxin and fungi. Phototropism and phototaxis are discussed by J. Reinert.

The remaining four articles are a miscellaneous assemblage, the subjects dealt with being lignins by R. E. Kremers, the pine tree by N. T. Mirov and R. G. Stanley, virus diseases by F. C. Bawden and plant chemotherapy by A. E. Dimond and J. G. Horsfall.

These articles are for the most part well written and generally avoid the fault of developing into a series of abstracts. They are highly informative and their production must have involved a vast amount of work on the part of the various authors. The high standard and usefulness of previous volumes is fully maintained in this latest annual review.

W. Stiles

ROTATING FLUID MASSES

Figures of Equilibrium of Celestial Bodies, with Emphasis on Problems of Motion of Artificial Satellites

By Zdeněk Kopal. Pp. vi+135. (Madison: University of Wisconsin Press, 1960.) 3 dollars.

This important monograph is an exposition of the hydrostatic theory of self-gravitating fluid masses subjected to the distorting effects of rotation and tidal attraction. After a short introductory chapter, Prof. Kopal describes in Chapter 2 the first-order theory, due essentially to Clairaut, Legendre and Laplace, and discusses the mathematical properties of Clairaut's equation. The first-order theory assumes that the fluid mass departs from spherical symmetry by only a small amount, the square of which can be neglected. In Chapter 3 the theory is extended to cover the second-order effects of either the rotation of the body or the tides raised on it by a near neighbour; and in Chapter 4 the effects of interaction between rotation and tides are worked out. Second-order theory has previously been formulated by Callandreau, Darwin, de Sitter, Jeffreys and others; but Prof. Kopal's treatment is more general, and the contents of his Chapters 3 and 4 represent an impressive extension to the existing theory. The short Chapter 5, which concludes the book, discusses the free and forced oscillations of fluid bodies, with special reference to the possibilities of resonance.

The main application of the new theory is in double-star astronomy: in close binary systems the tidal effects in particular can be large enough to require a treatment correct to the second-order.

The subtitle of the book, "with Emphasis on Problems of Motion of Artificial Satellites", is most misleading, and would seem to have been added as an afterthought. These problems are not discussed, except in brief assertions on pages 4, 53 and 113 that the new theory will have an impact on Earth-satellite orbital studies. Since neither the solid Earth nor the atmosphere is exactly in hydrostatic equilibrium, and the Earth's surface is not an exact equipotential, it is difficult to see how the new theory can be directly relevant to the study of Earth-satellite orbits, and more explanation would certainly have been welcome.

It cannot be pretended that the book is easy to read, though this is due partly to the difficulty of the theory. When the author has the chance to relax from the rigours of mathematics, as in the introductory paragraphs of each chapter, his writing is lucid and lively: the last paragraph on page 87 is particularly admirable in giving new life to a well-worn metaphor. The book is printed by a photographic method from a typescript. The resulting product is extremely clear, but the appearance of some of the formulæ would have been improved by more frequent use of small type, especially in fractions. Trivial errors and misprints are commendably rare, though equation (1–39) of Chapter 2 seems to be wholly erroneous and should be replaced by equation (2–3) of Chapter 3.

D. G. King-Hele

FROM NUCLEUS TO UNIVERSE

From Nucleus to Universe
A Course of Selected Lectures in Physics and Astronomy, University of Sydney, January 11–22, 1960. Edited by Prof. S. T. Butler and Prof. H. Messel. Pp. 335. (Sydney: Shakespeare Head Press, Pty., Ltd., 1960.) 84*s*.

THE excellent lectures delivered at the first of the summer schools for science teachers at the University of Sydney, sponsored by the Nuclear Research Foundation, were reviewed in these columns some two years ago (*Nature*, 182, 623; 1958) and have recently been re-issued by Messrs. Macmillan. This present volume contains those given at the third summer school of January 1960. They are of the same high standard, and given by a most distinguished group of scientists. The chief difference from the earlier volume is the thread of continuity that makes it more like a symposium on a single central theme.

The first contribution, by Prof. S. T. Butler, on introductory atomic and nuclear physics, deals with nuclear structure in general, and the interaction between charged particles and radiation. Next, Prof. C. N. Watson-Munro, on advances in thermonuclear research, discusses the physical conditions for maintaining a thermonuclear reaction and the orders of magnitude to be expected. The problems of stability in both linear and toroidal pinch machines, the field convolutions of the Stellerator type, the magnetic-bottle devices and the means of ion injection, are described with helpful diagrams; and there is a short summary of the means available for studying what goes on inside a plasma.

Prof. G. Gamow's account of the universe and its origin is the longest individual contribution. He discusses both the evolutionary and steady-state cosmologies, together with the kind of evidence which would help to discriminate between them. On the evolutionary theory, for the first tenth of the lifetime of the universe, radiation must have preponderated over matter; and the first critical stage from which the protogalaxies emerged came when matter began to play a significant part in affairs. This lively field of controversy was, it appears, submitted to American astronomers by the Gallup pollsters; unanimity was expressed in the answer to one question only—that asking whether such a poll was of any use! Prof. Bart J. Bok continues Prof. Gamow's story with an account of the observational basis for stellar evolution.

R. Q. Twiss, on stellar interferometers, describes the Michelson interferometer as originally used for the measurement of stellar diameters, and then shows how, as an 'intensity' interferometer, it was adapted to measurements on radio stars. The next stage in the development, which involved so much discussion a few years ago on the correlation of photons in two coherent interfering beams, was to bring it back as an intensity interferometer into optics. This work has led to a new type of interferometer, of which an account is given.

T. Gold discusses the origin of the solar system, the structure and evolution of the Earth, and the probable state of the surface of the Moon. A. A. Day, on the interior of the Earth, takes two models of the mantle-core arrangement and describes the physical conditions associated with each, mentioning the information expected to be given by the project of boring a hole down to the Mohorovičić-discontinuity. "Space Physics" is the title of D. F. Martyn's contribution, which describes the problems of launching satellites, the processes of observing and tracking and obtaining information from them, and the results of satellite observations. H. D. Rathgeber describes the Van Allen belt of radiation, and its probable part in the origin of the auroræ. G. B. A. McCusker gives an account of cosmic radiation, mentioning the association with solar flares, and describing some of the very high-energy nuclear events observed in photographic emulsions exposed to cosmic rays. The study of conditions in the upper atmosphere by observations of meteor trails, micrometeorites and the zodiacal light are among the topics mentioned by G. Elford in his account of the science of meteors. Finally, K. B. Mather writes of research in Antarctica during the International Geophysical Year, and of work on the structure of the Antarctic continent.

The original aim of the summer school was to give teachers the means of arousing enthusiasm for science among their pupils, and to stimulate the flow of entrants to the university science courses; and the 1958 publication was effectively a permanent record for the participants. This is a more luxurious production, which is intended for a wider circle of teachers, and could be understood by their more enterprising pupils or by the interested layman. I do not feel justified in complaining about the price, which seems fair for a handsome limited edition of real intrinsic value; indeed, it would be conniving at the major education heresy of our times to imply that one can expect to get what is first-rate on the cheap. At the same time, it is a pity that this book is out of the reach of the thousands of teachers who would read it with delight, and of most of the librarians who are working to a budget. There must be some way of meeting the latent demand and the not-so-latent need for such a book; and perhaps on a future occasion it may be found. For this is more than a shot in the arm for the jaded teacher whose equipment is a little obsolete; it embodies the new outlook, or the resurgence, of a science that is still an adventure of the human spirit rather than the mere handmaid of technology. If we are to begin to think seriously, as we shall surely have to, about science as a liberal study in schools, this is the kind of book that will direct our thoughts along the right lines.

G. R. Noakes

SPACE SCIENCE

THE First International Space Science Symposium held during the second week of January at Nice was attended by nearly two hundred delegates from all over the world. The meeting was organized by the International Council of Scientific Unions Committee on Space Research and was held in the Centre Universitaire Méditerranéen. In the foyer and on the landing was arranged an exhibition of instruments for space research with a display of some experimental results. A particularly strong contribution from the United Kingdom brought the work of this country for the first time before the eyes of the world.

During the first decade after the War geophysical and astronomical research by means of rockets, or space research as it has now come to be called, made important but for the most part undramatic progress. With the approach of the International Geophysical Year the rate of firings increased greatly as rockets were launched by way of a dress rehearsal for that period of intensive effort. During the period itself this research with rockets ceased to be the prerogative of the United States and the U.S.S.R., as they were joined by Australia, Britain, Canada, and Japan and later by France. In the meantime artificial satellites were launched, and scientists of several nations who did not have facilities for their own launchings joined in the tracking of these bodies and made use of their orbital behaviour to determine more precisely the figure of the geoid and to study the density of the atmosphere above 200 km.

The meeting at Nice was the first opportunity for a comprehensive presentation of the work being done in various parts of the world, and it provided, both in its formal sessions and in informal periods, time for the discussion which was now due. Much of the work had been carried out during the International Geophysical Year, but important results obtained since, especially with lunar and deep space probes, were also presented. Indeed, the success of the International Geophysical Year firings, together, it must be admitted, with an element of international competition between the U.S.S.R. and the United States, has ensured that more use than ever is being made of rockets for research.

Table 1 compiled from the Committee of Space Research reports on national activities gives an indication of the various national efforts. Only successful firings are included, that is those in which the original objective was largely achieved.

The rockets used were generally either of the 1 ton–150 lb. payload class (for example, the British *Skylark*) or of the multi-stage small solid-propellant type (for example, the American *Nike-Cajun*). Altitudes were generally around 150 km. However, the Russians used their geophysical rockets. These can carry payloads of about 2 tons and reach altitudes of more than 450 km. Frequently much of this payload was used for experimental animals. In terms of payload carried, therefore, their effort compares favourably with that of the United States. Aspect control in the Russian work has been achieved by spherical containers, weighing about 700 lb. ejected from the geophysical rocket. *Lunik III* was of similar form. The Americans have made good use of aspect control for solar spectroscopy by employing *Aerobees* fitted with the University of Colorado *Sun-Seeker*.

Table 1. VERTICAL SOUNDING

	Rockets fired above 100 km. in 1959	Artificial satellites up to Dec. 31, 1959	Space probes up to Dec. 31, 1959
U.S A.	More than 36	4	1
U.S.S.R.	6	3	3
U.K.	7	—	—
Japan	4	—	—
France	3	—	—
Canada	1	—	—

Russian work has been characterized by a relatively high degree of standardization in the instrumentation (so that one type of instrument is flown again and again) and in the use of one rocket to carry many different experiments. On the other hand, the field of study of the Americans has been wider both as regards the phenomena investigated and the techniques used.

The hundred papers read at the conference were classified under seven headings. I shall endeavour to direct attention to some of the more important conclusions and results rather than to remark on individual papers.

In the opening session, on the Earth's atmosphere, Wexler discussed some of the doubts which have been current concerning the value of meteorological pictures made from satellites. He showed a film made during an *Atlas* firing which revealed a broad band of cloud associated with a front over the North Atlantic, the complex zone of the tropics and the organization of tropical clouds into streets, many of them aligned with the wind in the sub-cloud layer.

Important results obtained by the velocity of sound method in the Arctic, reported by Stroud *et al.*, showed the seasonal variation of wind and temperature. In the summer the prevailing winds were relatively gentle, usually less than 50 m./sec. from the east, while the temperature minimum at 80 km. was very deep, about 170° K. In the winter it was 60° warmer at this height and the winds were twice as fast and from the west. Two winter firings showed a breakdown of the circulation with strong northerly and southerly winds associated with sharp temperature increases in the stratosphere.

A comprehensive paper by Poloskov presented the Russian results on the neutral gas and the ionization. On the whole the data agreed well with the better-known American data. Mass spectrometer results showed the degree of dissociation of nitrogen up to 203 km. to be less than 2 per cent. Diffusive separation set in above 100 km., and the major positive ions found were atomic and molecular oxygen and nitric oxide.

In view of the importance of the ionosphere, and the amount of work done on it, the number of important results reported was remarkably small. Conspicuously lacking were data on sporadic and polar ionization, and on irregularities and motions. There was a tendency for the papers to deal with methods rather than results in this section. It is clear that Langmuir probes are emerging from the cloud of suspicion which has surrounded them since Langmuir's immediate successors found that their use was not always simple. Several of the papers were concerned with results from a study of satellite radio signals. Especially interesting are Garriott's results on the Faraday effect, which tend to confirm Evan's Moon echo measurements, that there are four times as many electrons above the *F* maximum as below. Thus above the maximum the concentration falls slowly. It was also found that magnetic activity could be accompanied by severe distortions of the profile, although the total content did not change.

The great importance of the discovery of the Van Allen belts of charged particles, trapped in the geomagnetic field, was reflected in the session on cosmic radiation and interplanetary gas. Eighteen papers were read, with important contributions from Van Allen, Vernov, Dolgmov and Kursanova and their collaborators. Van Allen gave the flux of electrons in the outer zone of energy greater than 40 keV. as 10^{11} (cm.^{2} sec.)$^{-1}$. At 200 keV. this had fallen by three orders of magnitude. The proton flux in the outer zone was less than 10^2 (cm.^{2} sec.)$^{-1}$ for particles more energetic than 60 MeV. The outer zone undergoes large fluctuations associated with solar activity, auroræ, atmospheric heating and magnetic storms. The inner belt is very constant in intensity and form and is thought to be due to decay of cosmic-ray neutrons. The electron fluxes are 100 times smaller than in the outer zone while the proton flux is about 100 times greater.

The Russian data agree fairly well with Van Allen's and extend the energy-range of the measurements. However, Vernov reported some apparent magnetic control of the inner zone intensity. In the same paper he gave the γ-ray flux in interplanetary space as less than 0·1 photon cm.$^{-2}$ sec.$^{-1}$ for energies greater than 450 keV., and less than 3 photons cm.$^{-2}$ sec.$^{-1}$ for energies greater than 45 keV.

Magnetic field measurements made by flux gate magnetometers were reported by Dolginov. These showed the existence of the field associated with the outer terrestrial radiation belt and also that the field of the Moon was less than 100γ. This gives a value for the lunar magnetic moment not more than ¼ per cent of the Earth's, in accordance with the idea that the Moon has no liquid core. The same general conclusion is indicated by the lack of evidence for a lunar -radiation belt in the data obtained by *Lunik II*.

Cosmic ray measurements by *Lunik II* gave the following ratios for the fluxes of heavy rays, 1,000 : 75 : 3 for *Z* values 2 : 5 : 15. An interesting possibility suggested by some of these results, but not yet confirmed, is the trapping of α-particles in a radiation-belt situated 20,000 km. from the Earth's centre.

In the sessions on tracking and telemetry the paper by O'Keefe was of geophysical importance. Early studies of artificial satellite orbits gave a value of 1/298·3 for the equatorial bulge, which is about 1½ per cent less than the internationally accepted value. These studies considered only the second harmonic, but in 1958 it was pointed out in Great Britain that the use of orbits at various inclinations would make it possible to determine higher harmonics simply from the precession-rates. On the other hand, it was found that a careful elimination of the effects of drag from the high satellite *Vanguard I* resulted in a motion containing two secular terms and four terms of period equal to the period of revolution of the line of apsides. Two of the periodic terms are interdependent, but the remaining five coefficients lead to values for the 2nd, 3rd, 4th and 5th harmonics. These results show that the shape of the geoid is not that which it would have if it were in rotational equilibrium. Indeed, it is not even symmetrical, as there is a significant 3rd (but not 5th) harmonic. O'Keefe considers the possibility that the distortion is due to convection currents, and rejects it on energetic grounds in favour of Jeffrey's model. He concludes that the Earth has considerable mechanical strength. It does not seem possible that the Earth's interior is a viscous fluid with a viscosity around 10^{22} poises as has been supposed.

The study of solar radiation is one of the most important branches of space science. As a sample star, close at hand, the Sun is of immense astrophysical significance, while its short-wave radiation is responsible for the ionosphere, with its varied structure and behaviour. The extensive and systematic work of the team at the Naval Research Laboratory, Washington, was among the most beautiful (if the term may be allowed) reported at the symposium. This team has used ionization chambers, high-resolution grating spectrographs and double-grating imaging monochromators to obtain valuable data on the emission spectrum, and to photograph the solar-disk in Lyman-α radiation. Good use has been made of the University of Colorado *Sun-seeker* to obtain details of the Lyman-α profile and to reveal strong reversal in the centre of the line.

Taking the American work as a whole (no work on solar ultra-violet or X-rays was reported from the U.S.S.R.) the outstanding results to date are summarized in the following quotation from a paper by Rense: "(1) Extension of the solar Fraunhofer spectrum to about 1500 Å. and the identification of over 1,000 absorption lines. (2) The detection of the prominent hydrogen Lyman-α line and the measurement of its absolute intensity. (3) The determination of the half-width and profile of the hydrogen Lyman-α line. (4) The detection of several members of the Lyman series and the continuum. (5) The detection of the ionized helium resonance line at 303·8 Å. and the establishment of its relatively high intensity. (6) The detection and wave-length measurements of several hundred emission lines extending from about 1900 Å. to 84 Å., with positive identification in many cases. (7) The measurement of the approximate absolute intensities of several of the less-intense emission lines. (8) Successful photography of the Sun's disk in hydrogen Lyman-α radiation".

The work on X-rays has concentrated chiefly on the effects of the flares. For flares in the range class 2–3 the flux between 20 and 100 Å. has averaged about 2 ergs cm.$^{-2}$. Between 8 and 20 Å. it was found to be about 3×10^{-2} erg. cm.$^{-2}$ and between 2 and 8 Å., about one-third of this value. Considerable hardening of the radiation thus occurs during such flares, together with a doubling of the total flux. Results suggest the existence of local thermal sources with a temperature of the order of 10^6 ° C.

The session on the Moon and the planets contained a number of papers, reflecting the stimulation of interest in these fields by the rapid development of space technology. Of special note is the serious consideration now being given to space biology. The only rocket results reported in this session, however, concerned the now well-known *Lunik III* photograph of the reverse side of the Moon. It is a pity that the unique techniques employed in this superb piece of work were not discussed in greater detail.

R. L. F. Boyd

PRIMARY PROCESSES IN THE ACTION OF IONIZING RADIATIONS ON WATER: FORMATION AND REACTIVITY OF SELF-TRAPPED ELECTRONS ('POLARONS')

By Prof. JOSEPH WEISS

Department of Chemistry, King's College, University of Durham, Newcastle upon Tyne

DURING recent years, the study of the chemical action of ionizing radiation has been largely based on the hypothesis that the chemically active species are atoms and free radicals produced by radiation. This was introduced into the radiation chemistry of water, when it was suggested[1] that the absorption of the radiation leads to H atoms and OH radicals ($H_2O \rightsquigarrow H + OH$). These general ideas were later also extended to other systems. From a physical point of view, the absorption of ionizing radiations is known to lead to ionization and excitation. It seemed likely, therefore, that some primary species in the nature of ions and excited molecules could play some part in these processes. At first, it was generally assumed that any such species formed would be very short-lived precursors and of no importance for the chemical reactions. In 1953, it was suggested[2] that such a view cannot be wholly correct, because while it was reasonable to suppose that excited molecules would undergo pre-dissociation into free radicals in times of the order of 10^{-13} sec., it seemed probable that, in general, the ionic precursors may play quite an important part in the mechanism of chemical reactions induced by radiation. In 1957, some definite evidence could be produced[3] to show that positive as well as negative ionic species formed from the water may be important in the radiation chemistry of aqueous systems. In fact, it could be demonstrated that there were two reducing species present in solution, namely, hydrogen atoms and electrons. The ('self-trapped') electrons in the dielectric medium (water) were tentatively identified with the 'polaron', which was known from the work of Landau[4], Mott[5] and Pekar[6] on the behaviour of electrons in ionic crystals.

Recent work has fully confirmed these views[7,8] and has also shown that these 'polarons' are normally relatively stable. On the basis of the known physics of the 'polaron', this is exactly what was to be expected: the polaron is an electron produced by radiation and thrown into the water, where it polarizes the surrounding medium and in turn, by its own field, keeps the polarization of the medium in a stationary state. From the theory of Pekar, one can calculate the mean radius (r_p) of the polaron, which is given by the equation[6]:

$$r_p \simeq \frac{10\hbar^2}{c\mu e^2} \qquad (1)$$

where the parameter c is $(1/n^2 - 1/\varepsilon)$, in which n^2 is the optical dielectric constant; ε is the static dielectric constant; μ is the effective mass of the electron; $\hbar$ is Planck's constant; e is the electronic charge. In the case of water ($c \simeq 0{\cdot}55$), this would lead to a value of the order of $r \sim 10$ Å., assuming that μ is equal to the rest mass (m) of the electron. In water, the conditions for the existence of a polaron are, in fact, fulfilled[6], as the electronic frequency of the polaron is always very much greater than the proper frequency of the ionic vibrations and considerably less than the frequency of the bound electrons in the dielectric medium.

The polaron is thus not to be pictured as an electron attached to a particular water molecule, but as an electron belonging collectively to a comparatively large number of water molecules with a radius corresponding to the de Broglie wave-length of the electron. This makes it conceivable that the polaron should be relatively stable with regard to dissociation, according to:

$$(H_2O)^- \rightarrow H + OH^- \qquad (2)$$

which is due to the fact that the average time which the electron spends on a particular water molecule is small compared with the time (10^{-11} sec.) necessary for the dissociation and solvation of the resulting OH^- ion.

On the other hand, it is equally obvious that the polaron should be capable of interacting with a suitable centre in the water, by which it can be trapped or annihilated. In the absence of any other 'traps', the positive centres resulting from the removal of an electron from a molecule of the solvent, which may be regarded as positive polarons, would react according to:

$$(H_2O)^- + (H_2O)^+ \rightarrow 2H_2O \qquad (3)$$

Such a reaction may, in fact, be the main cause for the relatively low yields of free radicals produced by irradiation of liquid water as compared with the yields in water vapour[9]. If, on the other hand, there are, for example, a sufficient number of hydrogen ions in solution, competition will be set up by the reaction of the polaron with the hydrogen ions, according to:

$$(H_2O)^- + H^+ \rightarrow H + H_2O \qquad (4)$$

leading to the formation of hydrogen atoms. There is, however, also some direct formation of hydrogen atoms, in a relatively low yield, from the dissociation of excited water molecules according to:

$$H_2O^* \rightarrow H + OH$$

The above considerations do not affect the secondary formation of H_2^+ ions[3] from H atoms and hydrogen ions ($H + H^+ \rightleftarrows H_2^+$) in relatively acid solutions.

In the presence of a suitable solute which can act as a polaron acceptor, this will also be competing for the polaron. For example, in the case of monochloroacetic acid, this reaction can be represented by[3]:

$$(H_2O)^- + Cl.CH_2.COOH \rightarrow Cl^- + CH_2COOH + H_2O \quad (5)$$

Other reactions are, for example, the reaction with hydrogen peroxide, according to:

$$(H_2O)^- + H_2O_2 \rightarrow OH^- + OH + H_2O \quad (6)$$

or

$$(H_2O)^- + O_2 \rightarrow O_2^- + H_2O \quad (7)$$

In solutions containing more than one acceptor one will, of course, have competition, as, for example, between reactions (3) and (7), respectively.

Another point of interest concerns the interaction of two polarons. It is well known that in the radiolysis of water a certain amount of molecular hydrogen is produced directly, presumably in the tracks of the ionizing particles. It has been thought previously that this may be due to the interaction of hydrogen atoms. However, such an assumption is not in agreement with many of the experimental facts. More recently[3], it has been suggested that this is due to the interaction of two of the ionic precursor species, which may lead to the formation of molecular hydrogen on one hand, and molecular hydrogen peroxide on the other hand, according to:

$$2(H_2O)^- \rightarrow H_2 + 2OH^- \quad (8)$$

$$2(H_2O)^+ \rightarrow H_2O_2 + 2H^+ \quad (9)$$

In view of the relatively great stability of the polarons, it is now perfectly conceivable that such bimolecular interactions may take place, particularly in regions of relatively high-ionization density.

It is interesting to look again at the physical situation: it is well known that the so-called *F′* centres can exist in an ionic crystal; these are believed to be two electrons occupying a negative vacancy. Such a configuration is stable and its stability is essentially due, in spite of the repulsion of the electrons, to the interaction of the electrons with the positive charges surrounding them. In fact, the net charge of the *F′* centre is the same as that of a mononegative particle. The situation is, however, different if there are no free positive charges present. In the case of a single polaron, the theory predicts considerable stability in a medium of high dielectric constant. However, for the same reasons one can show that what could be a 'bi-polaron' must be a highly unstable entity[8]; that is, if two polarons meet, they either repel each other or, if there is a possibility of a chemical interaction, mutual annihilation will occur.

Irradiated Ice

Some other indications for the existence of polarons can be derived from electron spin resonance measurements on irradiated ice and frozen acids (for example, sulphuric or perchloric acid). When acids are present in the ice, atomic hydrogen has been definitely established from observations of the hyperfine structure, and this was also confirmed by work on the D_2O-system[10]. On the basis of the above considerations, the formation of hydrogen atoms would be due to a capture of the polaron by the hydrogen ions of the acid according to equation (4). Such a view is to some extent supported by the fact that, in pure ice, no evidence for hydrogen atoms could be obtained[11]. A doublet and some other unresolved lines were observed after irradiation of pure ice, the former corresponding to a $g = 2 \cdot 0085$. Such a spectrum would not be incompatible with the presence of polarons, but cannot, of course, be regarded as a proof for these species.

When pure ice is irradiated, for example, with X-rays, a steady-state fluorescence and a weak, but reproducible, thermoluminescence is observed[12]. The fluorescence induced by irradiation of ice is suppressed in the presence of 2×10^{-5} *M* hydrogen peroxide, but on further irradiation the original luminosity is restored; this was found to be due to the gradual decomposition of the hydrogen peroxide during the irradiation. Presence of hydrogen peroxide likewise suppresses the thermoluminescence.

These phenomena, again, can be interpreted on the basis of the conversion of radiation energy into ionization and excitation.

Excitation in the solid may result in the formation of an 'exciton', and it is quite possible that the emission of fluorescence is, in fact, due to the radiative deactivation of 'excitons' in the ice.

On the other hand, ionization would lead to the formation of polarons: the observed decay of thermoluminescence, which is a first-order process and corresponds to a trap depth of about 0·3 eV., would be compatible with such an assumption. The trap depth of 0·3 eV. is, in fact, rather close to the value for the binding energy of the polaron in the ground state (H_0), which can be derived from Pekar's theory, who gives the expression[6]:

$$H_0 = -1 \cdot 47 \frac{\mu}{m} c^2 \text{ (eV.)} \quad (10)$$

Thermoluminescence could thus be due to the radiative annihilation of a positive and negative polaron according to reaction (3), or the radiative interaction of the polaron with an impurity centre. For water ($c^2 \simeq 0 \cdot 3$) and $\mu \sim m$, this gives a value of $H_0 = -0 \cdot 44$ eV.

I wish to thank Prof. N. F. Mott for his very helpful comments.

[1] Weiss, J., *Nature*, 153, 748 (1944).
[2] Weiss, J., "Ann. Rev. Phys. Chem.", 4, 143 (1953).
[3] Hayon, E. M., and Weiss, J., Second U.N. Int. Conf. Peaceful Uses of Atomic Energy, Geneva (1958).
[4] Landau, L. D., *Phys. Z. Sowjetun.*, 3, 664 (1933); 9, 158 (1936).
[5] cf. Mott, N. F., and Gurney, R. B., "Electronic Processes in Ionic Crystals" (Clarendon Press, Oxford, 1948).
[6] Pekar, S. I., in "Investigations on the Electronic Theory of Crystals" (in Russian) (Moscow–Leningrad, 1951).
[7] Allan, J. T., and Scholes, G., *Nature* (in the press).
[8] Hayon, E. M., and Weiss, J., *J. Chem. Soc.* (in the press).
[9] Firestone, R. F., *J. Amer. Chem. Soc.*, 5593 (1957).
[10] Livingston, R., Zeldes, H., and Taylor, E. A., *Disc. Farad. Soc.*, 19. 166 (1955).
[11] Flournoy, J. M., Baum, L. H., Siegel, S., and Skolnik, S., Fourth Int. Symp. Free Radical Stabilization, Nat. Bur. of Stand., B-IV-1 (Washington, 1959).
[12] Grossweiner, C. I., and Matheson, M. G., *J. Chem. Phys.*, 23, 1514 (1954).

EQUIVALENCE OF LIGHT AND ADENOSINE TRIPHOSPHATE IN BACTERIAL PHOTOSYNTHESIS

By DR. M. LOSADA, Dr. A. V. TREBST, S. OGATA and PROF. DANIEL I. ARNON
Laboratory of Plant Physiology, University of California, Berkeley

PHOTOSYNTHETIC phosphorylation[1,2] has provided direct experimental evidence for the view that the key event in photosynthesis, the conversion of light into chemical energy, is independent of the classical manifestations of this process in green plants—oxygen evolution and carbon dioxide reduction. In the light-dependent phosphorylation of the cyclic type, that is the common denominator of photosynthesis in plants and bacteria, carbon dioxide is not assimilated nor is oxygen evolved; the only identifiable chemical product of the absorbed light energy is adenosine triphosphate[3,4].

In photosynthesis of green plants the contribution of light is not limited to the synthesis of adenosine triphosphate, but also includes the formation of reduced triphosphopyridine nucleotide[3]. Adenosine triphosphate and reduced triphosphopyridine nucleotides, jointly called assimilatory power[5], are then used for carbon dioxide assimilation. All the reactions of carbon dioxide assimilation occur in the dark and are also present in non-chlorophyllous cells[6-9] and must therefore be considered as being removed from the energy conversion process peculiar to photosynthesis. The validity of this concept of photosynthesis has been documented in isolated chloroplasts by separating experimentally their light and dark reactions, and by characterizing their carbon dioxide assimilation[10-13].

We have recently reported that, in the presence of hydrogen gas, the contribution of light in bacterial photosynthesis may be limited to the formation of adenosine triphosphate[3]. Similar views have also been expressed on the basis of independent evidence by Stanier, Doudoroff, Kunisawa and Contopoulou[14]. The reductant required for carbon dioxide assimilation, reduced pyridine nucleotide, is, unlike in green plants, formed in the *dark* by the external hydrogen donor, molecular hydrogen[3,4]. It follows, therefore, that if light is replaced by exogenous adenosine triphosphate, photosynthetic carbon assimilation should proceed entirely in the dark.

The substitution of adenosine triphosphate for light would be particularly significant if it could be demonstrated in such photosynthetic bacteria as *Chromatium*, that are unique in the living world in being strict phototrophs. *Chromatium*, unlike, for example, *Chlorella*, or photosynthetic bacteria of the genus *Rhodospirillum*, cannot replace its light-dependent mode of life by a heterotrophic, aerobic metabolism in the dark[15-17]. *Chromatium* grows only in the light[15,16], and being an obligate anaerobe, cannot carry out oxidative phosphorylation.

The purpose of this article is to report evidence which we have now obtained for the equivalence of light and adenosine triphosphate in the photoassimilation by *Chromatium* of carbon, supplied either as carbon dioxide or acetate. The findings to be reported support the view that bacterial photosynthesis is the prototype of photosynthesis in green plants, where it became modified in the course of biochemical evolution, to include oxygen evolution and the formation by light of a reductant for carbon dioxide assimilation[3].

Carbon Assimilation by Whole Cells

Until recently, the prevailing view of carbon assimilation in photosynthetic bacteria was that these organisms resemble green plants in forming most of their carbon compounds by reducing carbon dioxide. It was known for a long time that *Chromatium* can assimilate organic substrates in light[16]; but, in the main, these came to be regarded as hydrogen donors, rather than as sources of organic carbon for further photosynthetic elaboration into cellular material[17]. Stanier *et al.*[14] have now reopened this subject by showing that in "resting" cells of *Rhodospirillum rubrum* "acetate is converted anaerobically in the light largely to poly-beta-hydroxybutyrate". We have therefore re-examined the assimilation of carbon under different conditions using 'growing' *Chromatium* cells.

As shown in Table 1, significant fixation of carbon dioxide, labelled with carbon-14, by *Chromatium* cells occurred, as expected, only in the light and was greatly increased by the addition of malate, succinate, thiosulphate, sulphide, and molecular hydrogen. Acetate was an exception; it did not increase fixation of carbon dioxide.

The assimilation of acetate acquired special interest when we found, in parallel experiments, that *Chromatium* was able to grow with acetate as the sole source of carbon without added carbon dioxide. *Chromatium* has been grown with acetate previously[16] but always in the presence of added carbon dioxide. Since acetate did not aid the assimilation of labelled carbon dioxide (Table 1) and supported growth without the addition of carbon dioxide, it might have served as

Table 1. EFFECT OF LIGHT AND OF INORGANIC AND ORGANIC 'REDUCTANTS' ON CARBON-14 DIOXIDE ASSIMILATION BY *Chromatium* CELLS

Treatment	Total $^{14}CO_2$ fixed (counts × 1,000/min.)
1. No 'reductant' added*, dark	80
2. No 'reductant' added, light	270
3. Acetate, light	270
4. Malate, light	630
5. Succinate, light	1,000
6. Hydrogen, light	1,320
7. Thiosulphate, light	1,020
8. Sulphide, light	1,040

* In the dark, no increase in carbon dioxide fixation was observed on adding any one of the 'reductants' listed in treatments 3–8.

Each vessel contained a modified culture solution (ref. 26) and cells equivalent to 0·2 mgm. bacteriochlorophyll; also the following in µmoles: *Tris*, *p*H 7·8, 60; carbon-14 bicarbonate, 10; 'reductant', 10 (except in treatment 6). Final volume 2·5 ml. Gas phase was argon, except in treatment 6, which received hydrogen gas. The reaction was carried out at 25° C. and stopped after 30 min. by adding 0·1 ml. 5 *N* hydrochloric acid.

Table 2. EFFECT OF LIGHT AND CYANIDE INHIBITION ON CARBON ASSIMILATION BY *Chromatium* CELLS

Treatment	Total carbon-14 fixed (counts × 1,000/min.)
1. Carbon-14 acetate, dark	8
2. Carbon-14 acetate, light	480
3. Carbon-14 acetate, light	520
4. Carbon-14 acetate, 10^{-3} *M* cyanide, light	520
5. Carbon-14 dioxide, hydrogen, light	3,200
6. Carbon-14 dioxide, hydrogen, 10^{-3} *M* cyanide, light	1,500

Prior to the experiments the cells in treatments 1–4 were grown with acetate as the 'reductant' and the cells in treatments 5 and 6 with hydrogen gas (ref. 26). Treatments 1 and 2 were run for 20 min. and included, in each reaction vessel, cells equivalent to 0·13 mgm. bacteriochlorophyll; final volume 1·9 ml. Treatments 3–6 were run for 30 min. and included cells, equivalent to 0·2 mgm. bacteriochlorophyll, and 3 μmoles carboxyl-labelled acetate; final volume 2·5 ml. Gas phase was argon, except in treatments 5 and 6. Other conditions as in Table 1.

a direct source of carbon, but one that in *Chromatium* cells could be assimilated only in light.

We tested this interpretation by supplying radioactive acetate in the light and in the dark to 'growing' *Chromatium* cells in short-term experiments. The results are shown in Table 2. No significant assimilation of labelled acetate occurred in the dark. In the light a marked incorporation of acetate took place and was not affected by the addition of carbon dioxide.

Table 2 also presents evidence that the photoassimilation of acetate occurred by a pathway independent of that of carbon dioxide assimilation. We have previously reported that, in chloroplasts, the reductive carbohydrate cycle for carbon dioxide assimilation is inhibited by cyanide[13]. Table 2 shows that, in *Chromatium* cells, cyanide inhibited the assimilation of carbon dioxide, but not that of acetate. It seems, therefore, that carboxydismutase, which is the enzyme of the reductive carbohydrate cycle that is specifically inhibited by cyanide in *Chromatium* and in chloroplasts[13], is not involved in the photoassimilation of acetate by *Chromatium*. Acetate was apparently used by *Chromatium* cells not as a reductant in carbon dioxide assimilation but as a carbon compound that was readily photo-assimilated into cellular substance without external carbon dioxide and without being first oxidized to carbon dioxide.

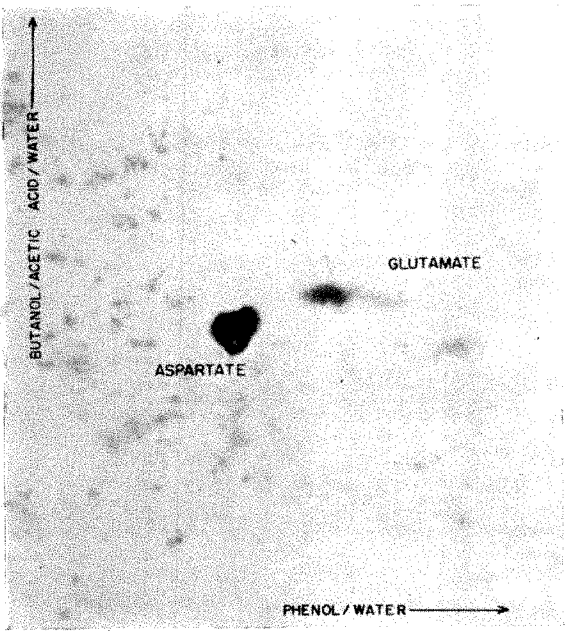


Fig. 1. Radioautograph of a chromatogram showing soluble products of carbon-14 dioxide assimilation in the light by *Chromatium* cells. Experimental conditions as in treatment 5 of Table 2, except that thiosulphate was used instead of hydrogen

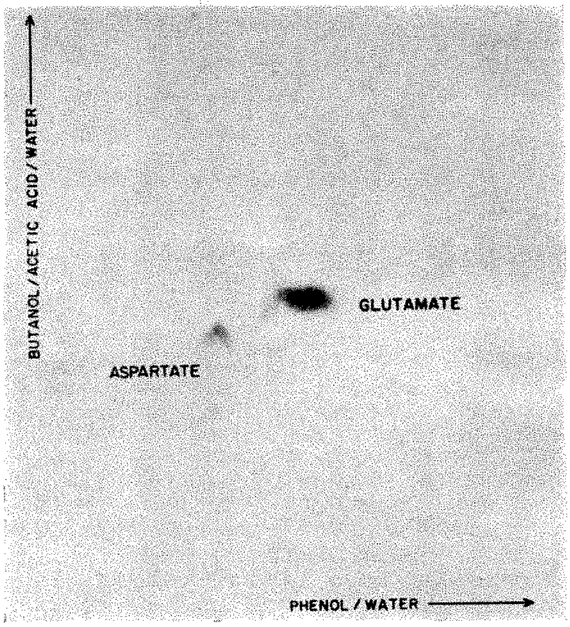


Fig. 2. Radioautograph of a chromatogram showing soluble products of carbon-14 acetate assimilation in the light by *Chromatium* cells. Experimental conditions as in treatment 3 of Table 2

The conclusion that carbon dioxide and acetate represent two independent pathways for carbon assimilation in *Chromatium* cells was strengthened by a comparison of the products formed. The identification was made by the techniques of paper chromatography and radioautography[11]. When labelled carbon dioxide was the sole source of carbon, and the reductant was either molecular hydrogen, thiosulphate, sulphide, malate or succinate, the main soluble products formed (approximately 50 per cent of the total carbon fixed) were in all cases amino-acids, principally aspartic acid.

A typical chromatogram is shown in Fig. 1. In general, phosphorylated sugars were much less prominent in *Chromatium* than in isolated chloroplasts[11–13] and in certain experiments no sugars were detectable by the identification techniques which we used. The prominence of aspartic acid among the products of carbon dioxide fixation is in agreement with the report of Fuller[18] that "in *Chromatium* the primary pool of fixed carbon is aspartic acid".

With radioactive acetate the products of photoassimilation in the soluble fraction (about 10 per cent of the total carbon fixed) were again mainly amino-acids, but here glutamate was the principal product formed (Fig. 2).

To recapitulate, then, carbon dioxide and acetate assimilation seemed to proceed in *Chromatium* by two separate pathways that had a common link in being strictly dependent on light. It now remains to be shown that, in both pathways, light is replaceable by exogenous adenosine triphosphate.

Carbon Dioxide Assimilation by Cell-free Preparations

The equivalence of light and adenosine triphosphate might have been directly demonstrated in whole cells if it were possible to accumulate or introduce substrate quantities of adenosine triphosphate for driving carbon dioxide fixation in the dark. However, a preliminary accumulation of adenosine triphosphate in the light is not possible because whole cells have only catalytic amounts of adenosine diphosphate. The introduction of exogenous adenosine triphosphate is also excluded by the impermeability of whole cells to adenylates. Experimentally, therefore, the problem is how to overcome the permeability barrier of the cells to adenylates without damaging excessively the photosynthetic apparatus.

In the case of green plants the permeability barrier of whole cells was set aside by using broken chloroplasts[10]. In the case of *Chromatium* the cells were ground with alumina and the cell-free fluids were separated by differential centrifugation into chromatophores that contained the photochemical apparatus proper, capable of photosynthetic phosphorylation outside the cell[19-21], and into a supernatant fluid which contains the carbon dioxide fixing enzymes[22]. The role of light and adenosine triphosphate in carbon assimilation by the cell-free preparations was investigated in parallel experiments using either carbon dioxide or acetate as the source of carbon.

Carbon dioxide assimilation in cell-free preparations of *Chromatium* seemed to proceed, as was the case in broken chloroplasts[12], by the reductive carbohydrate cycle. However, in the case of *Chromatium*, phosphoglycerate was the product that was being removed from the cycle and converted into phosphoenolpyruvate, which is the substrate of a second carboxylation reaction resulting in the formation of oxalacetate and aspartate. The enzyme that catalyses this carboxylation, phosphoenolpyruvate carboxylase, is also present in chloroplasts[23], but there, on present evidence, it does not seem to play as direct a part in photosynthetic carbon dioxide assimilation.

In the presence of exogenous ribulose diphosphate or phosphoenolpyruvate, cell-free preparations of *Chromatium*, like whole cells, assimilated carbon dioxide mainly into aspartic acid without any further requirement for energy either as light or as adenosine triphosphate. The dependence for either light or exogenous adenosine triphosphate became apparent, however, when ribulose diphosphate or phosphoenolpyruvate were replaced in the reaction mixture by ribose-5-phosphate or pyruvate.

Typical results, shown in Table 3, indicate that in the presence of ribose-5-phosphate, a marked increase in carbon dioxide fixation was observed in the light when adenosine diphosphate and inorganic phosphate were added to the reaction mixture. The addition of adenosine diphosphate made photosynthetic phosphorylation by chromatophores possible and thus supplied adenosine triphosphate to the reaction mixture. In the dark, a similar increase in carbon dioxide fixation occurred on adding exogenous adenosine triphosphate. The main product of carbon dioxide assimilation, aspartate, was the same in the light as in the dark with exogenous adenosine triphosphate (Fig. 3).

Table 3. EFFECT OF LIGHT AND ADENOSINE TRIPHOSPHATE ON CARBON-14 DIOXIDE FIXATION BY CELL-FREE PREPARATIONS OF *Chromatium* IN THE PRESENCE of RIBOSE-5-PHOSPHATE

Treatment	Total $^{14}CO_2$ fixed in soluble compounds (counts × 1,000/min.)
1. Dark, control	54
2. Dark, ATP, R-5-P omitted	48
3. Dark, ATP	138
4. Light, control	54
5. Light, ADP + P	108

Each vessel contained in a final volume of 1·5 ml.: cell-free extract, containing 0·3 mgm. bacteriochlorophyll and the following in μmoles: *Tris*, *p*H 7·8, 80; cysteine 20; magnesium chloride, 5; manganese chloride, 2; potassium chloride, 20; carbon-14 bicarbonate, 10; ribose-5-phosphate (R-5-P), 5; and, when added, adenosine diphosphate (ADP), 0·5; orthophosphate (P), 5; and adenosine triphosphate (ATP), 4. Other experimental conditions as in Table 1.

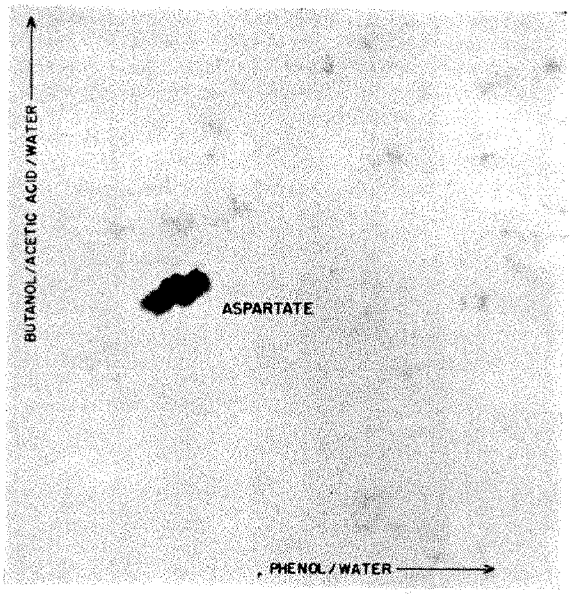
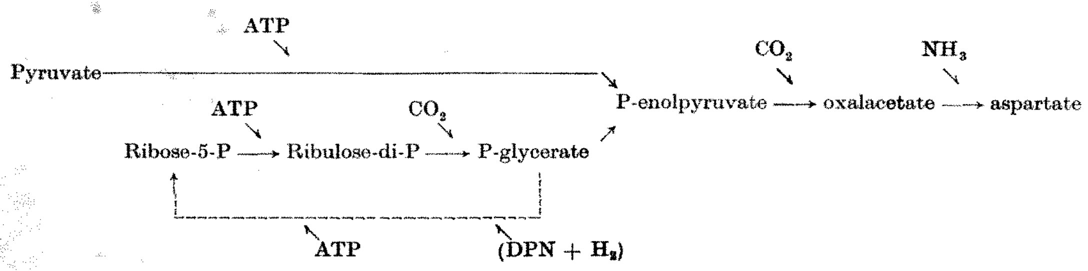


Fig. 3. Radioautograph of a chromatogram showing the soluble products of carbon-14 dioxide fixation in the *dark* by a cell-free preparation of *Chromatium* in the presence of ribose-5-phosphate and added adenosine triphosphate. Experimental conditions as in treatment 3 of Table 3. The same pattern of carbon dioxide fixation was obtained in the light without added adenosine triphosphate

The equivalence of light and adenosine triphosphate was also observed when pyruvate was used as a carbon dioxide acceptor. The bacterial preparations were found to have a very active enzyme catalysing an exchange reaction (cf. ref. 24) between the carboxyl group of pyruvate and carbon-14 dioxide. The exchange reaction itself was independent of light or adenosine triphosphate, but carbon-14 dioxide fixation into aspartate and other dicarboxylic acids occurred only when light or adenosine triphosphate was present. For example, in the presence of pyruvate, carbon-14 dioxide, and exogenous adenosine triphosphate the main radioactive compounds formed (Fig. 4) were aspartate and pyruvate (by the exchange reaction). Other identifiable compounds were alanine, malate and fumarate. The formation of malate was in agreement with the presence in *Chromatium* extracts of the malic enzyme reported by Sisler and Fuller[25] and confirmed by us in other experiments[26].

A 'photosynthetic' pattern characteristic of *Chromatium* was also obtained without either light or exogenous adenosine triphosphate, in the presence of 3-phosphoglycerate or phosphoenolpyruvate as carbon-14 dioxide acceptor. The prominence of aspartate as the product of carbon-14 dioxide assimilation via the phosphoenolpyruvate carboxylation is illustrated by Table 4.

The pathway of carbon dioxide assimilation in *Chromatium*, which is now documented by these and other experiments[26] with cell-free preparations, either in light or in dark with exogenous adenosine triphosphate, is summarized below. The diagram shows the regeneration of ribose-5-phosphate from phosphoglycerate. We found in *Chromatium* extracts an active diphosphopyridine nucleotide-linked triose phosphate dehydrogenase, the enzyme which accounts for the reduction of phosphoglycerate that is involved in this step.



Assimilation of Acetate by Cell-free Preparations

The assimilation of acetate by cell-free preparations confirmed and extended the conclusions drawn from the acetate experiments with whole *Chromatium* cells. As shown in Table 5, in the presence of coenzyme *A*, acetate assimilation was greatly increased by light and by the addition of acetate 'acceptors', namely, oxalacetate or pyruvate.

Table 6 shows that the role of light was specifically concerned with the formation of adenosine triphosphate. Acetate assimilation occurred also in the dark, but only when exogenous adenosine triphosphate was added. No significant assimilation occurred when adenosine triphosphate was either omitted or when it was made unavailable for acetate assimilation by being trapped, in the light or in the dark, by a hexokinase–glucose system. These results, as well as the response from added coenzyme *A*, suggest that the role of light in acetate assimilation by *Chromatium* is to provide adenosine triphosphate that is required for the formation of acetyl–coenzyme *A*.

Table 4. PROPORTION OF ASPARTATE IN SOLUBLE PRODUCTS OF CARBON-14 DIOXIDE ASSIMILATION BY CELL-FREE PREPARATIONS OF *Chromatium*

Treatment	Per cent of $^{14}CO_2$ fixed as aspartate
1. Dark, pyruvate	15·7
2. Dark, pyruvate, ATP	50·1
3. Light, pyruvate, ADP + P	69·5
4. Dark, phosphoglycerate	40·0
5. Dark, phosphoenolpyruvate	81·0

The reaction mixture common to all treatments was that given for treatment 4 in Table 3, except that ribose-5-phosphate was omitted and the following additions were made (in μmoles) where indicated: pyruvate, 5; phosphoglycerate, 5; phosphoenolpyruvate, 4; adenosine triphosphate (ATP), 4; adenosine diphosphate (ADP), 0·5; and orthophosphate (P), 5.

Table 5. EFFECT OF LIGHT, OXALACETATE AND PYRUVATE ON THE ASSIMILATION OF CARBON-14-ACETATE BY CELL-FREE PREPARATIONS OF *Chromatium*

Treatment	Carbon-14 fixed in soluble compounds (counts × 1,000/min.)
Dark, control	5
Light, control	42
Dark, oxalacetate	42
Light, oxalacetate	300
Light, control	27
Light, pyruvate	75

The reaction mixture common to all treatments was that given for treatment 1 in Table 3, except that ribose-5-phosphate and carbon-14 bicarbonate were omitted and 0·3 μmole of coenzyme *A* and 3 μmoles of carboxyl-labelled carbon-14 acetate was added. 10 μmoles each of oxalacetate or pyruvate was added where indicated.

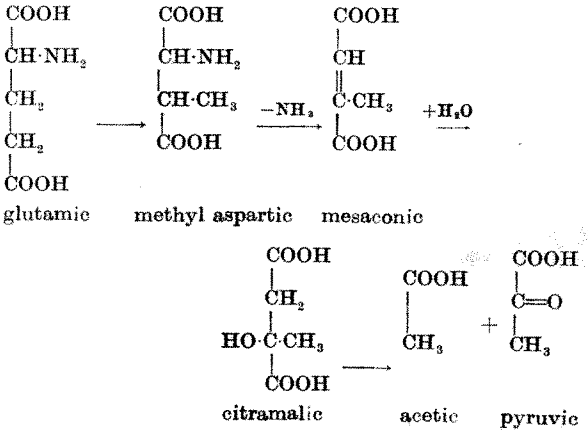
In cell-free preparations, as in whole cells, acetate was assimilated to glutamate. The investigation of glutamate synthesis from acetate revealed the presence in *Chromatium* of certain new synthetic pathways that have not been found in chloroplasts. *Chromatium* preparations, like chloroplasts (unpublished data), are able to activate acetate by converting it to acetyl-coenzyme *A*, and condensing acetyl-coenzyme *A* with oxalacetate to give citrate. Citrate is then converted via *iso*citrate and α-ketoglutarate to glutamate. Unlike chloroplasts, *Chromatium* preparations also condense acetyl–coenzyme *A* with glyoxylate[18,25] and, as we have now found with α-keto acids, pyruvate (reaction 1) and its analogue, α-ketobutyrate (reaction 2):

pyruvate + acetyl coenzyme *A*→ citramalate (methyl malate) (1)

α-ketobutyrate + acetyl coenzyme *A*→ethylmalate* (2)

* The compound has been isolated but not yet unequivocally identified.

Of the newly found condensations, the one of special interest was that of citramalate since Barker *et al.*[28] have shown that in *Clostridium tetanomorphum*, another obligate anaerobe, the citramalate pathway provides a mechanism for the degradation of glutamate to pyruvate and acetate:



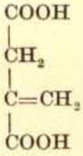
It now appears that in *Chromatium* the reversal of the degradative citramalate pathway may lead to

Table 6. EQUIVALENCE OF ADENOSINE TRIPHOSPHATE (ATP) AND LIGHT IN THE ASSIMILATION OF CARBON-14-ACETATE BY CELL-FREE PREPARATIONS OF *Chromatium*

Treatment	Carbon-14 fixed in soluble compounds (counts × 1,000/min.)
1. Dark, control	27
2. Dark, ATP	180
3. Dark, ATP, hexokinase	186
4. Dark, ATP, hexokinase, glucose	6
5. Light, control	414
6. Light, hexokinase	348
7. Light, hexokinase, glucose	20

Experimental conditions as in the oxalacetate treatments in Table 5. 1·5 mgm. hexokinase, Type III (Sigma Chemical Co.) and 10 μmoles glucose were added where indicated.

glutamate synthesis. Among the products of pyruvate condensation with acetyl-coenzyme *A*, we have identified citramalate and glutamate and another compound, which at first seemed to be mesaconate, but turned out to be the closely related itaconic acid (it may be noted that the R_F value for citramalate resembles that of compound *X* which Glover *et al.*[29] reported as the main product of acetate assimilation in *R. rubrum*):



$$\begin{array}{l}\text{COOH}\\ |\\ \text{CH}_2\\ |\\ \text{C}{=}\text{CH}_2\\ |\\ \text{COOH}\end{array}$$

itaconic acid

When oxalacetate was the acetate acceptor, the main products, that is, citrate and glutamate, were the same in light as in the dark with added adenosine triphosphate (Fig. 5). With pyruvate as the acetate acceptor the main products of acetate assimilation, either in light or with added adenosine triphosphate in the dark, were citramalate and glutamate (Fig. 6).

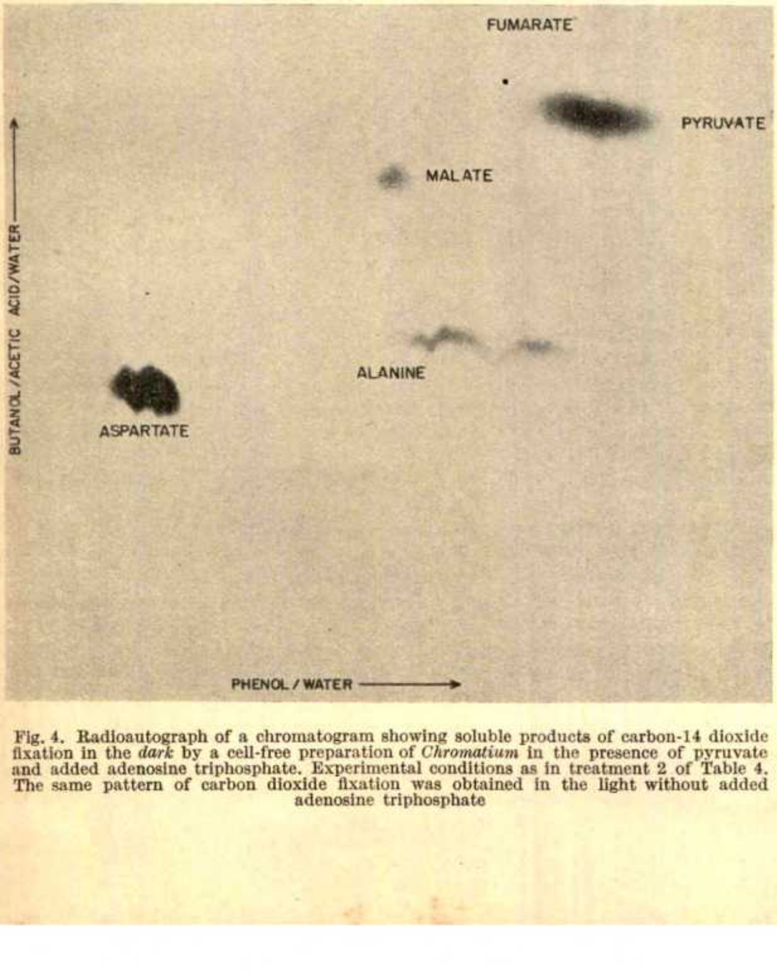


Fig. 4. Radioautograph of a chromatogram showing soluble products of carbon-14 dioxide fixation in the *dark* by a cell-free preparation of *Chromatium* in the presence of pyruvate and added adenosine triphosphate. Experimental conditions as in treatment 2 of Table 4. The same pattern of carbon dioxide fixation was obtained in the light without added adenosine triphosphate

The reactions of carbon assimilation in *Chromatium*, for which there is now experimental evidence, are summarized in Fig. 7. Most of the component reactions have already been discussed. In this scheme the only contribution of light (except perhaps in the photo-production of hydrogen[30]) for both carbon dioxide and acetate assimilation is in the formation of adenosine triphosphate. Carbon dioxide assimilation is shown in Fig. 7 to be dependent on exogenous hydrogen, whereas the assimilation of acetate by the citrate or citramalate pathway indicated yields hydrogen for metabolic purposes in accordance with the overall equation 3 or 4:

$$3\ \text{acetate} + \text{NH}_3 \underset{\text{(citrate pathway)}}{\xrightarrow{5\ \text{ATP}}} \text{glutamate} + \text{CO}_2 + 6\text{H} \qquad (3)$$

$$3\ \text{acetate} + \text{NH}_3 \underset{\text{(citramalate pathway)}}{\xrightarrow{4\ \text{ATP}}} \text{glutamate} + \text{CO}_2 + 6\text{H} \qquad (4)$$

Further evidence for the reactions shown in Fig. 7 will be given elsewhere[26].

Concluding Remarks

The similarity between the carbon assimilation patterns of cell-free systems supplemented with adenosine triphosphate in the dark, and those found in whole cells of *Chromatium* in the light, provides, in our judgment, significant evidence that in this obligate phototroph exogenous adenosine triphosphate is equivalent to light. The role of adenosine triphosphate, whether formed by photosynthetic phosphorylation or supplied from without, was twofold. Adenosine triphosphate was either required for the formation of an 'activated' substrate (ribulose diphosphate, phosphoenolpyruvate or 1,3-diphosphoglycerate) for a subsequent carboxylation or reduction, or it was required for the formation of an 'activated' carbon source, as by forming acetyl-coenzyme *A* from acetate and coenzyme *A*. The activated compounds are then ready for participation in the synthetic reactions that are catalysed by specific enzyme systems, all of which function in the dark.

In this view of photosynthesis, carbon dioxide assimilation, although quantitatively the dominant form of photosynthesis on the Earth, is fundamentally only a special case of the use of light energy. It was previously suggested[5] that even in green plants, light energy, when converted to adenosine triphosphate, may be used for driving endergonic reactions other than carbon dioxide reduction. Experimental evidence

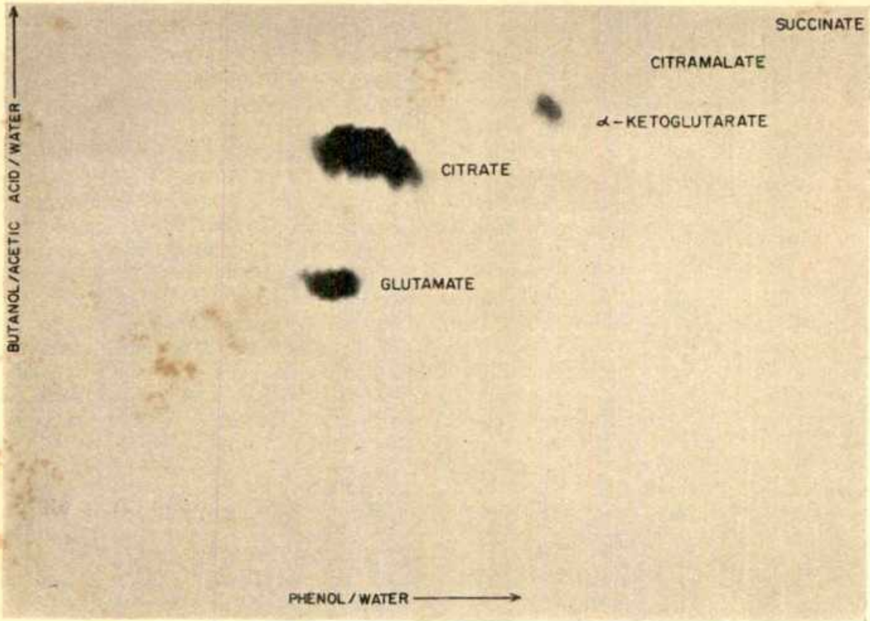


Fig. 5. Radioautograph of a chromatogram showing products of carbon-14-acetate assimilation in the *dark* by a cell-free preparation of *Chromatium* in the presence of adenosine triphosphate, coenzyme *A* and oxalacetate. Experimental conditions as in treatment 2 of Table 6. The same pattern of acetate assimilation was obtained in the light without added adenosine triphosphate

for this has recently come from the work of Maclachlan and Porter[31].

In the case of photosynthetic bacteria, carbon dioxide assimilation may, in certain circumstances, not even be the principal pathway for using the converted light energy for the synthesis of organic compounds (cf. ref. 14). As was shown here, *Chromatium* is able to assimilate acetate directly without an external source of carbon dioxide, either with the aid of light or with exogenous adenosine triphosphate. In this instance, therefore, the photo-assimilation of acetate is a case of photosynthesis without either carbon dioxide assimilation or oxygen evolution. In the conventional view of photosynthesis this state of affairs would be inadmissible, but according to the present concept the photo-assimilation of acetate by *Chromatium* constitutes photosynthesis because it involves biochemical syntheses that are being driven by light energy after it has been converted into adenosine triphosphate.

Carbon dioxide assimilation, in any event, in both green plants and photosynthetic bacteria, consists of exclusively dark reactions that are not peculiar to photosynthesis. It was already anticipated by Benson and Calvin, that "it is not to be expected that this type of work (investigation of the carbon cycle) will lead directly to a solution of the unique problems of photosynthesis, namely, the knowledge of the act or acts by which electromagnetic energy is transformed into chemical energy"[32]. The discovery of photosynthetic phosphorylation has since provided evidence that this transformation of energy is more closely linked with phosphorus than with carbon assimilation.

The photo-assimilation of acetate by *Chromatium* with the aid of adenosine triphosphate formed by light supports the suggestion made earlier[5], that, if in the early period of evolution of life forms, organic compounds were abundant and the Earth's atmosphere was a reducing one[33], then the light-dependent mechanism for adenosine triphosphate formation was

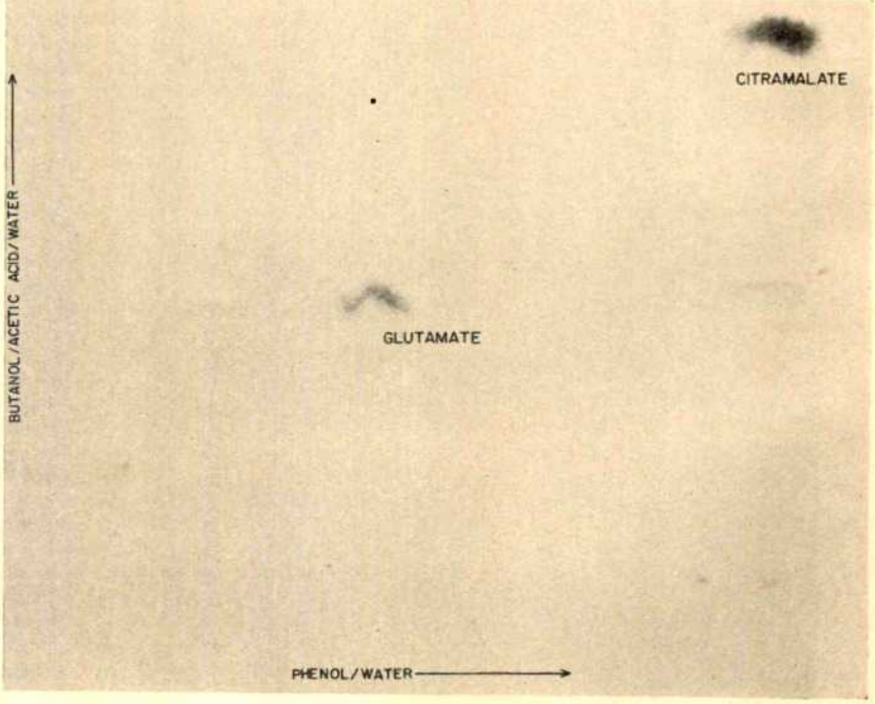


Fig. 6. Radioautograph of a chromatogram showing products of carbon-14 acetate assimilation in the *dark* by a cell-free preparation of *Chromatium* in the presence of adenosine triphosphate, coenzyme *A* and pyruvate. Experimental conditions as in treatment 2 of Table 6, except that pyruvate (5 μmoles) replaced oxalacetate, the gas phase was air, and chromatophores were removed from the cell-free preparation by centrifugation. The same pattern of carbon-14 acetate assimilation was obtained in the light, in the presence of chromatophores, without added adenosine triphosphate

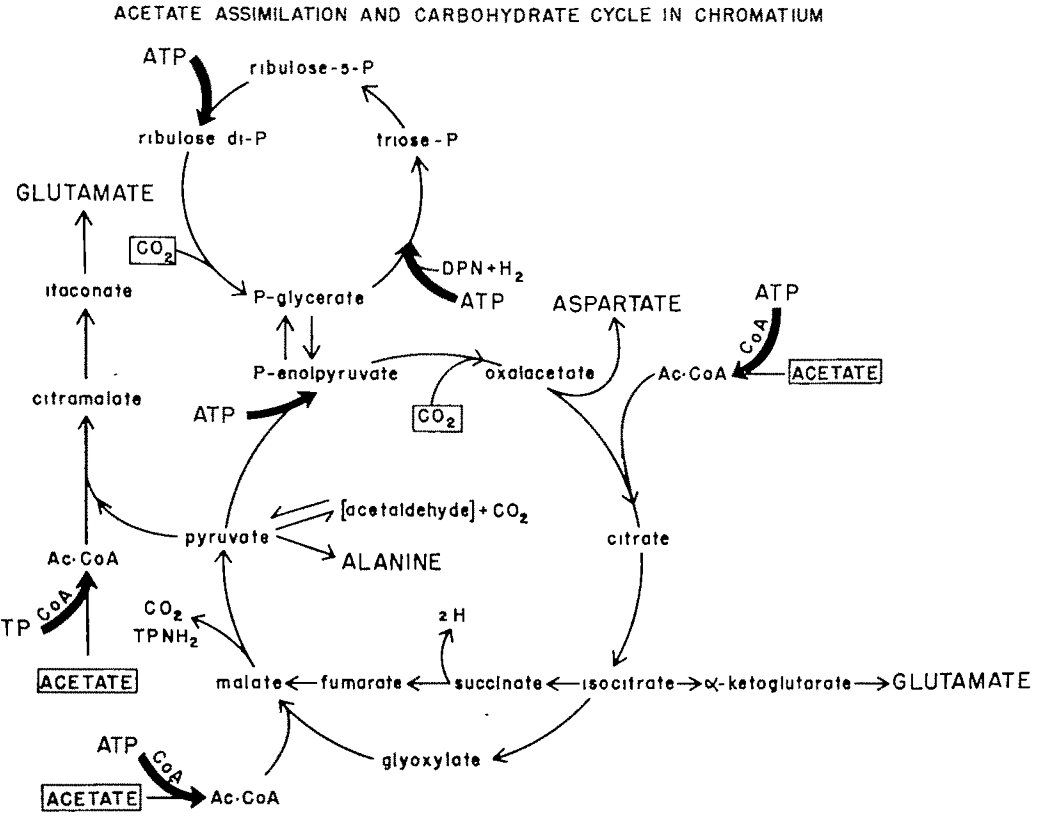


Fig. 7. Reactions of carbon assimilation in *Chromatium*. Further details are given in the text

the most important event for the newly emerging photosynthetic organisms. In this view, an obligate anaerobic phototroph such as *Chromatium* would represent the most primitive type of photosynthesis, one in which no oxygen is evolved, organic compounds serve as carbon sources and the main contribution of light is the formation of adenosine triphosphate. This primitive type of photosynthesis, it seems reasonable to suppose, was paralleled by transitional types in which the contribution of light was still the formation of adenosine triphosphate, but carbon dioxide was an important source of carbon, and the carbon dioxide reductant, reduced pyridine nucleotide, could be formed by dark reactions as, for example, with hydrogen gas. Finally, in the most advanced type of photosynthesis, carbon dioxide became the sole carbon source and the function of light was to provide both adenosine triphosphate and reduced pyridine nucleotide. Only in the last case, typified by green plants, when photosynthesis became strictly dependent on water for pyridine nucleotide reduction by light did oxygen evolution form an inseparable part of photosynthesis, as is envisaged by the electron-flow mechanism proposed elsewhere[3].

It would thus appear that oxygen evolution, which gave Priestley[14] almost two hundred years ago the first clue to the existence on this planet of what we now call photosynthesis, is, in the evolutionary time scale, the most recent aspect of the process (cf. van Niel, ref. 17). Photosynthetic bacteria, which have greatly contributed to our understanding of photosynthesis by showing that this process can occur without oxygen evolution[17], now also provide us with evidence that photosynthesis can occur without carbon dioxide assimilation. What remains fundamental to all photosyntheses is the conversion of light into chemical energy. This conversion appears to be intimately bound to photosynthetic phosphorylation and its product adenosine triphosphate, which is the universal 'energy currency' of all cells, whether they live in the light or in the dark.

This investigation was aided by grants from the National Institutes of Health and the Office of Naval Research.

[1] Arnon, D. I., Allen, M. B., and Whatley, F. R., *Nature*, 174, 394 (1954).
[2] Arnon, D. I., Whatley, F. R., and Allen, M. B., *J. Amer. Chem. Soc.*, 76, 6324 (1954).
[3] Arnon, D. I., *Nature*, 184, 10 (1959).
[4] Ogata, S., Nozaki, M., and Arnon, D. I. (in preparation).
[5] Arnon, D. I., Whatley, F. R., and Allen, M. B., *Science*, 127, 1026 (1958).
[6] Vishniac, N., Horecker, B. L and Ochoa, S., "Adv. Enzymol.", 19, 1 (1957).
[7] Fuller, R. C., and Gibbs, M., *Plant Physiol.*, 34, 324 (1959).
[8] Trudinger, P. A., *Biochem. J.*, 64, 274 (1956).
[9] Aubert, J. P., Milhaud, G., and Millet, J., *Ann. Inst. Pasteur*, 92, 515 (1957).
[10] Trebst, A. V., Tsujimoto, H. Y., and Arnon, D. I., *Nature*, 182, 351 (1958).
[11] Trebst, A. V., Losada, M., and Arnon, D. I., *J. Biol. Chem.*, 234, 3055 (1959).
[12] Losada, M., Trebst, A. V., and Arnon, D. I., *J. Biol. Chem.*, 235, 832 (1960).
[13] Trebst, A. V., Losada, M., and Arnon, D. I., *J. Biol. Chem.*, 235, 840 (1960).
[14] Stanier, R. Y., Doudoroff, M., Kunisawa, R., and Contopoulou, R., *Proc. U.S. Nat. Acad. Sci.*, 45, 1246 (1959).
[15] Van Niel, C. B., *Ark. Mikrobiol.*, 3, 1 (1931).
[16] Müller, F. M., *Ark. Mikrobiol.*, 4, 131 (1933).

[17] Van Niel, C. B., in "Photosynthesis in Plants", edit. J. Franck and W. E. Loomis, 437 (Iowa State College Press, 1949).
[18] Fuller, R. C., *Proc. Ninth Intern. Bot. Congr.*, 2, 125 (1959).
[19] Frenkel, A. W., *J. Amer. Chem. Soc.*, 76, 5568 (1954); *J. Biol Chem.*, 222, 823 (1956).
[20] Newton, J. W., and Kamen, M. D., *Biochim. Biophys. Acta*, 25, 462 (1957).
[21] Anderson, I. C., and Fuller, R. C., *Arch. Biochem. Biophys.*, 76, 168 (1958).
[22] Fuller, R. C., and Anderson, I. C., *Plant Physiol.* (Supp.), 32, xvi (1957).
[23] Rosenberg, L. L., Capindale, J. B., and Whatley, F. R., *Nature*, 181, 632 (1958).
[24] Mortlock, R. P., Valentine, R. C., and Wolfe, R. S., *J. Biol Chem.*, 234, 1653 (1959).
[25] Sisler, E. C., and Fuller, R. C., *Fed. Proc.*, 18, 1286 (1959).
[26] Losada, M., Trebst, A. V., Ogata, S., and Arnon, D. I. (in preparation).
[27] Lynen, F., and Decker, K., *Ergebn. Physiol.*, 49, 327 (1957).
[28] Barker, H. A., Weissbach, H., and Smyth, R. D., *Proc. U.S. Nat. Acad. Sci.*, 44, 1093 (1958).
[29] Glover, J., Kamen, M. D., and Van Genderen, H., *Arch. Biochem. Biophys.*, 35, 384 (1952).
[30] Arnon, D. I., in "Light and Life", edit. by McElroy, W. D., and Glass, B. (Johns Hopkins Univ. Press) (in the press).
[31] Maclachlan, G. A., and Porter, H. K., *Proc. Roy. Soc.*, B, 150, 460 (1959).
[32] Benson, A. A., and Calvin, M., "Ann. Rev. Plant Physiol.", 1, 40 (1950).
[33] Oparin, A. I., "The Origin of Life on the Earth", third ed. (Academic Press, New York, 1957)
[34] Priestley, J., "Experiments and Observations on Different Kinds of Air", 1, 49 (J. Johnson, London, 1774).

OBITUARIES

Prof. W. E. Garner, C.B.E., F.R.S.

THE news of the death of Prof. W. E. Garner at his home in Bristol on March 4 was received with much sadness by his former colleagues at the University of Bristol, and particularly by those who had the privilege of working with him and under his leadership.

Garner was a man of great charm and kindness who won the affection and admiration of all who came into contact with him. His unselfishness and sincerity made him the most likeable of men. He was quiet, unobtrusive, entirely devoid of personal ambition and devoted to his work, whether it be in his laboratory, the councils of the University, or in the committee room. But these unassuming qualities did not obscure the greatness of the man. He was an enthusiastic and inspiring leader of research: keenly critical in scientific matters, yet very kindly and tolerant in his attitude to the ideas of others. Always most conscientious in the discharge of his duties, he maintained the tradition of lecturing to first-year students and he liked to know the students personally. The wide circle of friends, students and of many others who sought his advice and received it, valued a friendship which will endure as a cherished memory of a lovable character.

Garner was a student of the University of Birmingham, where he carried out research with Prof. P. F. Frankland. He was awarded an 1851 Exhibition in 1913 and proceeded to the University of Göttingen to work with Prof. Gustav Tammann. His work there was interrupted by the outbreak of the First World War, and on his return to England he worked at Woolwich Arsenal with Sir Robert Robertson on the calorimetry of high explosives.

On leaving Woolwich, Garner was appointed assistant lecturer in the University of Birmingham (January 1919) and assistant lecturer at University College, London (October 1919). From that time began a close and happy association with Prof. F. G. Donnan and a fruitful period of research.

In 1927, Garner was appointed to the Leverhulme chair of physical and inorganic chemistry in the University of Bristol, a post which he held until his retirement in 1955.

During the Second World War he established an extra-mural research team in the University of Bristol under the Ministry of Supply to assist Government ordnance factories in research on explosives and munitions. The group continued until the end of the War, although Garner himself moved to Fort Halstead in Kent to become in turn superintendent of Chemical and Explosives Research, deputy chief, and later chief, superintendent of Armament Research in the Ministry of Supply. His wide knowledge, enthusiasm and wise guidance were of paramount importance to the war effort, and he was associated with many important developments in armaments and munitions. His services were recognized in 1946 when he was made C.B.E.

On the cessation of hostilities, Garner once again returned to Bristol and continued his fundamental researches with increasing vigour. He had a wide interest in, and keep knowledge of, many branches of physical chemistry, and his mental qualities were only fully employed when he was simultaneously developing many research lines. Broadly, his main contributions to physical chemistry fall into the following groups: (*a*) The study of explosive reactions in gases and the ionization and radiation from flames; notable among these researches was the discovery of the effect of small amounts of hydrogen on the radiation from carbon monoxide flames. (*b*) Heterogeneous catalysis and particularly the measurements of heats of adsorption. He and his colleagues in Bristol made outstanding contributions to the mechanism of adsorption on metals and metallic oxides, and he was a leader in applying the newer ideas of the physics of the solid state to the interpretation of heterogeneous reactions. (*c*) The kinetics of solid reactions. Garner's pioneering studies on the mechanism of the interface reactions and nucleation processes in solid reactions, and the development of suitable experimental techniques, constitute a chapter to the progress of a subject in which he was the acknowledged leader in Britain.

After his retirement in 1955 his continued interest in these topics and his freedom from other responsibilities enabled him to organize a symposium on chemisorption at Keele, Staffordshire, which was published by the Chemical Society, and to edit a large volume on the "Chemistry of the Solid State". Most of the contributors to the latter volume were his former students or close scientific colleagues, and the book is very much a tribute to his work and inspiration.

Garner was a well-known figure at scientific gatherings, and scientific societies and Government committees made great calls upon his time. He was president of the Faraday Society (1945–47); a member of the Scientific Advisory Council of the Ministry of Supply for most of the period 1942–60, and also a scientific advisor for civil defence in the south-west region of Britain.

He received many honours: he was elected to the fellowship of the Royal Society in 1937; and was a Fellow of University College. He was well known abroad; he was an honorary member of the Polish Chemical Society, a corresponding member of the Patronato "Alfonso el Sabio", Madrid (1959), and a member of the Joint Services Mission to the United States and Canada in 1948.

C. E. H. Bawn

Prof. A. J. H. Goodwin

Astley John Hilary Goodwin was born in Pietermaritzburg on December 27, 1900, and died on December 5, 1959, after a long illness. The son of Canon W. A. Goodwin, he was educated at St. John's College, Johannesburg, and at the University of Cambridge, where he graduated in archæology. At the age of twenty-three he joined the staff of the University of Cape Town, serving there until his death. He was appointed associate professor in 1954 in recognition of his academic achievements and original work.

From the sixties of the nineteenth century, collectors had amassed considerable quantities of stone implements from large numbers of sites in southern Africa. Goodwin, on his return from Cambridge, first applied his mind to the problem of the systematic classification and chronological arrangement of this material and soon realized the need for a terminology that would be more applicable to the southern African facts than the European one hitherto accepted. He envisaged a subdivision of the Stone Age into three—Earlier, Middle and Later—each of which embraced a number of cultures and their variations. Collaboration with van Riet Lowe and Neville Jones led to the foundations of South African prehistoric classification being laid and to the elaboration of conjoint ideas in "The Stone Age Cultures of South Africa". This contained basic systematic descriptions and has been used as the foundation for prehistoric studies in both South and East Africa.

Goodwin stressed the need for a strictly scientific approach to field exploration and to the drawing of conclusions. His method of approach is to be found in his handbook entitled "Method in Prehistory". His own field-work was intensive and marked by meticulous accuracy of observation, whether it was concerned with the excavation of caves and shelters or with the examination of sequences of styles in rock engravings. Mainly undertaken within the confines of the Cape Province, his original field observations were supplemented by visits to many critical sites in other parts of Africa; and he excavated and studied important more recent archæological sites in Nigeria on the invitation of the Government of that country.

Goodwin's methodical and lively mind embraced many cultural interests and made him a good organizer. He took a leading part in founding the South African Archæological Society, was its secretary for a number of years, edited its *Bulletin*, and at the time of his death was its president. With A. L. du Toit he was enthusiastic in founding the Athenæum Trust, which provided a 'home' for the scientific and cultural societies, the headquarters of which are in Cape Town. For some years he served as the honorary general secretary of the Royal Society of South Africa and on its council and, again in the year of his death, was elected to its presidency. Whatever task of this nature he was called upon to perform, he carried it out with quiet unobtrusive natural efficiency and forthrightness; what he had to say was said quietly, succinctly and directly. Discussion with him was a pleasure, but acrimonious discussion was impossible. To all those who had contact with him he was "John".

Our late colleague is survived by his widow, a son and a daughter.

S. H. Haughton

Prof. C. J. Bakker

Prof. C. J. Bakker, whose death in an aeroplane accident in New York occurred on April 23, was on his way to attend a meeting of the American Physical Society in Washington. He had been invited to address the Society on recent researches at CERN and particularly on the successful operation of the 25-GeV. proton synchrotron.

Cornelis Jan Bakker was born in 1904 and studied physics under Zeeman in Amsterdam. After taking his doctorate (*cum laude*) in 1931 for original research on the Zeeman effect in the spectra of the noble gases, he spent a year in London at the Imperial College of Science and Technology continuing his work in spectroscopy. In the following year he joined the scientific staff of Philips, Eindhoven, where he worked on the physical problems of radio communications. His interests soon turned to nuclear physics and during the War, in collaboration with Prof. Heyn, he designed the Philips cyclotron. In 1946, he succeeded Gorter as professor of physics and director of the Zeeman Laboratory of the University of Amsterdam. He also became director of the Institute of Nuclear Physics, the focal point of Dutch nuclear research sponsored by Fundamental Onderzoek der Materie, by the City of Amsterdam and by Philips. He was a member of the Royal Netherlands Academy of Sciences.

In 1951, Prof. Bakker was invited by Prof. Auger, director of the Unesco Department of Natural Science, to be one of the eight experts charged with drawing up plans for the future European Organization for Nuclear Research (CERN).

At the first session of the Council of CERN during May 5–8, 1952, Prof. Bakker was appointed a member of the directorate and director of the Synchro-Cyclotron Division. On July 1, 1955, he became deputy director-general of CERN, succeeding Prof. Felix Bloch as director-general on September 1, 1955.

During the years 1955–60 CERN has grown from an idea put forward by a few European scientists to one of the best-equipped laboratories for high-energy nuclear physics research in the world. In 1957 the CERN 600-MeV. synchro-cyclotron was commissioned, and since that time it has been in full use as a nuclear physics research tool. More recently, at the end of 1959, the 25-GeV. proton-synchrotron came into operation at CERN.

In June 1957, Prof. Bakker received an honorary doctorate from the University of Geneva, and in April 1960 the Queen of the Netherlands awarded him the high honour of "Ridder in de orde van de Nederlandse Leeuw". His death took place before the official ceremony at which this award was to have been given.

Prof. Bakker believed firmly in European collaboration in science, and CERN, which is a unique and successful example of such collaboration, was inspired by his devoted leadership. His sudden death is a tragic loss to his wife and children, to CERN and to international scientific collaboration.

J. B. Adams

NEWS and VIEWS

J. H. Plummer Professorship of Experimental Physics at Cambridge: Prof. A. B. Pippard, F.R.S.

DR. A. B. PIPPARD, who has been elected to the John Humphrey Plummer professorship of experimental physics in the University of Cambridge, went to the Royal Society Mond Laboratory immediately after the Second World War, and in a series of elegant experiments on the high-frequency behaviour of metals at very low temperatures laid the foundations of much of his subsequent work. Observations on metals in the superconducting state led him to postulate a 'non-local' relation between superconducting current and magnetic field, which proved very suggestive in the later development of a fundamental theory by Bardeen, Cooper and Schrieffer. The study of normal metals brought not only a detailed understanding of the 'anomalous skin effect', first noticed by H. London, but also led Pippard to consider other aspects of the theory of metals, and he has recently been particularly concerned with the relation between the electronic structure of a metal and its physical properties. All his work has been distinguished by a remarkable combination of experimental skill with an ability to see his way through complicated theory in terms of simple physical concepts. This has enabled him not only to devise ingenious experiments but also to contribute effectively in fields which are usually regarded as the preserve of the professional theoretician. He was elected a Fellow of the Royal Society in 1956 and was awarded the Hughes Medal of the Society in 1959; his election to the John Humphrey Plummer chair at Cambridge is a well-merited recognition of his outstanding position in metal physics.

Physics at Southampton: Prof. G. W. Hutchinson

DR. HUTCHINSON, who has been appointed to a newly established second chair of physics in the University of Southampton, was educated at Abergele Grammar School and at St. John's College, Cambridge. After graduating in physics, he spent five years in industry and then, in 1947, started research in the Cavendish Laboratory under Prof. O. R. Frisch. He first investigated the properties of liquid argon as a conduction counter for nuclear particles, and, as a result, became interested in the analysis of pulse-height distributions. After trials of a number of systems Hutchinson realized the possibilities of computer techniques in this field, and working with G. G. Scarrott, devised in 1950 the pulse-height analyser which now bears their names. This elegant and powerful instrument represented a major advance in nuclear counting technique, and its widespread use was fitly recognized by the award of the Duddell Medal of the Physical Society to Hutchinson and Scarrott jointly in 1959.

Since 1952 Hutchinson has been Fellow and lecturer in the Department of Natural Philosophy, University of Glasgow, and lecturer and senior lecturer in the Department of Physics, University of Birmingham. His research interests have ranged widely, and include nuclear reactions at low energies, the proton–proton interaction at 1 GeV. and the origin of cosmic rays. Recently, he has been responsible for the experimental programme of the Birmingham proton synchrotron, and has developed techniques of fast counting and new forms of Čerenkov counter which have proved valuable for work with this machine. Hutchinson has always wished to extend his work through contact with the National Institute for Research in Nuclear Science, and his appointment to a chair in the University of Southampton at this time should help him to further his interests in high-energy physics.

The Advanced School of Automobile Engineering, Cranfield: Prof. J. R. Ellis

THE governing body of the College of Aeronautics has appointed Mr. John Romaine Ellis as professor of automobile engineering and first director of the Advanced School of Automobile Engineering being established at Cranfield in Bedfordshire, in association with the College of Aeronautics. Mr. Ellis graduated in mechanical and aeronautical engineering in the University of London in 1947, and was awarded a master's degree in 1954. He became an associate member of the Institution of Mechanical Engineers in 1952 and of the Automobile Division in 1958. During the period January 1944–December 1948, Mr. Ellis was employed successively at the Royal Aircraft Establishment and the Fairey Aviation Co., Ltd. In 1949 he joined the lecturing staff of the Royal Military College of Science, Shrivenham, first in the Materials and Structures Branch, and is at present principal lecturer in the Machines Branch. His published papers have dealt with wind-up in multi-axle drive vehicles, the effect of speed of rotation and torque on the effective rolling radius of a pneumatic tyre, and with torque converters. He is at present investigating the steering mechanics of the pneumatic tyre.

Chemistry at Queen Mary College, London: Prof. M. J. S. Dewar, F.R.S.

AFTER eight years as head of the Department of Chemistry at Queen Mary College, London, Prof. M. J. S. Dewar was appointed to the chair of organic chemistry in the University of Chicago, in October 1959. His stimulating personality and exceptionally wide scientific interests, ranging from physical theory to organic synthesis, produced striking developments in both teaching and research at Queen Mary College. Outstanding among his achievements, which led to his election to the fellowship of the Royal Society earlier this year, are his contributions to the molecular orbital theory of conjugated molecules, the synthesis of tropylium salts and new hetero-aromatic boron compounds, and the development and use of radio-spectroscopic techniques for nuclear quadrupole, electron spin, and nuclear magnetic resonance. His departure is a great loss to chemistry in Great Britain, but every good wish goes with him for success and happiness in the United States.

Prof. B. C. L. Weedon

DR. B. C. L. WEEDON has been appointed to the chair of organic chemistry at Queen Mary College, where he will take up his duties in October 1960. Dr. Weedon graduated with first-class honours at the Imperial College of Science and Technology, London, in 1942 and, after a year's research, joined the Dyestuffs Division of Imperial Chemical Industries, Ltd. In 1947, he returned, as a lecturer in organic chemistry, to the Imperial College where he collaborated with the late Sir Ian Heilbron and afterwards with Sir Patrick Linstead. He was awarded the Meldola Medal of the Society of Maccabæans and the Royal Institute of Chemistry for 1952, and became reader in organic chemistry in 1955. Dr. Weedon is well known for his distinguished work in the fields of natural and synthetic polyenes, carotenoids and vitamin A, terpenes, acetylenes, fatty acids, pigments and other constituents of algae, fungi and bacteria, and the reactions of organic compounds in molten alkali and at electrodes. He is co-author, with Sir Patrick Linstead, of "A Guide to Qualitative Organic Chemical Analysis", and this year became scientific editor of *Pure and Applied Chemistry*, a journal to be published by the International Union of Pure and Applied Chemistry. Dr. Weedon will be a source of great strength to the Chemistry Department at Queen Mary College in the period of expansion and development which undoubtedly lies ahead.

Commonwealth Scientific and Industrial Research Organization (Australia) Division of Entomology

Dr. Douglas F. Waterhouse has been appointed chief of the Commonwealth Scientific and Industrial Research Organization (Australia) Division of Entomology in succession to Dr. A. J. Nicholson, who has occupied the post for twenty-seven years. The Division of Entomology was one of the first Divisions formed when the Council for Scientific and Industrial Research was set up in 1926. Dr. Nicholson has been appointed to a C.S.I.R.O. research fellowship and will continue in the Division of Entomology his notable research in the field of animal populations. He was a foundation Fellow of the Australian Academy of Science and a member of its first Council, and has held the offices of secretary (1954–55) and vice-president (1955–57).

Dr. Waterhouse graduated with first-class honours and the University Medal from the University of Sydney in 1937. During the War he held the rank of captain in the Australian Army Medical Corps. He was awarded the degree of D.Sc. from his University in 1952, and in the following year he shared the David Syme Research Prize with Dr. F. J. P. Dwyer. He has made two trips overseas in connexion with his research work in insect physiology and toxicology, spending six months in Cambridge just after the War, and six months in New Haven, U.S A., during 1955–56.

Movements of Scientific Men

In a written answer in the House of Commons on May 19, the Minister of Education, Sir David Eccles, as representing the Minister for Science, stated that the Department of Industrial and Scientific Research is at present undertaking, in co-operation with industry, a series of combined technical and economic studies of particular industries of national importance designed principally to discover where additional scientific research and development effort can most usefully be applied. A question was also asked referring to the emigration to the United States of another member of the scientific team working the Jodrell Bank radiotelescope. Sir David stated that as regards investigation into the reasons for emigration of scientists, he had nothing to add to replies given on March 28 and April 14, when he had pointed out that the general problem had been under consideration for some years by the Advisory Council on Scientific Policy, and had stated that, while there were no complete statistics of scientists who had emigrated to the United States or Canada, in 1958 7 scientists were recruited in America by the Civil Service Commissioners and the Atomic Energy Authority and in 1959, 16 were so recruited. Many scientists go overseas purely for further education, and others obtained valuable experience with which they later returned to Britain. In Sir David's opinion, a scientist should not be denied such opportunities, nor does it seem feasible for Britain to provide in every field of science, facilities identical with those in the United States.

Industrial Research in the United States

The final results of surveys, conducted for the National Science Foundation by the United States Department of Labour, Bureau of Labour Statistics, of funds and personnel for industrial research and development in 1956 present a picture generally very similar in character to that shown in Britain by the recent report from the Department of Scientific and Industrial Research (Science and Engineering in American Industry—Report on a 1956 Survey. Pp. ix + 117. (NSF 59-50.) (Washington, D.C.: Government Printing Office, 1960.) 70 cents). There was an increase of 75 per cent in expenditure on industrial research and development in the period 1953–56 from 3,500 million dollars to 6,200 million, and in January 1957, 223,000 scientists and engineers and 396,000 other personnel were engaged in research and development. The Federal Government's contribution rose by 126 per cent to almost 3,000 million dollars and company-financed research and development increased by 45 per cent; in 1956 about 48 per cent of industrial research and development was Government-financed, compared with 37 per cent in 1953. In 1956 basic and applied research projects accounted for nearly one-fourth of the volume of research and development, basic research accounting for 244 million dollars and applied research for 1,200 million dollars. Manufacturing and other industries employed 728,000 scientists and engineers in all activities in January 1957, an increase of 28 per cent on January 1954, as well as 570,000 technicians, of whom 157,000 were employed in research and development. It is estimated that independent commercial laboratories, engineering service firms and trade associations spent more than 100 million dollars on research and development in 1956, and employed a further 5,000 engineers and scientists and 7,000 other personnel on such activities. The chemical industry spent about 55 million dollars on basic research in 1956 and the electrical equipment industry 50 million dollars, aircraft manufacturing coming third with 41 million dollars. Projects in engineering sciences accounted for about 30 per cent of the total cost of basic research and research in chemistry for another 30 per cent, but the most rapid growth in basic research was in the medical sciences, on which the chemical industry spent nearly 25 per cent of its basic research effort.

Haffkine Institute of Bombay

The annual report of the Haffkine Institute for 1958 (pp. iii + 56. (Bombay: Government Books Depot; London: High Commissioner for India, 1959.) Rs. 0.62; 1*s*. 1*d*.) records the supply of large amounts of typhoid vaccine to Ceylon and cholera vaccine to Thailand during epidemics, through the World Health Organization; the demand for cholera vaccine was unusually high, while that for plague vaccine continued to be low. Assistance was also offered in an epidemic of encephalitis, and influenza vaccine was prepared at the Institute and released for distribution. Research activities included investigation of the anti-coagulant action of cobra venom in human and horse blood, and the preparation of new chromogenic substrates for detection and location of enzymes in venom after separation by starch electrophoresis. New thiourea derivatives of the type R.SO$_2$.NH.CS.NH.R' were synthesized to study their anti-tubercular properties, and tolylbutylamide was prepared by desulphurizing N′-p-methylbenzenesulphonyl-N^3-n-butylthiourea with hydrogen peroxide. Various epidemiological features of salmonellosis are under study and also the pharmacological actions of cholera endotoxins with the view of determining the pathogenicity of the disease, while a gravimetric method has been developed for determining the halogen derivatives of 8-hydroxyquinoline commonly used in medical practice. Manufacture of cholera vaccine by the submerged culture method was attempted, and studies were continued on salivary glands of rabid animals, while trials of influenza vaccine in animals led to the development of a biological test for the standardization of the potency of the vaccine. A study of the iron-binding capacity of serum was started as well as further work on the nutritive evaluation of foodstuffs commonly consumed in the State of Bombay. A list of papers published during the year is included.

Bulletin of the Provisional International Computation Centre

The *Bulletin of the Provisional International Computation Centre*, the eighth issue of which has just appeared, is essentially a serial publication listing computing laboratories, facilities, and conferences throughout the world (Rome: Palazzo degli Uffici, Zona dell'UER, 1960). A few articles are printed from time to time, and the latest issue contains an account of electronic computing facilities in Czechoslovakia. Many of the machines described in this article are unfamiliar in the Western world, and it is to be hoped that fuller details may appear in future issues of the *Bulletin*. It is interesting, also, to read the paper, by Dr. J. E. Holmstrom, on his multilingual terminology project. This seeks to rationalize the computer vocabulary and, most appropriately, takes the new draft British standard on the subject as its basic material.

Comparative Biochemistry and Physiology

The first number of *Comparative Biochemistry and Physiology* (Vol. 1, No. 1 (January 1960). Pp. iv+100. Subscription rate (including postage): (A) For institutions, 20 dollars per volume; (B) for individuals, 15 dollars per volume. New York and London: Pergamon Press, 1960) contains a foreword by Dr. Joseph Needham, in which he points out that in the development of physiology and biochemistry, the emphasis has been on the study of man and the mammals because of the close association of these sciences with medicine. This journal, in which special attention is to be given to the comparative aspects of animal physiology and biochemistry, will help to increase knowledge of all types of animals. It should appeal to zoologists and marine biologists as well as to physiologists and biochemists. The first number contains, among others, communications on toads, fishes, worms, snails and insects. The editors are Dr. G. A. Kerkut, University of Southampton, and Prof. Bradley T. Scheer, University of Oregon, and there is an honorary editorial advisory board of distinguished scientists from many different countries.

Solvents and Dry Cleaning

Unlike laundries, which have been facing serious competition from washing machines and 'launderettes' for more than a decade, the dry cleaning business has been little changed by technical development. During the past twenty years the gross annual turnover of this growing industry has increased from £10,000,000 in 1939 to a probable £35,000,000 to-day. 43,000 people are employed in dry cleaning, two-thirds of them women, in about 2,000 separate companies. The industry handles nearly 400,000 garments a day, which represents about three garments a year for every man, woman and child in Britain. In a dry-cleaning establishment the cleaning liquids are organic solvents, either petroleum-derived white spirit or chlorinated hydrocarbons, such as perchlorethylene. While solvents alone will release and carry away much of the dirt held in the fibres by greasy matter, they make little or no impression on water-soluble sugar and food stains. The advent of the steam gun has speeded up what is called the 'spotting' process. The gun spurts a jet of steam on to the stains, softening them and knocking the food and other particles off the fibres of the garment. In the more modern charged system of cleaning, electronic controls are widely used and give a very high and consistent standard of cleaning. The subject is treated in more detail in *Catalyst* (Vol. 3, winter edition 1959–60).

Flora of the Belgian Congo

The ninth volume of the monumental "Flore du Congo Belge et du Ruanda-Urundi" has now been published by the Institut National pour l'Etude Agronomique du Congo Belge. In its format it follows the same lines as its predecessors. It contains the families Buxaceae, Anacardiaceae, Aquifoliaceae, Celastraceae, Hippocrateaceae, Salvadoraceae, Icacinaceae, Sapindaceae, Melianthaceae, Balsaminaceae, Rhamnaceae, Vitaceae and Leeaceae, some of which are both large and taxonomically complicated. Among the more noteworthy treatments are that of Anacardiaceae by P. Van der Veken, in which the largest genera are *Trichoscypha* with 20 species and *Heeria* with 10; the troublesome Sapindaceae, including 26 species of *Allophylus*, by Hauman; the revision of *Impatiens* by Wilczek and Schulze in which 35 species are enumerated; and the Vitaceae by De Wit and Willems in which the genus *Cissus* runs to no less than 95 species in addition to others imperfectly known. The Hippocrateaceae (which are maintained as distinct from Celastraceae) have been subjected to an elaborate revision by Wilczek. Thirteen genera are recognized, from which it will be seen that the increase in generic segregation in this family, as carried out in recent years by A. C. Smith for America and N. Hallé for Africa, is supported. The largest genus is *Salacia* with 54 species. Students of the family Melianthaceae will have to take notice of a new classification of the formidable genus *Bersama* differing considerably from that of Verdcourt published in 1950.

Health of the Executive

DURING the past six years the Diagnostic Clinic of the Graduate School of Medicine, University of Pennsylvania, has carried out investigations into the health of 2,000 executives from 70 firms (Medical Affairs, University of Pennsylvania. 1, No. 3, Spring, 1960). On their first examination in the Clinic, 40 per cent of these individuals were found to have previously unrecognized disorders and only 28 per cent were diagnosed as completely healthy; the remaining 31 per cent had had previous illness which currently had an adverse effect on their physical status. Of the newly discovered disease, 57 per cent was considered potentially serious, 34 per cent was minor in importance, and 9 per cent insignificant. Disease in the serious category increased with age. In those 40 years of age or under, only 38 per cent of the newly diagnosed disease was considered serious, while in those over 60 years it rose to nearly 70 per cent. The conditions occurring in the older age groups are as susceptible to treatment as are those in younger individuals. 54 per cent of the newly discovered disease was concentrated in only 13 per cent of the group. There is thus a healthy group of 28 per cent having no disease, either new or old, and 13 per cent of the group having more than half of all the disease found. This small 'disease prone' group is being further examined.

Rugby School Natural History Society

THE report of the Rugby School Natural History Society for 1959 contains a number of articles for which the boys concerned were awarded school prizes (Pp. 24+2 plates. Rugby: Rugby School Natural History Society, 1960). One of the most interesting is by I. H. R. Thompson, who obtained a distinguished-work prize. During a period of three years, Thompson has been collecting information about the disposal of dung and carrion and, in this article, describes the part played by beetles in dung and carrion disposal. Although four-footed scavengers and maggots play the greater part in disposal of carrion, Thompson shows that *Necrophori* beetles are responsible for the elimination of considerable quantities of carrion. Almost invariably, the beetles bury the corpses by excavating the earth under it and allowing the body to sink down into the hole. During burial the fur or feathers are usually removed, but the animal is never dissected. Beetles play a much larger part in the disposal of dung than they do of carrion. Although other agents, such as flies and worms, dispose of some dung, the bulk of it is dealt with by beetles. As early as March a patch of dung will yield a quantity of the smaller dung beetles, particularly the smaller *Aphodius*; by May the larger *Geotrupes* can be found in large numbers. About this time the smaller *Aphodius* appear in numbers again.

Population in 1958

THE second part of the Registrar General's Statistical Review, which used to be called "Civil Tables", is now published under the title "Tables, Population" (pp. xi+181. London: H.M. Stationery Office, 1960. 11*s*. 6*d*. net). The contents remain unchanged, however; mortality statistics continue to be published in the medical tables, and Part 2 of the volume for 1958 deals with births, marriages and total population. There have been no major changes in the presentation of statistics compared with previous years. Nor were there any striking new trends in the figures themselves during that period. Divorces continued to decline in numbers, new petitions filed stood at the lowest figure since 1945, when the married population was lower in absolute numbers than to-day. Live births were up by about 18,000 compared with the previous years, raising the birth-rate from 16·1 to 16·4 per thousand of the total population and the legitimate birth-rate from 111·5 to 113·9 per thousand married women of reproductive age. Births have been increasing steadily since 1955, and provisional figures for 1958 indicate that the rise has continued in that year.

Principles of the Extraction of Metals

MONOGRAPH No. 3 of the series being published by the Royal Institute of Chemistry for the guidance of teachers in schools is concerned with the application of physico-chemical principles to extraction metallurgy (Royal Institute of Chemistry Monographs for Teachers. No. 3: Principles of the Extraction of Metals. By Dr. D. J. G. Ives. Pp. vi+57. London: Royal Institute of Chemistry, 1960. 6*s*.). The author, Dr. D. J. G. Ives, has done a very good bit of work, and no better preparation for a prospective student of metallurgy could well be imagined. The first of the four chapters is concerned with the thermodynamical background, the reader being introduced to, or reminded of, the fundamental concepts. In the next, these are applied to pyrometallurgical processes. Chapter 3 gives a short account of the factors which govern the choice of extraction methods, and the booklet ends with a description of some typical operations such as roasting, the extraction of iron and copper and an outline of hydrometallurgy. This is an excellent introduction to the subject; the only question which can arise is whether the treatment may not be a bit too ambitious for its purpose, but this is a fault, if indeed it be one at all, which is easily remedied.

A Blood Parasite from the California Yellow-legged Frog

DURING the summer and early autumn of 1958, eleven *Rana b. boyli* were collected from Dutch Mill Creek, Sonoma County, California. Examination of the peripheral blood showed the presence of extra-cellular and intra-erythrocytic hæmogregarine-like parasites (considered to be *Karyolysus sonomae*) in five of the hosts. Sections and tissue impressions of the viscera indicated that the parasite underwent schizogony in endothelial cells. Donald L. Lehmann reports that this is the first authentic report of a species of this genus to be recorded from any group but the Reptilia (*Proceedings of the American Philosophical Society*, 103, No. 4; August 1959). Previous reports from the Amphibia have been based upon the morphology of the parasite in the peripheral blood and were not confirmed by demonstrating the vertebrate life-cycle.

The genus *Karyolysus* was established by Labbe (1894) to include those intra-erythrocytic sporozoans capable of fragmenting the nucleus of the host-cell. Reichenow (1921) found that this lytic activity was of uncertain generic worth; he did, however, demonstrate that the parasite could be distinguished from other hæmogregarine-like species on the basis of the life-cycle in the vertebrate host, where schizogony occurs in endothelial cells and the resulting merozoites, following their penetration into erythrocytes, develop into gametocytes. Infections were determined by staining thin smears of peripheral blood with Wright's stain, and more detailed observations were made following Giemsa's stain. Sections of viscera (liver, spleen, kidney, lung and heart) were fixed in alcohol–formalin–acetic acid, stained with Heidenhain's iron hæmatoxylin and cut 15 microns in thickness.

Factors affecting Tubers in *Begonia evansiana* Andr.

THIS species of *Begonia*, which is evidently a useful plant for investigations of developmental physiology, has buds which consistently form aerial tubers when exposed to short days. These tubers, when given sufficient short-day treatment, do not sprout when afterwards exposed to long days. However, if the plants are transferred to long days after a certain minimal short-day exposure, the tuberizing buds resume growth. There is evidence, from defoliation experiments, that the tuber may itself be sensitive to light (Esashi and Nagao, *Sci. Rep. Tohoku Univ.*, Ser. 4 (Biol.), 24, 81; 1958). These authors (*ibid.*, 25, 191; 1959) have now reported that aerial tubers of *Begonia evansiana* Andr., which are formed under short-day conditions, begin to sprout when isolated and exposed to continuous light while they are actively thickening. After the completion of thickening, however, the tubers sprout no more in response to light. These dormant tubers can be induced to sprout after low-temperature treatments. Whether or not the tubers sprout, they develop roots. In a study of the action of gibberellin on the dormancy of the tubers, Nagao and Mitsui (*ibid.*, 199) found that gibberellin treatments in the concentration range from 0·1 to 100 p.p.m. had no dormancy-breaking effect. Gibberellin treatments at concentrations of 10 and 100 p.p.m. inhibited the sprouting of aerial tubers. The gibberellin effect was greater in more dormant tubers. Gibberellin seemed to induce or prolong the tuber dormancy. The gibberellin-induced dormancy appeared to be broken by low-temperature treatments like natural dormancy. Rooting of aerial tubers was affected but slightly by gibberellin.

Rensselaer Polytechnic Institute

A REPORT on gifts, grants and bequests to Rensselaer, 1958–59, has been issued by the Rensselaer Polytechnic Institute as a supplement to the annual development report, and to emphasize the major importance of such assistance in helping the Institute to achieve its educational goals (pp. 16. Troy, New York: Rensselaer Polytechnic Institute, 1960). Without such contributions the Institute could neither survive nor establish firm plans for future growth. In the past fiscal year such gifts of cash and equipment amounted to 1,362,854 million dollars.

Summer School in Crystal Structure Determination

A SUMMER School in "Modern Methods of Crystal Structure Determination" will be held in the Manchester College of Science and Technology during August 29–September 9. The main topics to be dealt with, by lectures, practical work and discussions, will be direct methods, Fourier-transform and optical-transform methods, anomalous scattering, and refinement procedures. In addition, there will be some lectures and discussions on recent results in various fields, with assessment of their implications. The fee for the course will be £25, including accommodation in one of the University halls of residence. The fee for attendance without accommodation will be £5. Further information can be obtained from the Director, Extra-Mural Department, The University, Manchester 13.

Association of Consulting Scientists

AT the annual general meeting of the Association of Consulting Scientists, held in London recently, the following officers and Council for 1960–61 were elected: *chairman*, Dr. J. G. Davis; *hon. treasurer*, Dr. G. W. Ferguson; *hon. secretary*, Mr. W. H. Stevens; *other members*, Dr. M. Barent, Dr. H. H. Chambers, Dr. Julius Grant, Dr. J. H. Oliver, Mr. O. W. Roskill, Mr. F. G. Sarel Whitfield.

The Linnean Society of London

AT the anniversary meeting of the Linnean Society of London, held on May 24, the following were elected officers and Council for the session 1960–61: *president*, Prof. C. F. A. Pantin; *treasurer*, The Earl of Cranbrook; *secretaries*, Dr. C. R. Metcalfe (botany), Dr. H. G. Vevers (zoology), Dr. John Smart (editorial). *Vice-presidents* appointed were: Mr. E. J. H. Corner, The Earl of Cranbrook, Asst. Prof. H. R. Hewer and Dr. W. G. Templeman. *New members of Council*: Dr. A. J. Cain, Prof. A. R. Clapham, Dr. W. P. Crowcroft, Mr. F. C. Deighton and Mr. J. F. Levy. *Linnean Gold Medals* were presented to: Dr. Libbie Henrietta Hyman and Dr. H. Hamshaw Thomas. *The Trail Award and Medal* was presented to Dr. Laurence Ernest Rowland Picken. Prof. Dr. C. G. G. van Steenis and Dr. Robert E. Snodgrass were elected foreign members and Mr. H. F. Comber, Mr. Dennis A. Kempson and Prof. Alexander Eric Kohts were elected associates *honoris causa*.

Royal Society of South Africa

THE following were elected as officers and Council for 1960: *president*, Dr. S. M. Naudé; *honorary general secretary*, Mr. W. J. Talbot; *honorary treasurer*, Dr. N. Sapeika; *acting honorary editor of transactions*, Mr. A. M. Talbot; *honorary librarian*, Dr. J. H. Day; *other members of council*, Dr. R. A. Alexander, Dr. S. F. Bush, Dr. A. L. Hales, Dr. W. E. Isaac, Dr. M. R. Levyns, Dr. R. H. Marloth, Dr. S. H. Skaife, Dr. R. H. Stoy and Dr. C. L. Wicht.

The Leopoldina German Academy of Sciences: Elections

DIE Deutsche Akademie der Naturforscher, Halle, recently elected the following new members to the Sections indicated: *Astronomy*, Prof. Paul ten Bruggencate (Göttingen), Prof. A. A. Michailow (Pulkowo, Leningrad), and Prof. Martin Schwarzschild (Princeton); *Medicine*, Prof. Heinrich von Hayek (Vienna), Prof. Josef Kimmig (Hamburg), Prof. Friedrich Matzen (Leipzig), Prof. Hans Netter (Kiel), Prof. Karlheinz Sommer (Halle), and Prof. Werner Wachsmuth (Würzburg).

"Ataxia in Hens poisoned by Tri*para*ethylphenyl Phosphate"

WITH reference to her communication under this title in *Nature* of January 23, p. 247, Miss Ann Silver writes: "I should like to emphasize that the first evidence that this substance produces ataxia in hens was observed by Bondy, Field, Worden and Hughes at the Nutritional Research Station in Huntingdon, and it was first synthesized in the laboratories of Coalite and Chemical Products, Ltd., and the sample tested by me was provided by Dr. H. F. Bondy".

University News :

Belfast

THE following appointments to lectureships are announced: Dr. S. M. Nelson (organic chemistry); Dr. A. R. Johnston (physics); Dr. L. T. Threadgold (zoology); Mr. T. J. Black and Mr. D. McCloy (mechanical engineering).

Birmingham

THE title of reader in reactor physics has been conferred on Dr. J. Walker, senior lecturer in physics. Appointments to lectureships are as follows: Gillian Vaisey (civil engineering); G. Lees (road materials); Dr. G. H. Burkhardt (mathematical physics); Dr. M. J. Lawrence (genetics); G. H. Trengrouse and E. Amini (mechanical engineering); Dr. D. C. Champeney and D. A. O'Connor (physics). D. R. Milner has been appointed Lucas Fellow in metal-joining in the Department of Industrial Metallurgy for seven years.

Edinburgh

THE following have been appointed Imperial Chemical Research Industries Fellows: Dr. J. L. Holmes, Dr. K. R. Jennings, Dr. G. R. H. Jones, Dr. A. J. Charlson, and Dr. J. W. Sutherland. Mr. M. J. O'Hara has been appointed lecturer in geology and Mr. E. R. S. Fifoot, University librarian (as from October 1).

Leeds

APPOINTMENTS to lectureships are as follows: W. G. Collins and J. A. Fox (civil engineering); Dr. C. M. Reeves (electronic computing); C. G. Woods (pathology); Dr. P. J. Wyllie (experimental petrology). Dr. D. M. Robertson has been awarded the Portsmouth fellowship for research in multiple sclerosis for three years. The Department of Zoology has received a grant of £2,055 from the Department of Scientific and Industrial Research for research projects under the direction of Dr. Broadhead. The Department of Biomolecular Structure received grants of 152,517 dollars from the United States Public Health Authority and £1,100 from the Medical Research Council; the latter is to be used in establishing a research fellowship. The Houldsworth School of Applied Science has received among other grants £3,500 from the British Coke Research Association and £1,200 a year to establish a research fellowship in ceramics from the Thermal Syndicate, Ltd.

Nottingham

DR. CYRIL CLIFFORD ADDISON, at present reader in the Department of Chemistry, has been appointed professor of inorganic chemistry as from October 1. Dr. Addison graduated at Durham in 1934 and obtained the research degrees of that University of Ph.D. in 1937 and of D.Sc. in 1947. During the War he worked for the Ministry of Supply at Runcorn and Preston, and was later head of the Analytical Research Laboratories at Sutton Oak. He was appointed lecturer in inorganic chemistry at Nottingham in 1946, and in 1952 the title of reader was conferred upon him.

Dr. Maurice William Partridge, at present Lord Trent reader in pharmaceutical chemistry, has been appointed to the Lord Trent chair in the same subject as from October 1. Dr. Partridge graduated with honours at University College, Nottingham, and in 1941 was awarded the research degree of Ph.D. of the University of London. During the War he was research assistant to the British Pharmacopœia Commission and later was senior scientist in the chemical research laboratories of Boots Pure Drug Co., Ltd. He was appointed lecturer in pharmaceutical chemistry in 1947, and in 1955 was appointed to his present readership.

Oxford

THE following appointments to readerships have been announced: Dr. E. P. Abraham (chemical pathology); Dr. E. Bülbring (pharmacology); Dr. W. A. Waters (physical organic chemistry); and Dr. N. Kurti (physics).

St. Andrews

THE following appointments to senior lectureships are announced: Dr. Ann R. Sanderson, Department of Zoology, Queen's College; and Dr. D. V. Osborne, Department of Natural Philosophy, St. Salvator's College.

Announcements

LORD HIVES, who was the first chairman of the National Council for Technological Awards, has been given an honorary diploma in technology (engineering); this is the first honorary award to be made by the Council.

THE Chemical Research Committee of the Indian Council of Scientific and Industrial Research is organizing a two-day symposium on "Proteins" at Mysore during the first week of August. Further information can be obtained from Dr. A. Sreenivasan, Central Food Technological Research Institute, V. V. Mohalla, P.O., Mysore 2.

THE tenth International Congress of the History of Science will be held in the United States during August 26–September 2, 1962. Opening sessions of the Congress will be held at Cornell University, Ithaca, New York, and the concluding sessions will be held at the American Philosophical Society, Philadelphia, Pennsylvania. The president of the Congress is Prof. Henry Guerlac, of Cornell University. Further information can be obtained from the secretary, Prof. C. Doris Hellman, Cornell University, Ithaca, New York.

THE fourteenth congress of the International Scientific Film Association will be held in Prague during September 16–24, and will include, as in previous years, a festival of films on "Presenting Science". Responsibility for selecting the British film entry for the Congress rests with the Scientific Film Association of Great Britain. Further information can be obtained from the Scientific Film Association, 3 Belgrave Square, London, S.W.1.

AN international conference on "Natural Rubber Research", sponsored by the Rubber Research Institute of Malaya with the support of the Government of the Federation of Malaya and the Rubber Producers' Council, will take place in Kuala Lumpur during September 26–October 1. Further information can be obtained from the Rubber Research Institute of Malaya, P.O. Box 150, Kuala Lumpur.

NEW PHYSICS LABORATORY OF THE UNIVERSITY OF READING

THE new physics laboratory of the University of Reading was opened on May 17 by Sir George Thomson, who named the building "The J. J. Thomson Physical Laboratory". On the occasion of the opening, honorary degrees were conferred on Dr. T. E. Allibone, Prof. N. F. Mott, Prof. F. Seitz and Sir George Thomson. It is of interest to recall that Sir J. J. Thomson received an honorary degree from the University in 1935 and that both the first professor of physics at the University of Reading (J. A. Crowther) and the present professor (R. W. Ditchburn) worked in the Cavendish Laboratory under him.

The Laboratory was planned to accommodate undergraduate classes of up to 100 in each of the first two years (post-intermediate), and about thirty in the special honours final year. Facilities for about fifty research workers (including members of staff) were also provided. It was expected that the intermediate science class would be very small, but that teaching at this level would be required for about 100 students in agriculture, etc. It now appears probable that the numbers of students in these elementary classes will be much smaller than was expected, but the teaching laboratory space released will be required to deal with the large increase of students now predicted for the next decade.

The Laboratory is a three-storey steel-framed building with a floor area of about 63,000 sq. ft. The structure has brown-grey brick walls and the greater part has a low pitch roof covered in copper. The western end of the Laboratory, connected to the main building by a two-storey glazed link, is the lecture theatre block. This has a flat roof surrounded by a parapet wall. The ground floor contains two lecture theatres, with a projection room for each and a preparation room common to both. On the first floor, above the lecture theatres, are two large teaching laboratories for the general honours students and for special honours students in their first and second years. These laboratories cover an area of 5,000 sq. ft. with a single-span roof, internal steel partitions being used to provide dark-rooms, etc. The absence of internal structural pillars and load-

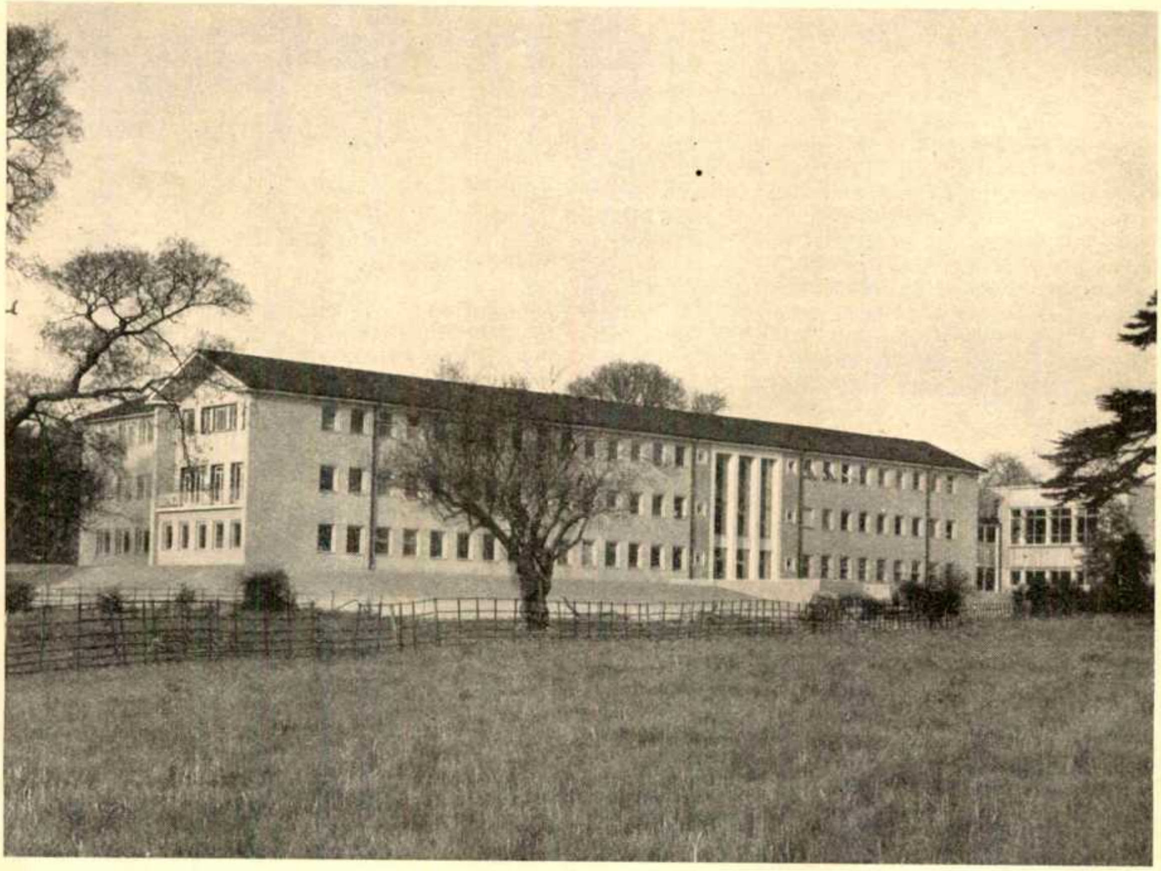


Fig. 1. The J. J. Thomson Physical Laboratory, University of Reading

bearing walls enables the space to be utilized in a very economical way.

The larger lecture theatre contains seating for 180 and the smaller for 105. Each has bench-type seating, specially modelled for maximum comfort, and fitted with hinged writing flaps. In each theatre the lecturer's demonstration bench is equipped with all laboratory services and, in addition, the electrically operated windows, blinds and dimming apparatus for the lighting can be controlled from it. The walls behind the demonstration benches are prepared to form a permanent projection surface 12 ft. wide and 6 ft. high, on which two pictures can be projected side by side. Below the projection surface is a 12-ft. glass chalk-board. On the left-hand side of the central wall is a splayed wall with a translucent glass chalk-board, which can be illuminated from behind when the room is darkened; on the right-hand side is another splayed wall fitted with a chalk-board of conventional type.

Heating in the lecture theatres is by means of radiant wall panels combined with a heated air plenum ventilation system. Elsewhere in the building heating is by 'Frenger' acoustic heated ceilings. All windows are double-glazed to reduce heat losses. Many of the rooms are provided with inlet and extract ventilation, particularly those fitted with dark blinds.

The main laboratory is planned on a repeating bay unit 7 ft. 6 in. wide and 16 ft. deep, with laboratory services arranged beneath the windows in a service rack. The services available in every bay of the building include alternating current supplies at 415 V. (3-phase) and 240 V. and 6 V. (single phase) and direct current at 240 V. and 24 V. Hot and cold water, gas and compressed air are also available.

It was estimated that one and a half million gallons of cooling water per annum would be required for diffusion pumps, compressors, etc., and a recirculation system is therefore provided. This service is generally available in the centres of rooms, together with 240 V. a.c. and one other service at choice.

Walls throughout the building are plastered and tinted and the doors are decorated in bright colours. The floors of most rooms are covered with 'Tarkett P.V.C.' tiles and the corridors with 'Korkoid'. The library has been designed to enable the beautiful surroundings of the Laboratory to be seen to advantage. Part of a gift from Imperial Chemical Industries, Ltd., has been used to provide books for the library, which will be especially useful during the next three years when the University Library is still on the old University site. Office accommodation for a theoretical physics group is provided near the library. This group is working on the application of quantum mechanics and statistical mechanics to problems in solid state physics, in particular crystal lattice vibrations, lattice imperfections and magneto-optic effects in semiconductors.

Most of the experimental work in the Laboratory is concerned with the physics of the solid state. One research group is studying the effects of imperfections in crystal structure on physical properties, particularly with reference to radiation damage (defects produced by irradiation with pile neutrons and other high-energy particles). A 2-MeV. Van de Graaff generator (purchased with a grant from the Department of Scientific and Industrial Research) is used to produce defects in a controlled way. It is housed in a small building at a convenient distance from the main laboratory.

A section of the research space is assigned to the radio-tracer laboratory, which is mainly concerned with atomic diffusion in metals. This laboratory contains also a mass spectrometer which is used to assist biological as well as physical research.

A research group, supported by the Admiralty, is working on the surface properties of semiconductors. Methods of breaking germanium in a very high vacuum (10^{-9}–10^{-10} mm. mercury) so as to expose a crystal plane have been devised, and the gradual contamination of these surfaces is being studied. Work on the etching of surfaces is being studied using high-quality optical microscopes, and an *E.M.*6 electron microscope is on order. Associated Electrical Industries, Ltd., have kindly agreed to provide a technical assistant to work this instrument for three years. Studies of solids by X-ray and electron diffraction are also in progress. The Royal Society has given a grant to assist the development of high-voltage electron diffraction using the Van de Graaff generator.

The Laboratory is equipped for spectroscopic studies for the infra-red, visible, ultra-violet and soft X-ray regions. The apparatus is used for measurements on solids chiefly in the infra-red and visible regions and in the vacuum ultra-violet. The results on gases have applications to studies on the upper atmosphere and to the physics of hot plasmas.

A biophysical investigation on vision is supported by the U.S. Public Health Service.

When the Laboratory was designed, the number of students in the University of Reading was expected to become stable at a figure in the range 1,500–2,000. An increase to 3,000 is now contemplated. The Laboratory will have to provide for larger numbers in the Physics Department and also for the early development of at least two new departments in the physical sciences. The design of the building provided for possible extension which, it was thought, might be needed after twenty-five years. The new conditions have led to discussion of this extension even before the building was opened.

R. W. DITCHBURN

GOVERNING TECHNICAL COLLEGES

A HANDBOOK, "The Technical Colleges and their Government", issued by the Joint Federation of British Industries Technical Colleges Committee under the auspices of the Federation's Education Committee, provides a concise but keen industrial appraisal of the structure of technical education, its historical background, academic pattern and finance as well as a close discussion of the government of technical colleges (pp. vii+44. F.B.I. Handbook. London: Federation of British Industries, 1960. 5s.).

Appendixes included a policy statement on the finance of advanced sandwich courses issued by the Federation, the Ministry of Education's Circular 7/59 on Governing Bodies for Major Establishments, and a selected bibliography which is thoroughly representative.

The recommendations based on this survey emphasize that it is the function of governors to ensure that their college fulfils its role as an academic institution within the national and regional framework of further education. To do so involves strong links with industry, commerce and the professions; a constant awareness of the changing needs of their students; and adequate powers to implement the governing body's decisions. Governors nominated by special interests can and should bring their special experience or background to bear on the affairs of the college, but the handbook emphasizes that the governors serve to promote the interests of the college and that they should be aware that each college occupies a distinct place in the pattern of further education as a whole.

On size, the handbook suggests a membership of about twenty as ideal, and it should include members of the professions with which the college is mainly concerned and of the universities. The contribution which headmasters of secondary schools could make should be considered and provision for co-opting independent persons with special knowledge or experience, representative of ex-students and for continuity is recommended. Stress is laid on the importance of the full implications of the recommendations of the Ministry of Education in regard to the powers of the governing body, and the handbook stresses the importance both of the power of governors being commensurate with the responsibilities they are asked to assume and of adjusting procedure to ensure the best possible use of the governors' time.

One meeting of two to three hours a term is suggested as covering most requirements, but apart from attendance at formal meetings of the governing body and its committees, governors can and should play a valuable part in the life of the college, and it is recommended that they should be encouraged to do so. Departmental advisory committees are usually appointed for each major discipline studied at a college, and these should consist of experts from industry or commerce, members of the governing body and the teaching staff and representatives of the appropriate professional body. They may also include H.M. Inspectors and should have room for co-opted independent experts. Close links between the advisory committees and the governing body are essential, but the constitutional position of advisory committees will vary according to the subject, and in fields which are undergoing continuous change, the establishment of permanent advisory committees may be advisable.

SOUTH-EASTERN UNION OF SCIENTIFIC SOCIETIES

THE South-Eastern Union of Scientific Societies held its sixty-fifth annual congress in Ipswich, during April 22–25, under the presidency of the Earl of Cranbrook. The headquarters of the congress was at Ipswich School, where an exhibition of natural history was on display. A young naturalists' evening was arranged and questions from the audience were answered by a panel under the chairmanship of Maxwell Knight. Lord Cranbrook's presidential address to the Union was on "East Anglian Mammals", and he began by explaining that most of the area is highly cultivated, therefore the habitats are largely man-made. The red deer in East Anglia are possibly the progeny of escapes of those introduced from Scotland and are larger than those of the same species in Scotland, the increased size being due to an environmental change. Introduced roe deer are now flourishing in the Breckland.

Dealing with the seal population he said that both common and grey species occurred, a colony of grey seals being established during 1958 on Grove Sands, off Yarmouth, which are dry at the high-water mark. Ringing experiments are being made for recording movements of individuals, breeding places and the months on which the young of different species are born.

Lord Cranbrook said that for some obscure reason there appeared to be a natural barrier on the Essex-Suffolk border which prevented a number of mammals from crossing to suitable habitats in Norfolk and Suffolk. The distribution of the dormouse, horse-shoe bat and grey squirrel is limited to the south of the Stour valley although the red squirrel is abundant in the coniferous woods of the Breckland. Coypu numbers increase and the animal has become a nuisance, damaging farm crops and banks of ditches and streams. Scientific investigation is necessary to find the steps to be taken for control. Defending the policy of the Forestry Commissioners in planting mainly conifers, he said that pine forests are useful for the preservation of mammals, badgers are increasing in numbers, and the pine marten, which is increasing its range, may be expected to reach the area in the near future. The question of the black rat race in the Fens needs careful consideration; there appears to be two varieties common in the south and east of England and their control may be necessary. He concluded his address by comparing the growth of teeth of the field and water voles. In the former the teeth continue to grow throughout their life, as much as 2½ in. a year, a corresponding amount being worn away by the hard food they consume. In the case of the water vole the teeth cease to grow when the animal is adult, calification then aiding the resistance to wear.

The presidential address to the Archæological Section was given by Mr. N. Smedley on "Archæology in Suffolk". Speaking on the early investigators he mentioned the finding of an Acheulean implement by John Frere in 1797 and the scepticism with which the suggestion of man's existence before the present world conditions was received. He traced the development of the beaker pottery forms through the neolithic, bronze and iron ages. Roman times in Suffolk showed a specialized form of kiln with no raised floor during firing. Mr. Smedley had supervised the reconstruction of a kiln of this type to prove the possibility of obtaining the necessary draught and temperature for the baking of clay vessels.

Mr. F. W. Simpson gave the presidential address to the Botanical Section, his subject being "Changes in the Suffolk Flora during the Past 100 Years". He emphasized the need for the conservation of habitats, pointing out that since Henslow's Flora was published in 1860 about 75 natives had become extinct, another 40 will soon be gone and others are in danger of such a fate. This is largely due to suitable habitats being reduced by human development for building purposes. The introduction of aliens may increase the number of species, and for an understanding of the general situation it is important that records of first and last appearances of species should be kept.

An appointment in America prevented Dr. R. G. West from delivering his presidential address to the Geological Section in person, but a recording was available on "Investigating Glacial and Interglacial Geology in East Anglia". Three methods have been used in the determination of the relations of the deposits: tracing the origins of the boulders by the identification of the materials; the study of the orientation of the boulders by the alignment of the long axes in undisturbed deposits; pollen analysis, the size and pattern of the pollen showing the genera and sometimes the species present, so from the vegetational sequence a climatic one could be deduced. Four main glacial periods may be correlated by these methods, the oldest Cromerian, followed in turn by Lowestoft, Gipping and Hunstanton. Implements occurs throughout, the most prolific deposit being the Hoxnian, between the Lowestoft and Gipping glaciations, where Acheulean specimens occur in a deposited brick-earth in conditions at least as warm as at the present time, the pollen grains including pine, birch and oak.

Mr. S. Beaufoy chose for his presidential address to the Zoological Section the subject of "Some East Anglian Butterflies". Illustrating his address with coloured slides of outstanding merit, he commenced by confirming the opinion that a natural boundary appeared to prevent species, including the Speckled Wood and Chequered Skipper butterflies, from occurring in Suffolk although recorded in adjacent Essex. The life-history of the Swallowtail, was described, a British sub-species occurring in Norfolk, the caterpillars feeding on wild carrot and, also, readily taking the leaves of the cultivated variety. The Silverwashed Fritillary is fairly common in woodlands, the eggs being deposited on moss during July and August, the caterpillar's first meal being its egg shell. It then hibernates and nothing more is eaten until the following spring when, by feeding on violet leaves, it completes its larval stage. The White Admiral, quite common in parts of East Anglia, deposits its eggs on honeysuckle, the caterpillars feed for about three weeks and then hibernate throughout the winter. The Purple Emperor was last recorded in 1919, the Large Tortoiseshell has become rare and an attempt to reintroduce the Large Copper has not been entirely successful.

Mr. J. E. Marston, the local secretary responsible for the arrangements of the congress, gave an illustrated talk on "Suffolk Ponds and Pond Animals". Tracing the life history of the mayfly he said that, although the life of the adult did not exceed 24 hr., the nymph takes three years to develop to this stage. The speaker wished for a full investigation into the breeding habits of the freshwater shrimp; preliminary researches at Belstead House have yielded some unexpected results.

Favourable weather conditions enabled the full programme of excursions to be carried out. The archæologists visited Little Wenham Hall, Earl Stonham church and Helmingham Hall. As a prelude to Mr. Smedley's lecture a visit was made to Christchurch Mansion under his direction. The botanists made an excursion to study the early spring flora of the heaths of East Suffolk and the coast, at Woodbridge, Shingle Street, Butley and Chillesford. The geologists were conducted around the quarries at Great Blakenham and Creeting St. Mary to view sections revealing the effect of moving ice-sheets during the Glacial periods.

The general excursion was to Flatford Mill Field Study Centre, where the warden, Mr. F. J. Bingley, conducted the party around the house and grounds, explaining the aims and work of the Field Study Council.

The sixty-sixth annual congress of the Union will be held next year, during May, at Haslemere.

F. J. Epps

ACTINOMYCIN

During March 31–April 1 a conference was held, under the auspices of the New York Academy of Sciences, on "The Actinomycins and Their Importance in the Treatment of Tumours in Animals and Man". The conference consisted of three sessions concerned with: "Microbiological and Chemical Aspects", "Pharmacology and Experimental", and "Clinical". Prof. Selman A. Waksman was the general chairman of the sessions.

Actinomycin was discovered in 1940 in the laboratories of the Soil Microbiology Division of the New Jersey Agricultural Experiment Station, Rutgers University. It was isolated from a culture of an actinomycete, later described as *Streptomyces antibioticus*. Since then, numerous other forms of actinomycin have been isolated throughout the world. The first was designated as A, and the subsequent ones as B, C, D, X, etc. Each of these consists of several chemical entities. Nearly fifty letters, numbers and subscripts have been used to designate the various entities. To clarify the nomenclatural problem, it has been suggested that names be applied to the various preparations only after the chemical constitution of each new form has been elucidated.

The actinomycins are produced by a variety of different species of *Streptomyces*. They represent a group of chromopeptide antibiotics which differ only at one site in the peptide portion of the molecule. The nitrogen source supplied to the medium influences greatly the quantitative and qualitative composition of the actinomycins. The chemical composition of the actinomycins can be controlled during biosynthesis, notably through the addition of sarcosine, pipecolic acid, valine, *iso*leucine, and certain other amino-acids to the medium. The chemistry of the actinomycins was reviewed by Prof. A. W. Johnson, of the University of Nottingham, and Prof. Hans Brockmann, of the University of Göttingen.

All the actinomycins contain the same chromophore group, which has been identified as 2-amino-4 : 6-dimethyl-3-phenoxazinone-1 : 9-dicarboxylic acid. The structural differences among the various actinomycins make for differences in their antimicrobial, cytostatic and toxic properties; but there appears to be limited differences in their therapeutic indices against animal tumours and lymphogranulomatosis. An attempt was therefore made to obtain actinomycin derivatives with better therapeutic indices, by means of chemical alterations in the chromophore or peptide portions of the actinomycins. Structural changes in the actinomycin chromophore may be accomplished if one exchanges the amino-grouping of the chromophore for chlorine, and if the resulting chloro-actinomycin is then made to react with primary or secondary amines, or with other compounds which contain amino or imino groups. Brockmann reported total synthesis of actinomycin C_3, identical in chemical and biological behaviour with the natural preparations.

Among the various actinomycin preparations tested upon animals and in clinical medicine, C (the German preparation) and D (the American preparation) received the greatest attention at the conference. The Sloan–Kettering group reported that fatal intoxication with actinomycin D, following supralethal doses which caused death in less than 24 hr., might possibly be due to extensive damage of the intestinal epithelium allowing entrance of an endotoxin or a toxic polysaccharide into the blood stream. The antibiotic, at the LD_{50} dose, induces extreme hypoplasia in the bone marrow. Neutrophilic granulocytosis is the usual finding; the short survival period is probably insufficient time to reflect the full consequence of destruction of bone marrow. Changes in the lymphoid tissues are presumably direct actions of actinomycin D, since they can be observed in adrenalectomized as well as in normal rats. Actinomycins D and F_1 produce about the same increase in survival time (less than 100 per cent) when tested against a variety of leukæmias. Actinomycin F_1 is active against spontaneous mammary cancer of mice, whereas actinomycin D is without effect. The majority of the 32 actinomycin derivatives tested have little effect against the leukæmias.

A group from the Institute of Microbiology of Rutgers University reported that the antitumour effects of actinomycins II, III and IV have been studied in four ascitic tumour systems. The intraperitoneal therapeutic index of actinomycin II was found to be twice that of actinomycin IV and 4-fold that of actinomycin III in the Gardner lymphosarcoma system. The effective dose chosen for this calculation was the minimal amount producing a 100 per cent increase in survival time. The maximal effect of the actinomycins was attained with a total dose ranging from 1/15 to 1/40 of the LD_{50} dose, when the actinomycins were administered intraperitoneally for three successive days. The group from the Children's Hospital (Boston) reported that the most striking effects on transplanted tumours in mice were produced on the *S*91 melanoma, *P* 1534 lymphatic leukæmia, *DBRF* mammary adenocarcinoma, and the Ridgway osteogenic sarcoma. A synergistic effect with actinomycin D and radiotherapy has been demonstrated in mice bearing the Ridgway osteogenic sarcoma, as well as on normal mouse skin. A variety of heterologous tumours, including human cancers, have been grown in hamsters and afterwards treated successfully with actinomycin D.

The work of the Bayer group in Germany with actinomycin C and other preparations were reported by Dr. C. Hackmann. In tissue-culture studies using HeLa cells, morphological changes of the nucleoli occur which are characteristic of the actinomycins. These changes have not been observed so far with other antitumour agents.

Clinically, when used alone or in conjunction with radiation, actinomycin D has produced objective remission of varying duration in a limited number of cancers. Regression of tumour-size as well as disappearance of metastatic lesions (especially pulmonary) may last for a few weeks to several years (up to five). The tumours which have thus far been found sensitive to actinomycin D are: Wilms's tumour, rhabdomyosarcoma, Ewing's sarcoma, chloriocarcinoma of testis and uterus, lymphomas (Hodgkin's disease and lymphosarcoma), and bronchogenic carcinoma. Of these 'responsive' tumours, the most extensively studied has been Wilms's tumour. The greatest proportion of regressions occurred in this group of patients. With the other tumours considered to be sensitive, a smaller number showed adequate results. Responses in children are more favourable than in adults.

Actinomycin is capable of reactivating, in distribution and amount, the skin and mucous membrane reactions produced by initial irradiation. When used during the course of irradiation, actinomycin can also cause severe reactions. This potentiating effect of actinomycin D must be considered when combination therapy is contemplated. Doses of X-ray and actinomycin D must be adjusted and scrupulous care taken to exclude all normal tissues possible from the radiation beam. Most, if not all, of the patients treated with actinomycin show one or more toxic manifestations, all of which are reversible when the drug is discontinued. The severity of toxicity varies markedly, being only partly dependent upon the dose of drug. Toxicity usually does not become apparent until 2–4 days after the course of actinomycin D is stopped, and may not be maximal before 1–2 weeks have elapsed. Nausea and vomiting, however, occur within several hours after administration.

Actinomycin C has an almost selective cytostatic effect on lymphatic tissue. Its clinical use is limited therefore to Hodgkin's disease and chronic lymphatic leukæmia. In Hodgkin's disease, Begemann reported that remissions occurred in 22 of 54 patients whose disease was far advanced and refractory to other treatment, and in 19 of 38 patients who were responsive to other forms of therapy (in whom actinomycin was used in combination with X-rays and other drugs). Remissions, however, are short-lived. Because actinomycin C does not produce depression of the bone marrow, it is particularly suited for therapeutic trials in patients with aleukæmic forms of Hodgkin's disease or chronic lymphatic leukæmia. Although bone-marrow depression does not occur, actinomycin C also produces gastrointestinal, dermatological, neurological, and soft tissue toxicity including: nausea, vomiting, diarrhœa, loss of feeling of well-being, gingivitis, stomatitis, glossitis, alopecia, polyneuritis, and irritation of veins and thrombophlebitis.

U.S NATIONAL ACADEMY OF SCIENCES

ELECTIONS TO MEMBERSHIP

AT the recent annual meeting of the U.S. National Academy of Sciences, Dr. Lloyd V. Berkner, president of Associated Universities, Inc., in New York City, was elected to a four-year term as treasurer of the Academy. Prof. G. Evelyn Hutchinson, Sterling professor of zoology, Yale University; and Dr. Robley C. Williams, professor of virology and research biophysicist, University of California, were elected members of the Council of the Academy in succession to Dr. Frederick Seitz and Dr. Harry L. Shapiro.

Also at this meeting, thirty-five new members were elected as follows:

Prof. H. L. Anderson, director of the Enrico Fermi Institute for Nuclear Studies;

Dr. A. V. Astin, director of the U.S. National Bureau of Standards since 1952;

Prof. N. Bloembergen, professor of applied physics, Harvard University;

Prof. A. T. Blomquist, professor of organic chemistry, Cornell University;

Prof. H. G. Booker, professor of electrical engineering, Cornell University;

Prof. A. C. Braun, professor of bacteriology, Rockefeller Institute;

Prof. O. Chamberlain, professor of physics, University of California;

Prof. N. R. Davidson, professor of chemistry, California Institute of Technology;

Prof. W. Feller, Higgins professor of mathematics, Princeton University;

Dr. Herbert Friedman, superintendent, Atmosphere and Astrophysics Division, U.S. Naval Research Laboratory.

Dr. R. Galambos, chief of the Department of Neurophysiology, Walter Reed Army Institute of Research;

Prof. M. Gell-Mann, professor of theoretical physics, California Institute of Technology;

Prof. D. R. Griffin, professor of zoology, Harvard University;

Prof. H. S. Gutowsky, professor of physical chemistry, University of Illinois;

Prof. B. Haurwitz, professor of astro-geophysics, University of Colorado;

Prof. H. D. Hedberg, professor of geology, Princeton University;

Prof. K. F. Herzfeld, professor of physics and head of department, Catholic University of America, Washington, D.C.;

Prof. C. I. Hovland, Sterling professor of psychology, Yale University;

Dr. R. J. Huebner, chief of the Laboratory of Infectious Diseases, U.S. National Institute of Allergy and Infectious Diseases;

Dr. A. B. Kinzel, vice-president in charge of research, Union Carbide and Carbon Corporation;

Prof. S. E. Luria, professor of microbiology, and chairman, Microbiology Committee, Massachusetts Institute of Technology;

Prof. D. Mazia, professor of zoology, University of California at Berkeley;

Prof. S. Moore, professor of biochemistry, Rockefeller Institute;

Prof. T. T. Puck, professor of biophysics and head of department, University of Colorado Medical School;

Prof. R. W. Sperry, Hixon professor of psychobiology, California Institute of Technology;

Prof. W. H. Stein, professor of biochemistry, Rockefeller Institute;

Prof. W. S. Stone, professor of zoology and director of gene research, University of Texas;

Prof. G. J. Stork, professor of chemistry, Columbia University;

Dr. R. N. Tousey, head of the Rocket Spectroscopy Branch, Atmosphere and Astrophysics Division, U.S. Naval Research Laboratory;

Prof. J. B. Wiesner, director, Research Laboratory of Electronics, Massachusetts Institute of Technology;

Prof. G. R. Willey, Bowditch professor of Central American and Mexican archæology, Harvard University;

Prof. C. M. Williams, professor and chairman, Department of Biology, Harvard University;

Dr. O. C. Wilson, astronomer, Mount Wilson and Palomar Observatories;

Prof. C. N. Woolsey, Charles Sumner Slichter research professor of neurophysiology, University of Wisconsin;

Prof. A. Zygmund, professor of mathematics, University of Chicago.

'EIDOPHOR' TELEVISION TECHNIQUE

A DEMONSTRATION of the 'Eidophor' system of projection television was given during the week beginning May 2 by Messrs. Ciba Clayton, Ltd., at Belle Vue, Manchester. A studio was set up in the technical service laboratories, and the programme was transmitted 'live' a distance of 1½ miles to Belle Vue by micro-wave link. The aim was to demonstrate the use of the new system to enable lecture demonstrations to be given to very large audiences. The organizers are to be congratulated; it was a most impressive demonstration.

The essential feature of the 'Eidophor' system is a special cathode-ray tube which modulates a beam of light derived from a high-power xenon arc. In principle, therefore, the limit to the size of screen used and the brightness of the picture is set only by the light output of the lamp, and not, as in most other systems, by the characteristics of the phosphor of a projection tube. A screen of up to about 800 sq. ft. may be used for black-and-white projection with the system in its present state of development; there is necessarily some diminution in brightness in colour television, but even then screens up to about 200 sq. ft. may be used.

It is not proposed to describe in detail the technical aspects of the system except to comment first on its extreme ingenuity, and secondly, on the skill and patience which must obviously have been used in its perfection. The 'modulator' is a mirror over which a thin film of oil is continuously re-formed. The thickness of the oil film is controlled by the electric charge pattern on its surface, and this in turn is controlled by the cathode-ray beam. The variations in thickness are used to control the intensity of the light from the source. The idea is simple in conception, but there are considerable technical difficulties that have had to be surmounted. The 'Eidophor' projector may be fed by signals from a broadcasting network or from a closed-circuit link. The large amount of light available makes possible the use of a simple frame-sequential colour system, and the demonstration at Belle Vue was of this kind. An ordinary television camera is used to provide the signals, but a three-colour rotating filter is mounted in front of the lens. A similar rotating filter—synchronized by special signals—rotates in front of the light source in the projector. The rate of frame repetition is 75 per sec., so that a complete set of three coloured images is transmitted in the normal frame-time of one-twenty-fifth of a second. The colour quality—though not perfect—was quite adequate for technical demonstrations.

A series of short lectures was given, starting with a technical description of the 'Eidophor' by Arthur Garratt and followed by three or four demonstration lectures of dyeing processes and techniques, including paper chromatography. After the lectures the audience was invited to ask questions, and these were answered from the studio over the television link. It was this last feature that demonstrated most clearly the fascinating possibilities of large-screen television. As research becomes more and more concerned with complex apparatus, so lectures with demonstrations become more and more difficult except for very small audiences. A really good colour projector would make it possible for a large audience to see and hear lectures with the same comfort as a single person ; it is possible, of course, to use close-up techniques and even to transmit the images from microscopes and other optical instruments. The 'Eidophor' system brings this idea into the realms of possibility, though as yet, of course, the number of projectors available is small and their cost relatively high.

The demonstration at Belle Vue involved the transportation of two large van-loads of equipment and a team of Swiss experts to Britain, and clearly involved a great deal of work for the organizers ; the result certainly justified the effort. C. A. TAYLOR

INSECTS AND LENGTH OF DAY

STANLEY D. BECK, of the University of Wisconsin, has studied the effect of temperature on the hibernation of the European corn borer, a species of moth that passes the winter not as an egg but as a mature larva (*Sci. American*, 202, February 1960). The corn borer is a long-day insect. Generation after generation can be reared in the laboratory if the cultures are maintained under any of three different conditions : 16 hr. of light a day, continuous darkness or continuous light. In the absence of suitable photoperiod—that is, in continuous light or darkness—temperature has only a slight effect on the incidence of hibernation. Similarly, if a batch of borer larvæ are exposed to short photoperiods of 10·5–13·5 hr. of light a day, they will go into diapause regardless of the temperature at which they are reared. At photoperiods of 8–10 hr. and 14–15·5 hr., however, temperature exerts a powerful influence on the incidence of hibernation : high temperatures tend to prevent it and low temperatures to increase it.

This sensitivity to temperature is important in the life-cycle of the borer. It explains why two generations of them are produced each season in southern corn-growing areas, while only one generation is produced in northern areas. If photoperiod were the only factor governing their reproduction the opposite would be expected, because on any given day in summer the period of daylight is shorter in the south than in the north. The higher temperatures of the earlier southern growing-season, however, more than compensate for the shorter days.

In contrast to the silkworm and the aphid, which are sensitive to photoperiod only in the early stages of development, the borer remains responsive for a longer time. Present evidence indicates that it becomes sensitive in the later stages of larval development or is uniformly sensitive throughout the entire period of growth.

Photoperiod affects members of the growing generation of corn borers but not their progeny. There is no carry-over to the next generation as in the silkworm and the aphid. In the corn borer the earliest detectable symptom of impending diapause is a failure of the reproductive organs to develop. At a stage when the sex cells are rapidly maturing in borers reared under long photoperiod, these cells have ceased to develop in larvæ reared under short photoperiods. The short-photoperiod borers still feed and grow rapidly, but the growth of their reproductive organs is arrested. Similar gonadal arrest has been observed in a number of other species of hibernating insects, including such diverse types as boll weevils and Colorado potato beetles.

In insects, as in higher animals, growth and gonadal development are controlled by hormones. The insect growth-hormone has been identified as ecdysone, which is produced by glands in the insect's thoracic tissue. Insects in diapause contain no detectable amounts of ecdysone, but if they are injected with it, they soon resume normal development. It appears that the change in photoperiod inhibits the production of ecdysone. How this inhibition is brought about is not known. Perhaps a diapause hormone is responsible, especially in forms like the aphid and silkworm. If this is so, the insects must be sensitive to the hormone only at certain times during their lives.

Another unresolved issue is the nature of the timing mechanism that enables an insect to distinguish between a 16-hr. photoperiod and one of, say, 12 or 13 hr. A light receptor is required, because the insect must discriminate between light and dark to respond to photoperiod at all. Apparently the eyes are not involved, and the shielding of different parts of the insect's body has not located any other organ or nerve ending that is specially sensitive to photoperiod. All parts of the body seem equally sensitive. It now seems likely that the receptors are either numerous cells scattered over the body surface, or that they are the cells of the integument itself.

The quantity of light involved has little to do with the photoperiod reaction, so long as the intensity is greater than a very low threshold value—usually less than 1 ft.-candle. This suggests that no photochemical reaction is involved; for the rate of most photochemical processes increases with greater light intensity. It is possible that a small-scale photochemical reaction may act as a trigger; in that case the most important cause of the photoperiod response would not be the presence or absence of light, but the stimulus produced by the change from light to dark, and vice versa. Each 24-hr. day involves one change of light to dark, and one change from dark to light, but these changes can provide no more than a series of stimuli that start a biological switch. Because different day-lengths induce different responses, the switch presumably activates the biological clock. The clock measures the changing interval between stimuli and regulates the physiology of the insect accordingly.

The existence of such a clock can easily be demonstrated in the European corn borer. When a batch of borers are reared under photoperiods of 12 hr. of light and 12 hr. of darkness, all of them go into hibernation. The ratio of light to dark in this case is one to one. When an artificial 12-hr. day is created with a one to one ratio of six hours of light and six hours of darkness, none of the borers hibernates. A 'day' of at least eight hours of darkness is apparently required to induce hibernation.

PAPER CHROMATOGRAPHY: MULTIPLE SPOT FORMATION BY PURE SUBSTANCES

By Dr. A. H. BECKETT, M. A. BEAVEN and Dr. ANN E. ROBINSON
School of Pharmacy, Chelsea College of Science and Technology, London

PURE pharmacologically active amines give more than one spot on paper chromatograms in the presence of certain acids (unpublished observations). Because this phenomenon lacked rationale and has important implications in relation to metabolic studies, we have examined the paper chromatographic behaviour of some amines and amine salts in detail. Using acidic (and neutral) solvent systems, we have shown that double amine spot formation on paper chromatograms is dependent on three major factors: the relative R_F values of the individual acids and bases of the salt, the relative concentrations of the acids and bases and the relative dissociation constants of the added acid and that present in the solvent system.

The chromatographic behaviour of monoacidic amines in a water-saturated *n*-butanol–acetic acid solvent system is summarized as follows: a single amine spot, having an R_F value similar to that of the free base, is obtained when weak acid salts (for example, propionates, mandelates, citrates) of many amines (for example, adrenalin, codeine, amphetamine, propylamine) are chromatographed. With an organic acid salt, in which the organic acid has a low *pKa* (less than 1) and a high R_F value (for example, trichloracetic acid *pKa* 0·65, R_F 0·90), two amine spots are obtained unless the amine and acid have similar R_F values (for example, chlorpromazine trichloracetate, R_F of the base 0·92) or the amine is very insoluble in water (for example, analgesics based on the piperidine structure[1]). Of the two amine spots, one has an R_F value corresponding to that of the free base while the other is associated with the acid spot. The position of the latter amine spot is dependent upon the R_F value of the acid. Thus, the separation of the amine into two spots and their relative positions is dependent on the relative R_F values of the components. The results for various amine trichloracetates are represented diagrammatically in Fig. 1.

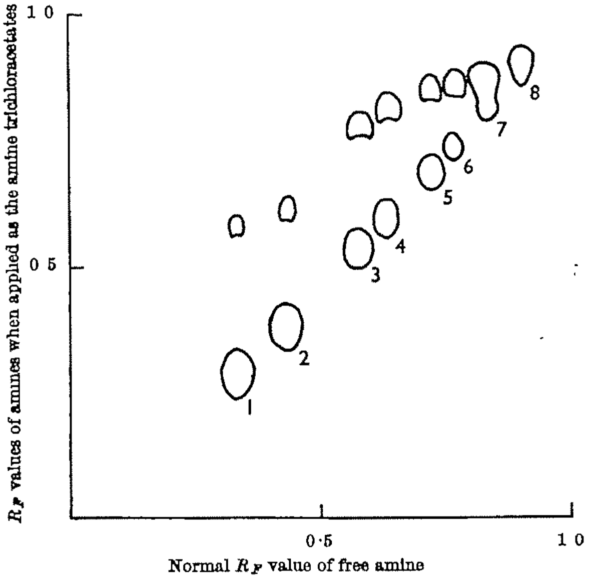


Fig. 1. Chromatograms of amine trichloracetates (about 20 μgm.) run in *n*-butanol–acetic acid–water (4 : 1 : 5) on Whatman No. 1 paper. Tailing is not shown. 1, noradrenalin; 2, adrenalin, 3, propylamine and codeine; 4, tyramine, 5, β-phenylethylamine; 6, ephedrine and amphetamine; 7, papaverine; 8, chlorpromazine

With salts showing double amine spot formation, chromatography of the salt in the presence of an excess of the acid results in a greater proportion of the base becoming located in the spot associated with the acid. A single amine spot is obtained if a sufficient quantity of acid is used, the amount of acid required being dependent on the difference between the R_F values of the individual components. However, amines of low R_F value (for example, noradrenalin and adrenalin, R_F 0·34 and 0·42) always formed two amine spots in the presence of trichloracetic acid even using a twenty molar excess of the latter. Increasing the acid concentration also results in the R_F value of the amine spot associated with the acid approaching that of the free acid, whereas the R_F value of the second amine spot (if still present) is analogous to that of the free base.

Tailing between the two base spots was most marked where the R_F values of the components were widely separated and with the salts of weaker acids. It became less obvious if smaller amounts of the amines were applied to the paper when discrete spots may be obtained, that is, the detection of tailing is a function of reagent sensitivity.

Salts of bases and organic acids in which the R_F value of the free base is greater than that of the free acid yield a single amine spot associated with the acid, unless the R_F values of the components are widely separated (for example, N-phenethyl 3-methyl 4-(*o*-tolyl)4-acetoxypiperidine trichloracetate R_F of the base is 1·0) when complete acid/base separation occurs. Examples are ephedrine maleate (R_F 0·77; ephedrine, R_F 0·76; maleic acid, R_F 0·71) and ephedrine picrate (R_F 0·88; picric acid, R_F 0·74). In contrast, propylamine maleate yields two amine spots (R_F 0·56 and 0·67 with tailing in between; propylamine, R_F 0·59).

Although double amine spot formation depends partly upon the relative dissociation constants of the acids present in the salts and in the solvent, the proximity of the R_F values of the acids and bases is the governing factor with the salts of weaker organic acids (*pKa* values of 1–3). If the difference between the R_F values of the acids and bases is small, two amine spots are obtained (for example, propylamine, isoprenaline and phenylethylamine dichloracetates, R_F values of the bases are 0·59, 0·60 and 0·73, respectively, and the R_F value of dichloracetic acid is 0·83. Complete separation of the base from the acid, with consequent single amine spot formation, occurs if the R_F values of the acid and base are widely separated (for example, noradrenalin and adrenalin dichloracetates).

The shapes and R_F values of amine spots are modified by inorganic acids such as sulphuric and hydrochloric acids (R_F 0·39 and 0·38, respectively). Elongated amine spots are produced by the sulphates and hydrochlorides of noradrenalin and adrenalin; the acid spots overlap those of the bases. Using excess of sulphuric acid but not hydrochloric acid both these substances formed spanner-shaped amine spots; the acid was located in the cup and also overlapping the base of the amine spot. Amines of intermediate R_F values (for example, propylamine) formed inverted crescent-shaped spots at the base of the main acid spot in the presence of an excess of a mineral acid. Complete acid/amine separation occurred with the sulphates and hydrochlorides of phenylethylamine and atropine (R_F 0·78) and normal amine spots were obtained. In contrast, phenylethylamine and ephedrine dissolved in an excess of trichloracetic acid produced crescent-shaped amine spots at the apices of the acid spots while, under the same conditions, codeine (R_F 0·57) and isoprenaline appeared as half-moon-shaped spots in the upper area of the acid spots.

Ghost spots[2] were observed with all phenolic amines in the presence of excess of any of the stronger acids.

In a neutral solvent system (water-saturated *n*-butanol) *all* except the more volatile acids profoundly affected the R_F values of the amines; acid/base separation of the salts occurred, but to a lesser extent than in the acidic solvent. If the R_F values of the base and acid were close (and the R_F value of the latter was greater than that of the former) one amine spot, associated with acid, was detected having an R_F value similar to that of the acid. With a greater difference between the R_F values of the individual components two amine spots were produced, whereas, with widely varying R_F values, complete acid/base separation occurred and a single amine spot was observed.

Using a basic solvent system (water-saturated *n*-butanol–ammonia) the R_F values of the amines, as expected, remained unchanged in the presence of any of the acids tested.

Multiple spot formation is not necessarily indicative of the presence of different substances. The present work re-emphasizes that reference substances and unidentified materials must be chromatographed under identical conditions, if valid deductions are to be drawn. This is particularly important with amines in biological extracts which may also contain certain organic acids, or to which trichloracetic acid has been added. Even when free bases are liberated with alkali and extracted and chromatographed, the presence of trace amounts of acid or salts carried over during extraction can cause multiple spot formation from single substances. Similar remarks also apply to the chromatographic examination of acids in basic solvents.

Thus the chromatographic investigation of the metabolism of basic drugs may readily yield more spots than there are metabolites if strongly acidic compounds are also products of metabolism. The addition of bases (for example, ephedrine) to urine, for example, may yield more than one base spot in neutral running solvents because of the presence of acids.

This and related work with other systems will be described in detail elsewhere.

[1] Beckett, A. H., Casy, A. F., and Kirk, G., *J. Med. Pharm. Chem.*, 1, 37 (1959).

[2] Hanes, C. S., and Isherwood, F. A., *Nature*, 164, 1107 (1949).

DISPROPORTIONATION AND DIMERIZATION OF THE BENZYLOXYL FREE RADICAL IN SOLUTION

By DR. J. B. de SOUSA
University of Malaya in Kuala Lumpur

AND

S. K. HO
University of Hong Kong

ALTHOUGH the mutually competitive processes of disproportionation (1) and dimerization (2) of alkoxyl radicals:

$$2R\text{CH}_2\text{O}\cdot \longrightarrow R\text{CHO} + R\text{CH}_2\text{OH} \qquad (1)$$

$$2R\text{CH}_2\text{O} \longrightarrow R\text{CH}_2\text{O—OCH}_2R \qquad (2)$$

have been much discussed from the thermochemical point of view[1,2] actual evidence in support of (1) and (2) is somewhat scanty.

Disproportionation for various alkoxyl radicals is regarded as a highly exothermic process. Gray[1] has assigned enthalpies in excess of 80 k. cal. mole^{-1}, and activation energies are expected to be very small or zero. Reaction (1) has been postulated to explain certain features of the decomposition of diethyl peroxide in presence of ethyl nitrite and nitric oxide[3]. The presence of benzaldehyde in the decompositions of benzyl nitrite and dibenzyl hyponitrite in solution has been considered by Gray[1] as evidence for disproportionation. However, this must await a kinetic study in order to ascertain the importance of induced reaction which may also yield benzaldehyde by the following reactions :

$$\left.\begin{array}{ccc} R\cdot + \mathrm{PhCH_2O{-}N = N{-}OCH_2Ph} & & R\mathrm{H} + \mathrm{PhCHO{-}N = N{-}OCH_2Ph} \\ \text{or} & \longrightarrow & \text{or} \\ \mathrm{PhCH_2O{-}N = O} & & \mathrm{Ph{-}\dot{C}HO{-}N = O} \end{array}\right\} \quad (3)$$

$$\left.\begin{array}{ccc} \mathrm{Ph\dot{C}HO{-}N = N{-}OCH_2Ph} & \longrightarrow & \mathrm{PhCHO + N_2 + PhCH_2O\cdot} \\ \mathrm{Ph\dot{C}HO{-}N = O} & \longrightarrow & \mathrm{PhCHO + NO} \end{array}\right\} \quad (4)$$

Wijnen[4] has considered evidence for disproportionation of methoxyl radicals in the photolysis of methyl $- d_3$ acetate at 30° and 90°.

At these comparatively low temperatures no evidence to support reaction (2) was available. Evidence for dimerization in solution is quoted for the 2-phenyl propan-2-oxyl radical by Gray[1] and Walling[5]:

$$2\mathrm{Ph{-}C(Me)_2 - O\cdot} \longrightarrow \mathrm{(Ph{-}CMe_2{-}O)_2} \qquad (5)$$

The work actually referred to is that of Kharasch *et al.*[6], who themselves doubt whether the peroxide is formed by dimerization. This case should be favourable to dimerization as competition from disproportionation is absent. Dimerization should be exothermic to the extent of 35–40 k. cal. mole^{-1}. The kinetics of thermal decomposition of dibenzyl hyponitrite in solution has been studied by us. The decomposition is first-order for at least 75 per cent of complete reaction. Induced reaction is, however, evident as the rates are lowered by presence of inhibitors such as quinones, and vinyl monomers. At sufficiently high concentration of *p*-benzoquinone the rate becomes independent of quinone concentration and the decomposition is first-order throughout the range of accurate observation (more than 90 per cent decomposition). The activation energy for this first-order decomposition is 24·9 ± 0·25 k. cal. mole^{-1}. This low value suggests a simultaneous rupture of both O—N bonds resulting in the elimination of a nitrogen molecule and the formation of two benzyloxyl radicals in a 'cage'[7]. Dibenzyl hyponitrite is known to polymerize methyl methacrylate[8]. We also have evidence to support radical intermediates in the decomposition of dibenzyl hyponitrite in solution :

$$\mathrm{PhCH_2O{-}N = N{-}OCH_2Ph} \longrightarrow 2\mathrm{PhCH_2O\cdot} + \mathrm{N_2} \quad (6)$$

Table 1. PERCENTAGE YIELD OF BENZALDEHYDE IN THE DECOMPOSITION OF DIBENZYL HYPONITRITE IN *cyclo*HEXANE AT 40° C.

Concentration of solution (mole/l.)	Per cent C_6H_5CHO
0 1000	65 34
0 0500	65 58
0 0100	57 38
0·00748	55 80
0·00500	53 15
0 00453	53·47
0 00399	53·50
0 00351	52 91
0·00301	53 95
0·00198	53 02
0 00149	51 29
0 00100	50·55
0 000500	50·29
0 000103	50 29

The products isolated from solutions were benzaldehyde (as 2 : 4-dinitrophenylhydrazone) and benzyl alcohol (as 3 : 5-dinitrobenzoate) in high percentage yields. In *cyclo*hexane solutions the benzaldehyde is readily detectable by its maxima at 240, 276 and 285·5 mμ. At 285 5 mμ benzaldehyde absorbs strongly (ε = 1,000) whereas benzyl alcohol absorption is negligible (ε = 2) and this maximum was used for quantitative analyses for benzaldehyde. As the induced reaction is a second-order reaction it should be less important at high dilutions whereas the 'cage' reactions are independent of concentration. A study of benzaldehyde yield for various concentrations is shown in Table 1.

The yield drops from 65 per cent at 0·1 *M* to 50 per cent at 0 001 *M* and remains stationary thereafter to the extreme dilution studied of 0·0001 *M*. The high and constant yield of benzaldehyde at high dilutions strongly supports the formation of benzaldehyde solely by a 'cage' disproportionation. A pair of benzyloxyl radicals formed in a 'cage' by decomposition of a molecule of dibenzyl hyponitrite may undergo disproportionation, dimerization or separate by diffusion. Benzaldehyde may thus be formed through a reversible fission of dibenzyl peroxide if any is formed. The half-life of dibenzyl hyponitrite at 35° in *cyclo*hexane is 2·46 hr.

Dibenzyl peroxide does not appear to be known ; it should have approximately the same half-life as comparable peroxides. In solution di-α-cumyl peroxide would have a half-life of 1·26 × 10^6 hr. at 35° (by extrapolation)[9]. Thus at 35° it would appear that benzaldehyde should be formed directly from the disproportionation of benzyloxyl radicals generated by the parent hyponitrite.

A study of the rate of appearance of benzaldehyde in *cyclo*hexane solutions using the 285 5 mμ maximum was attempted. The optical density increased rapidly though the kinetics were not strictly first-order. This may be due to the fact that dibenzyl hyponitrite has a small but finite absorption at 285 5 mμ (ε = 20). Half the final yield of benzaldehyde is formed in 2·75 hr. This compares with 2·46 hr. for the half-life of dibenzyl hyponitrite in *cyclo*hexane at 35°. After several half-lives at 35° the yield of benzaldehyde remains constant (Table 2).

Thus the yield after 96 and 151 hr. at 35° is the same (49 per cent), indicating that dibenzyl peroxide if present does not appear to give benzaldehyde in this

Table 2. BENZALDEHYDE ANALYSES (IN DUPLICATE) FOR 0 00076 *M* SOLUTIONS OF DIBENZYL HYPONITRITE IN *cyclo*HEXANE AFTER DECOMPOSITION

	Optical density			Per cent C_6H_5CHO
	Sample *A*	Sample *B*	Average	
96 hr. at 35°	0 378	0·374	0 376	49 01
96 hr. at 35° + 65 hr at 35°	0 379	0 373	0 376	49 01
96 hr. at 35° + 65 hr. at 100°	0·419	0 420	0 420	54 74

period of time. However, subjecting solutions which had undergone decomposition for 96 hr. at 35° to a further 65 hr. at 100° C. (where the calculated half-life of dibenzyl peroxide is 55 hr.) increased the yield of benzaldehyde by 5 per cent. The reverse of reaction (2) followed by disproportionation (1) is indicated.

It appears that benzyloxyl radicals undergo disproportionation and dimerization in a 'cage', and their relative rates may be thus studied. Experiments are being undertaken aimed at isolation of dibenzyl peroxide as well as detection, product and kinetic studies by gas chromatography and infra-red spectroscopy.

One of us (S. K. H.) is grateful to the Education Department, Hong Kong, for permission to participate in this work.

[1] Gray and Williams, *Chem. Revs.*, 59, 239 (1959); *Trans. Farad. Soc.*, 55, 770 (1959).

[2] Luft, *Z. Elektrochem.*, 60, 94 (1956).

[3] Steacie, "Atomic and Free Radical Reactions", 1, 240 (Reinhold, New York, 1954).

[4] Wijnen, *J. Chem. Phys.*, 28, 271 (1958).

[5] Walling, "Free Radicals in Solution", 505 (Wiley, New York, 1957).

[6] Kharasch, Nudenberg and Fono, *J. Org. Chem.*, 15, 753 (1950).

[7] Franck and Rabinowitsch, *Trans. Farad. Soc.*, 30, 120 (1934).

[8] Harris, Marshall and Jarrett, *Nature*, 159, 843 (1947).

[9] Bailey and Godin, *Trans. Farad. Soc.*, 54, 68 (1956).

SYNTHETIC POLYELECTROLYTES AS TUMOUR INHIBITORS

By Dr. WILLIAM REGELSON, STEPHAN KUHAR and MARVIN TUNIS

Roswell Park Memorial Institute, Buffalo, New York

AND

JOSEPH FIELDS, JOHN JOHNSON and EARL GLUESENKAMP

Monsanto Chemical Company, Dayton, Ohio

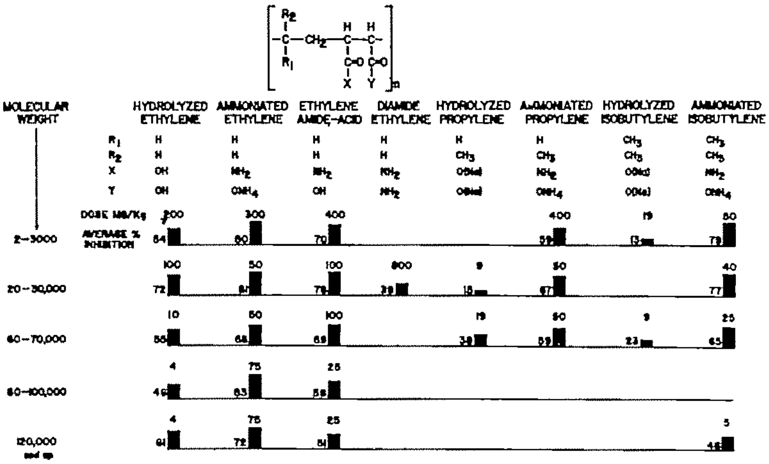
ANIONIC polysulphonates and polyphosphates of either natural or synthetic origin have been shown to be potent inhibitors of transplanted tumours in mice[1–4]. This inhibition of tumour growth may conceivably be a function of the density and distribution of ionic charges within the polyelectrolyte molecule. To test this hypothesis, the tumour-inhibiting properties of synthetic polymers of varied charge-densities were studied.

Two classes of synthetic polymers were chosen: polycarboxylates derived from ethylene/maleic anhydride copolymers and those derived from polyacrylic acid. (For convenience, in the ethylene/maleic anhydride copolymer (EMA) series, hydrolysed (free carboxyl) form is abbreviated HEMA and the ammoniated (amide-acid form) is noted as AEMA.) The charge-density and solution configuration of these compounds were varied over a wide range, by proper choice of substituents on the backbone of the molecule and by substitutions on the carboxyl groups. In the ethylene/maleic anhydride copolymers, functional groups are attached to immediately adjacent carbon atoms of the ethylene backbone, whereas in the polyacrylic copolymers functional groups are attached to backbone carbon atoms separated by a methylene unit. Because of this difference, the two classes of polymers differ in ion strengths as well as charge distribution. For each class of polymer two different series were studied: the free dicarboxylic acids and the carboxamide–carboxyl types, each in several molecular-weight ranges. The effect of these compounds on the growth of transplanted tumours in mice is reported in this article.

In most experiments, sarcoma 180 was the tumour used. Additional experiments were conducted with Krebs 2 carcinoma, leukæmia *L*-1210 and carcinoma 755, maintained and tested in appropriate host strains[5].

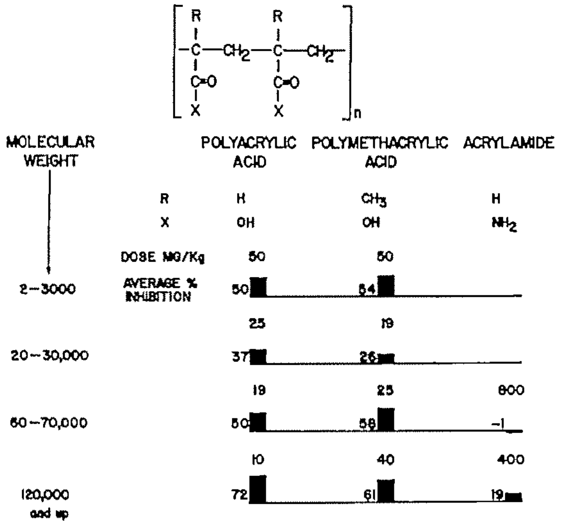
Sarcoma 180, Krebs 2 carcinoma or leukæmia *L*-1210 ascites tumour cells, grown for 5–7 days in the donor mouse, were injected subcutaneously into the flank of test animals as a 0·2-ml. suspension of approximately 5,000,000 cells. Non-necrotic solid sarcoma 180 or carcinoma 755 tumour, 6–14 days old when transplanted, was placed by trocar into the flank of the appropriate host as a fragment approximately 2 mm. in diameter. Solid tumour, derived from either solid tumour or subcutaneously placed ascites cells, responded in essentially the same manner to HEMA and AEMA. In all experiments, mice were uniform with respect to sex, age and weight. They were allocated at random 3–5 to a cage. Preliminary experiments in which several levels of the drugs were tested in groups of Swiss mice served to establish the minimal lethal dose of drug when given in six

Table 1. Ethylene/Maleic Anhydride Series (Hydrolysed Form)



INHIBITION OF SUBCUTANEOUS SARCOMA 180

Table 2. Polyacrylic and Polymethacrylic Series



INHIBITION OF SUBCUTANEOUS SARCOMA 180

daily doses. The final experimental groups consisted of a minimum of 10 mice.

Solutions of the compounds to be tested were prepared in isotonic saline and stored in the cold. If necessary, *p*H was adjusted to approximately 7 by titration with dilute sodium hydroxide.

Treatment consisted of a single daily intraperitoneal injection of 0·5 ml. of drug solution, beginning 24 hr. after tumour inoculation. Injections were given for 6 days and animals killed the eighth day after tumour inoculation. The same method was followed with carcinoma 755 except that the tumour was permitted to grow for 7 days prior to start of treatment. Each tumour was removed by dissection, weighed and compared with the tumour-weight of saline-treated control animals.

Experiments in which more than one-third of the treated animals died were not considered valid. Using this criterion of validity, consistent inhibition of sarcoma 180 from 50 to 83 per cent was noted in 41 consecutive experiments with AEMA of different molecular weights. In 19 of these experiments, no animals died. Thus, tumour inhibition is not necessarily a manifestation of non-specific toxicity. For the remaining 33 compounds, single experiments are presented. In 23 of these experiments, inhibition of sarcoma 180 tumour growth of 50 per cent or more occurred. Other experiments at different dose-levels with each of the 33 compounds confirm the general order of tumour inhibitory activity, usually with excessive toxicity when the dose was raised.

Body-weights were recorded at the beginning and end of each experiment. For all experiments, total gain in body-weight of the control mice averaged 3·9 gm. and that for the treated mice 1·9 gm. Loss of weight was found in only 8 out of 64 experiments where the inhibition of sarcoma 180 was 50 per cent or greater, and in only 3 of these experiments did the losses exceed 10 per cent of the pre-treatment weight.

Survival-time in mice bearing ascites tumour was determined after intraperitoneal inoculation of a uniform suspension containing approximately 2,000,000 ascites tumour cells. 24 hr. after tumour inoculation, AEMA or HEMA was given for six consecutive days either intraperitoneally or subcutaneously. Survival-time of these mice was contrasted with control mice treated in similar fashion with saline.

AEMA (mol. wt., 2–3,000 and 20–30,000) given intraperitoneally to mice with Ehrlich ascites tumour clone 2 or leukæmia *L*-1210 ascites and AEMA and HEMA (mol. wt., 20–30,000) given subcutaneously to mice with leukæmia *L*-1210 ascites and Krebs 2 carcinoma ascites did not increase survival-times.

Results in Tables 1 and 2 are presented as the average per cent inhibition of sarcoma 180 determined at dose-levels which range from just less than the minimal lethal dose to a dose which kills no more than one-third of the animals.

Table 1 includes the following maleic anhydride copolymers: the dicarboxylic acid–HEMA, the ammonium salt of AEMA, the amide-acid form of AEMA, the EMA diamide and hydrolysed and amidated propylene and *iso*butylene maleic anhydride. Molecular weights ranged in five groups from approximately 2,000 to 120,000 as estimated from measurements of solution viscosity. Where possible, each compound was tested for inhibitory activity in each of the five weight ranges.

It appears that at least one ionizable carboxyl group is required for the polymers to manifest significant tumour inhibition. The diamide of EMA showed a much lower order of both inhibitory activity and toxicity than HEMA or AEMA. Lethality of the dicarboxylic acid HEMA increased as the molecular weight increased up to 80–100,000. The dicarboxylic acid propylene and *iso*butylene copolymers tested were more toxic, and less active as tumour inhibitors against sarcoma 180 than the corresponding half-amide acid compounds.

Analogous results for polyacrylic acid, polymethacrylic acid, and polyacrylamide are presented in Table 2. In this series, also, the completely amidated product was not significantly effective as a tumour inhibitor and was much less toxic than carboxyl-containing compounds of similar molecular weight. In general, tumour inhibition by polymers of this series was similar to that of corresponding polymers of the series shown in Table 1. Based on the results obtained, the difference between the two series in position of carboxyl groups on the ethylene backbone does not alter greatly the tumour-inhibiting property of the compound.

Fig. 1 presents a comparison of the inhibiting action of low molecular weight (2–3,000) HEMA and AEMA against several tumours. At equivalent doses, monocarboxylic AEMA copolymer was effective against sarcoma 180, leukæmia *L*-1210, Krebs 2 carcinoma and carcinoma 755. Dicarboxylic HEMA

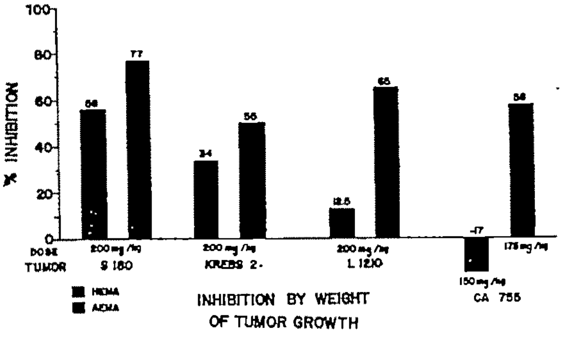


Fig. 1. Comparison of HEMA and AEMA 2–3,000 mol. wt. against a variety of transplanted tumours

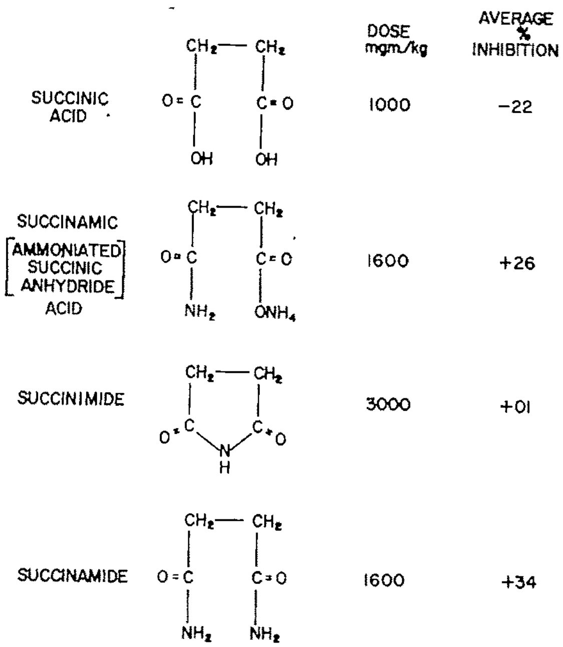


Fig. 2. Inhibition of sarcoma 180 by monomeric fragments of the ethylene/maleic anhydride series

copolymer inhibited only sarcoma 180. This same pattern of inhibition was observed for AEMA and HEMA in molecular weight ranges of 20–30,000 and 60–70,000. AEMA thus showed a broader spectrum of tumour inhibition than HEMA and is the more potent inhibitor of sarcoma 180 at equitoxic doses. (A comparative study with analogous derivatives in the acrylic acid series is being completed.)

The corresponding monomeric fragments of HEMA and AEMA such as succinic acid, succinamic acid, succinimide and succinamide, administered at levels of 1,000–3,000 mgm./kgm., did not show significant inhibitory activity against sarcoma 180 (Fig. 2). These results indicate the necessity for the polymeric structure in producing the observed tumour inhibition.

Tumour inhibition for the two polymer series reported (completely carboxylated and carboxyl–carboxamide types) was strongly dependent on carboxyl substitution, which varied molecular configuration in solution. Within each series, charge-density is one factor which may govern tumour-inhibiting effectiveness and toxicity.

Optimum activity was obtained in the series where carboxamide and ionizable carboxyl groups were interdispersed on the polymer backbone. When all carboxyl groups are converted to carboxamides, significant tumour inhibition was lost. In addition, proper carboxamide–carboxyl balance broadens the scope of activity against a variety of transplanted tumours. Within this series, amide-acids of either ethylene, propylene or *iso*butylene maleic anhydride copolymers exhibited equivalent tumour inhibitory activity at equitoxic dose-levels.

For the completely carboxylated polymers those of weaker degree of ionization (hydrolysed propylene and *iso*butylene maleic anhydride copolymers) were, in general, less active than those of higher charge-density (HEMA, polyacrylic and polymethacrylic acids).

The results of our studies support the hypothesis that tumour inhibition by polyelectrolytes may be a function of charge-density and distribution on the polyelectrolyte molecule. The inactivity of the monomeric fragments tested indicates the necessity for the polymeric structure.

Synthetic polyelectrolytes not only inhibit transplanted tumours but also certain vital enzymes such as ribonuclease and deoxyribonuclease[3,5,6]. The exact mechanism for these effects is not known. The variation which is possible in the physico-chemical characteristics of synthetic polyelectrolytes permits us empirically to define certain properties contributing to tumour inhibition. Predictable reactions between synthetic polyelectrolytes and selected biological systems may eventually be possible by consideration of physico-chemical characteristics of the synthetic and the naturally occurring polyelectrolytes.

This investigation was supported by research grants, *CY*-3887, from the National Cancer Institute, National Institutes of Health, Public Health Service, and the Monsanto Chemical Company.

[1] Balazs, A., and Holmgren, H. S., *Proc. Soc. Exp. Biol. and Med.*, **72**, 142 (1949).

[2] Regelson, W., and Holland, J. F., *Nature*, **181**, 46 (1958).

[3] Regelson, W., Tunis, M., and Kuhar, S., *Acta Unio Internationalis Contra Cancrum* (in the press).

[4] Muehlbaecher, C., Straumfjord, J., Jr., Hummel, J. P., and Regelson, W., *Cancer Res.*, **19**, 907 (1959).

[5] Heymann, H., Bulick, Z. R., DeBoer, C. J., Stevens, G. de, and Mayer, R. L., *Arch. Biochem. Biophys.*, **73**, 366 (1958).

[6] Hummel, J. P., Floras, M., and Nelson, G., *J. Biol. Chem.*, **233**, 717 (1958).

EFFECT OF OXYGEN AND NITRIC OXIDE ON THE RADIOSENSITIVITY OF HUMAN CELLS IN TISSUE CULTURE

By Dr. D. L. DEWEY

British Empire Cancer Campaign Research Unit in Radiobiology, Mount Vernon Hospital, Northwood, Middlesex

THE sensitivity of cells to radiation can be measured by several different criteria. From the point of view of radiotherapy of cancer, the relevant criterion is a loss of reproductive integrity, that is, the loss of the ability of the cell or its descendants to go on multiplying indefinitely. The work of Puck and his collaborators has shown that it is feasible to measure this form of radiation damage to human cells in tissue culture by observing the fraction of cells that survived, in that they were able to go on dividing and growing to form a visible colony. The radiation procedure used by Puck and Marcus[1] had the disadvantage of an uncertainty in dose, due to the close proximity of the cells to a glass surface[2]. This article reports the results obtained by an alteration of procedure that eliminates the glass surface, and at the same time permits an accurate control of the oxygen tension in the surrounding medium.

The cells used in this work were from human liver, obtained in tissue culture by Westwood[3] and kindly supplied to me by Dr. F. Sheffield. They were grown in closed bottles containing Earle's salt solution, lactalbumin hydrolysate, tryptic meat broth, serum, glucose, antibiotics and bicarbonate—the mixture having been pre-gassed with carbon dioxide. Before irradiation they were removed from the glass surface by incubating with 0·5 m*M* ethylene-diamine-tetraacetic-acid disodium salt for 15 min., then pipetted rapidly to break up clumps. One fraction of the suspension was used for microscopical examination for total cell-count and for a check against clumping. Other fractions were added immediately to phosphate-buffered media in which the bicarbonate had been omitted and replaced by 8 per cent by volume of buffer at *p*H 7·4, made by adding 4 volumes of 0·154 *M* disodium hydrogen phosphate to 1 volume of 0·154 *M* sodium dihydrogen phosphate.

The cells were irradiated in suspension in phosphate buffer in a 'Perspex' ('Lucite') vessel. The solution was bubbled with the gas under test as fast as foaming would permit, for at least 5 min. before, and during irradiation. The radiation used was from a Siemens 'Metalix' X-ray tube operated at 200-kV. constant potential, 8 m.amp., and filtered by 0·5 copper + 0·5 mm. aluminium. The cells were irradiated at room temperature, at a dose-rate of about 600 r./min. 0·1 ml. samples of cell suspension were withdrawn from the vessel before and after irradiation, diluted as necessary, and aliquots placed in closed bottles containing bicarbonate medium, carbon dioxide and an actively metabolizing X-rayed 'feeder layer'. Colonies were counted after 10 days incubation at 37° by scanning the bottle under the low-power objective of a microscope. A ruled grid was placed over the surface of the bottle during counting to ensure that the surface was scanned once, and only once.

The effect of X-rays on the viability of cells suspended in media gassed with oxygen, nitrogen, and 0·275 per cent oxygen in nitrogen, is shown in Fig. 1. The errors shown represent only the statistical error of counting and therefore under-estimate the total error of each point. The lines are the regression lines determined by 'least-square' analysis after giving each point a weight determined by the number of cells counted. The air value at 18·3 per cent survival was the first result to be obtained. Since a slightly different geometry was used during this run, the result has been omitted from the statistical calculations. The point itself has been included in the figure for completeness. The points for air and for 100 per cent oxygen were not significantly different, and both sets were put together in the regression analysis. The slope of the air–oxygen line corresponds to a 37 per cent survival dose of 118·8 ± 3·9 rads, and that of the nitrogen line to a dose of 263·1 ± 16·6 rads. Thus the oxygen–nitrogen ratio *m* is 2·2

Alper and Howard-Flanders[4] found that the sensitivity of bacteria to X-rays at different oxygen concentrations could be fitted by the equation:

$$S(O_2) + SK = S_n m(O_2) + S_n K$$

where S_n is the radiosensitivity in the absence of oxygen (= $1/D_{37}$ dose for nitrogen). S is the radiosensitivity at oxygen tensions (O_2) and m and K are constants. The same equation was found to apply for Ehrlich ascites cells by Deschner and Gray[5]. If these human cells are assumed to obey this equation, then $K = 8{\cdot}5$ μmoles/l., the same order of magnitude as was found for bacteria (7·8) and for mouse tumour cells (5 ± 2). A value of 4·2 has also been reported[6] for bean roots poisoned with cupferron. The plating efficiency varied between 40 and 70 per cent from one experiment to another, but was remarkably constant over all the controls in any one experiment. The experimental procedure alone, including filling the irradiation vessel, gassing with nitrogen for the longest periods used, and all other operations except switching on the X-ray set, gave the same survival as controls which were not subjected to these procedures.

During the cell count a record was also kept of the number of cells in the counting field that appeared to be touching one another. This was usually about 10 per cent of all cells counted, and is the sum of cells actually stuck together and cells which happen to be lying very close to one another. In the worst case, in which this proportion of cells remained in contact throughout the experiment, then the error from this cause would be 5 per cent, or about equal to the counting error. In fact the cells, when plated in bottles, are a thousand times more dilute than in the cell-counting chamber. Thus, the error due to cell clumping would be expected to be very much less than the statistical errors indicated in Fig. 1. The irradiated cell suspension was relatively dilute, between 10^4 and 10^6 metabolizing cells per ml. The total oxygen consumption of the cells would not make a measurable difference to the oxygen tension of the medium, during irradiation in oxygen or air. On the other hand, no help from the cells can be expected during equilibration with nitrogen for the anoxic radiations. Any error here would tend to make the value of *m* too small, and *K* too large. In order to assess the magnitude of these errors, aliquots of the equilibrated anaerobic solution were transferred to a Hersch cell[7] and the residual oxygen measured.

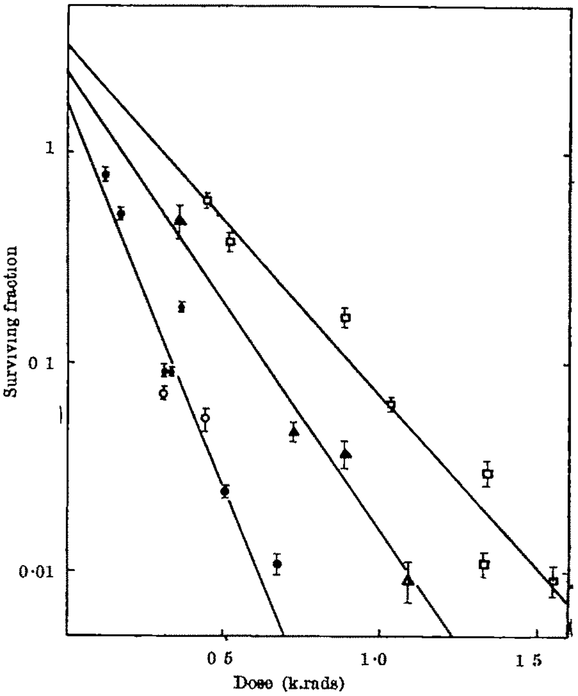


Fig. 1. Survival of human liver cells after 200-kV. X-rays during equilibration with oxygen, ○, air ●, nitrogen □ and 0·275 per cent oxygen in nitrogen △. The lines are the regression lines determined by 'least-square' analysis

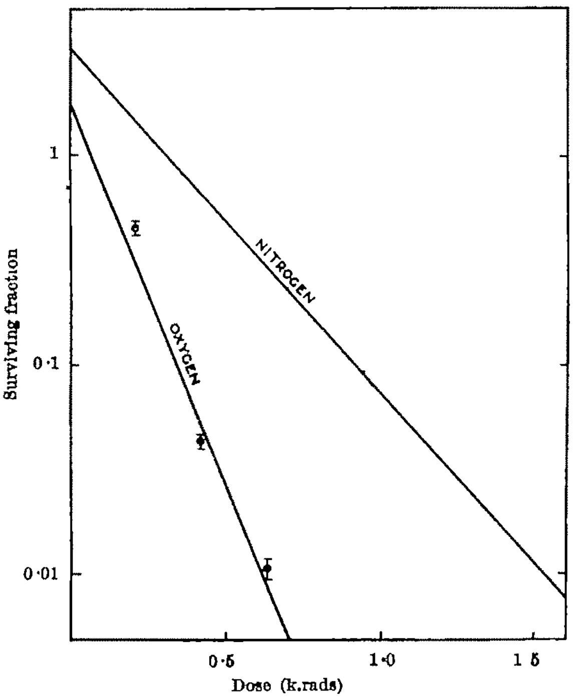


Fig. 2. Survival of human liver cells after 200-kV. X-rays during equilibration with 10 per cent nitric oxide in nitrogen. The oxygen and nitrogen lines are included for reference

These results indicated that the oxygen remaining in solution corresponded to equilibration with about 100 parts/million oxygen in the gas phase. Accurate measurement was made difficult by the foaming nature of the liquid; but if an upper limit of 275 parts/million is assumed then the corresponding value of m would be 2·4 and K would be 7·7 μmole/l. The feeder layer was made by giving bottles, containing a thick layer of growing cells, an exposure dose of 1,320 r. of 200-kV. X-rays. The medium was then poured off, the cells detached from the glass with ethylene-diamine-tetraacetic acid disodium salt, diluted in fresh bicarbonate medium and dispensed in clean bottles. The final concentration was about 10^5 cells per bottle. By extrapolating the air inactivation curve of Fig. 1, and applying the correction used by Morkovin and Feldman[2] for increased radiation-dose due to the proximity of the glass surface, then one colony in 10^2 bottles would be expected. This would introduce a negligible error.

The effect of adding 10 per cent nitric oxide during strict nitrogen anoxia is shown in Fig. 2. The lines are the oxygen and nitrogen lines from Fig. 1 and are included for reference. The conclusion from this experiment is that nitric oxide appears to act in a way similar to oxygen in sensitizing these human cells to X-rays, a phenomenon already found for bacteria by Howard-Flanders[8], for bean roots by Kihlman[9], and for Ehrlich ascites cells by Gray, Green and Hawes[10]. In dry systems nitric oxide acts in the opposite sense, in that it protects anaerobic spores of *Bacillus megaterium*[11] and dry seeds of *Agrostis stolonifera*[12] against damage by X-rays. The overall result is that with respect to the influence of oxygen and nitric oxide on radiosensitivity, human cells in tissue culture behave in a way similar to most other types of cell which have been studied. It is not suggested that cells in tissue culture are identical with those *in vivo*, or that results obtained by inactivating cells in culture can be applied indiscriminately to cells *in vivo*. The process of obtaining cells in tissue culture is by nature one of specifically selecting those cells best able to grow under those conditions supplied.

Nevertheless, the results reported here bear a striking resemblance to the results of irradiating leukæmia cells *in vivo* in live and dead mice reported by Hewitt and Wilson[13] and interpreted by them as the aerobic and anaerobic sensitivities.

I am indebted to Dr. Alma Howard for making the cell counts; to Dr. J. W. Boag, and Dr. R. E. Steele for help in the dosimetry; to Dr. L. H. Gray for suggesting the work and for encouragement and help, and to Mr. J. Steadman and Miss J. Liddon for technical assistance.

[1] Puck, T. T., and Marcus, P. I., *J. Exp. Med.*, 103, 653 (1956).
[2] Morkovin, D., and Feldman, A., *Brit. Inst. Radiol.*, 32, 282 (1959).
[3] Westwood, J. C. N., and Titmuss, D. H. J., *Brit. J. Exp. Path.*, 38, 587 (1957).
[4] Alper, T., and Howard-Flanders, P., *Nature*, 178, 978 (1956).
[5] Deschner, E. E., and Gray, L. H., *Rad. Res.*, 11, 115 (1959).
[6] Kihlman, B. A., *Nature*, 182, 730 (1958).
[7] Hersch, P., "Instrument Practice", 937 (United Trade Press, London' 1957).
[8] Howard-Flanders, P., *Nature*, 180, 1191 (1957).
[9] Kihlman, B. A., *Exp. Cell. Res.*, 14, No. 3, 639 (1958).
[10] Gray, L. H., Green, F. O., and Hawes, C. A., *Nature*, 182, 952 (1958).
[11] Powers, E. L., Kaleta, B. F., and Webb, R. B., *Rad. Res.*, 11, 461 (1959).
[12] Sparrman, B., Ehrenberg, L., and Ehrenberg, A., *Acta Chem. Scand.*, 13, 199 (1959).
[13] Hewitt, H. B., and Wilson. C. W., *Brit. J. Cancer*, 13, 69 (1959).

INFLUENCE OF CERVICAL SYMPATHECTOMY AND PITUITARY STALK SECTION UPON MILK SECRETION IN GOATS

By G. B. TVERSKOY

I. P. Pavlov Institute of Physiology of the Academy of Sciences of the U.S.S.R., Leningrad

THE hormones of the adenohypophysis play an important part in control of milk secretion. During some days after the operation, hypophysectomy causes a cessation of lactation in spite of an injection of oxytocin—a neurohypophysis hormone, which stimulates milk ejection[1,2]. The control of the hormone-forming function of the adenohypophysis stimulating milk secretion is not yet quite clear. Very little is known about the role that the sympathetic innervation of the adenohypophysis and the nervous and vascular tracts of the pituitary stalk are taking in the control of the hypophysis function stimulating milk secretion. It was therefore considered desirable to examine the influence of cervical sympathectomy and pituitary stalk section upon milk secretion in goats[3-5].

Influence of Cervical Sympathectomy on Milk Secretion

In order to analyse the part the sympathetic innervation of the adenohypophysis is playing in control of milk secretion, the influence of a bilateral cervical sympathectomy upon the secretory process in the mammary gland was studied in an experiment with eight goats. Cervical sympathectomy was performed in two stages at an interval of one month. At each stage the upper and the middle cervical sympathetic ganglia were extirpated from one side, and a piece 2–3 cm. long was cut from the vertebral nerve at the point of its leaving the stellate ganglion. In two goats the stellate ganglia were extirpated from both sides instead of an extirpation of vertebral nerves. The common carotid artery and the jugular vein in the cranial part of the cervix were stripped of their adventitia along 3–3·5 cm. and the vascular walls were carefully treated with 5 per cent aqueous and alcoholic carbolic acid solutions. Two goats underwent a 2-stage control operation of cervical sympathectomy. Cervical sympathetic ganglia of these animals were not extirpated but only exposed.

A unilateral cervical sympathectomy led to a moderate and short decrease in milk secretion. For 10 days after the first operation stage the average amount of milk given by sympathectomized animals was 76·3 per cent of the initial level, while with control-operated goats it was 92·2 per cent. The initial level of milk secretion was achieved after the first operation stage both in control-operated goats and in most of the sympathectomized ones 20–30 days after the operation.

The extirpation of the cervical sympathetic chain from the other side led to a much more profound and prolonged inhibition of milk secretion. During the first 10 days after the second operation stage the average amount of milk given by sympathectomized goats averaged 59·7 per cent of the initial level, while with control-operated animals it was 90·5 per cent. Further, a gradual increase of milk secretion was recorded; but the milk secretion in sympathectomized goats increased extremely slowly. After the second operation stage, the average daily amount of milk given by sympathectomized goats in stall conditions (the animals kept on the same ration as that before the operation) was 80·8 per cent of the initial level, while with the control-operated animals it was 103·4 per cent. Transferring the goats to pasture resulted in an increase of milk secretion in all animals. However, in pasture conditions also the amount of milk secretion in sympathectomized goats (104·6 per cent of the initial level) was lower than in control-operated ones (136·0 per cent).

The above results show that bilateral cervical sympathectomy results in a significant and prolonged inhibition of milk secretion.

Together with a desympathization of the adenohypophysis the cervical sympathectomy causes a desympathization of the neurohypophysis, the thyroid and parathyroid glands[6-8], the hormones of which play an important part in the control of the motor and secretory function of the mammary gland. Special experiments on the measurement of the amount of the residual milk before and after the sympathectomy showed that a desympathization of the neurohypophysis does not cause such disturbances of the milk-ejection reflex, which could lead to an incomplete evacuation of the alveolar part of the gland and, consequently, to an inhibition of milk secretion. If before the operation the amount of the residual milk averaged in six goats 37·8 ml., after the sympathectomy it was 35·0 ml. Neither was the decrease in milk secretion after the cervical sympathectomy a result of a desympathization of the thyroid gland and the internal parathyroid glands. Special experiments showed that a simultaneous denervation of both lobes of the thyroid and of internal parathyroid glands does not result in a decrease in milk secretion. The average daily amount of milk during the first three 10-day periods after this operation—when the sympathectomized goats showed the lowest milk secretion—was, in goat No. 59, 98·6, 100·5 and 100·2 per cent of the initial level and, in goat No. 108, 100·1, 112·5 and 110·6 per cent.

Many authors have demonstrated by their investigations[9-15] that the cervical part of the sympathetic nervous system plays an important part in the control of the hormone-forming function of the adenohypophysis. It is quite possible that in our experiments the decrease in milk secretion after the cervical sympathectomy is due, first of all, to a disturbance of the production of glandular lobe hormones. The decrease of the hormone-forming function of the adenohypophysis could have taken place as a result of a desympathization of the glandular lobe itself as well as of a desympathization of various parts of the brain and, first of all, of the hypothalamus, which plays an important part in the control of the function of the adenohypophysis.

Influence of Pituitary Stalk Section on Milk Secretion

Various authors have investigated the influence of pituitary stalk section on the lactation process in rats and rabbits. These experiments proved that pituitary stalk section in lactating animals brought about starvation of their litters[16-18]. Evidently, it was a result of a disturbance of the milk-ejection reflex[19-21], as the mammary glands of the experimental animals contained during the first post-operative days a sufficient amount of milk[18,22]. If oxytocin was injected into female rabbits after a pituitary stalk section[23], their milk secretion remained at its initial level, although the growth of their litters was slower, evidently due to a change in quality of the milk. As oxytocin causes not only an evacuation of the alveolar part of the mammary gland but probably also leads to an increased production of prolactin[24], these experiments do not allow the conclusion that pituitary stalk section does not cause any decrease in milk secretion. Thus, the results obtained so far do not solve the problem of the influence of pituitary stalk section on the milk secretion process. Owing to this we investigated the influence of pituitary stalk section on the amount of milk secretion.

The operation of section of the pituitary stalk was performed in six goats during their first lactation. Section was carried out by the temporal approach[25]. Four goats underwent a control operation of stalk section. The pituitary stalk of these animals was exposed, but not cut. Three months after the operation all animals were killed and a serial histological analysis of the hypothalamo-hypophyseal region was performed (I. G. Urazov). The results of histological studies showed that three goats (Nos. 112, 313 and 143) underwent complete section of the pituitary stalk. Goat No. 143 showed, contrary to goats Nos. 112 and 313, a thick scar at the site of the section, and its median eminence of the tuber cinereum was very seriously damaged. In three other goats pituitary stalk section was incomplete. Goat No. 146 underwent a complete section of the infundibular stem, whereas the glandular part of the stalk remained, to a great extent, intact. The infundibular stem in goats Nos. 322 and 319 remained intact, while the glandular part of the stalk was partially cut. All goats with a complete stalk section and goat No. 146 showed an atrophy of the neural lobe of the neurohypophysis. In goats Nos 319 and 322 the neural lobe remained intact. The hypophysis of goat No. 143 was significantly decreased in size. All goats showed areas of atrophy in the anterior part of the glandular lobe.

In all goats with a complete section of the pituitary stalk and goat No. 146 the milk-ejection reflex disappeared after the operation, but it reappeared in 7–11 days. However, during some weeks after the operation the milk-ejection reflex was somewhat defective: a prolonged latent period of the reflex and some increase of the amount of residual milk were noted. Goats Nos. 319 and 322 (an intact infundibular stem, a partial section of the glandular part of the stalk) showed a full milk ejection reflex immediately after the operation.

We can now discuss the results of the investigations of the influence of a pituitary stalk section on milk secretion. During the first month after the operation (stall conditions, the same ration as that before the operation) the average daily amount of milk given by goats Nos. 112 and 313 (complete stalk section) was on an average 28·9 per cent of the initial level; goat No. 143 (complete pituitary stalk section with the formation of a thick scar, severe damage of the median eminence) gave 12·6 per cent, three goats with incomplete stalk section 40·5 per cent, and the control-operated animals 55·7 per cent of the initial level. All animals showed an increase of milk secretion on being transferred to pasture conditions. However, in pasture conditions also milk secretion in goats with stalk section was significantly lower than that in the control-operated animals. The average daily amount of milk during the whole post-operative period of investigation (80 days in stall and pasture conditions) was 48·2 per cent of the initial level in goats Nos. 112 and 313 (a complete stalk section), 21·6 per cent in goat No. 143 (complete stalk section with formation of a thick scar, severe damage of the median eminence), 67·1 per cent in three goats with an incomplete stalk section and 77·6 per cent of initial level in control-operated animals. If we assume that during 80 post-operative days the amount of milk secretion in control-operated goats expressed as a percentage of the initial level is 100, the amount of milk secretion in goats Nos. 112 and 313 will average 62·1 per cent in comparison with the milk secretion-level in control-operated goats, in goat No. 143 it will be 27·8 per cent and in three goats with incomplete stalk section, 86·5 per cent. Thus, a complete stalk section leads to significantly decreased milk secretion. Goat No. 143, which had a thick scar formed at the site of the section, and of which the median eminence of the tuber cinereum was severely damaged, showed a very marked decrease of milk secretion An incomplete stalk section leads to a relatively small decrease of milk secretion.

These results prove that nervous and vascular tracts of the pituitary stalk play an important part in the control of the hormone-forming function of the adenohypophysis stimulating milk secretion.

[1] Cowie, A. T., *J. Endocrinol*, **16**, 135 (1957).

[2] Bradley, T. R., and Cowie, A. T., *J. Endocrinol.*, **14**, 8 (1956).

[3] Tverskoy, G. B., *Dokl Wses. Konfer. po molochn. delu*, 36 (1958).

[4] Tverskoy, G. B., *Wses. Sowestshan. po physiol. i biochem. s/ch zivotn., tes. dokl.*, 281 (1959).

[5] Tsakhaev, G. A., *Wses. Sowestshan po physiol. i biochim. s/ch zivotn., tes. dokl.*, 287 (1959).

[6] Sokolov, B. M, *Nevropatol. i psichiatr.*, No. 12, 30 (1939).

[7] Kuntz, A., "The Autonomic Nervous System" (Philadelphia, 1953).

[8] Raybuck, H. E, *Anat. Rec.*, **112**, 117 (1952).

[9] Aleshin, B. V., and Nikolaichuk, S. P., *Tr. V. Wses. Sjezda anatomov, gistologov i embriologov*, 655 (1951)

[10] Lisogor, O. P, "The Role of the Uterus in the Control of the Gonadotropic Functions of the Hypophysis and the Œstrus Cycle (thesis, Kharkov, 1955).

[11] Vogt, M., *Arch. exp. Pathol. Pharmacol.*, **162**, 197 (1931).

[12] Haterius, H. O., *Amer. J. Physiol.*, **103**, 97 (1933).

[13] Kiselshtein, M, *Arch. biol. nauk*, No. 1, 43 (1935).

[14] Eskin, I. A., *Bull. Mosk. Obs. ispyt. prirody, otd. biol.*, No 5–6, 125 (1940).

[15] Uotila, U. U., *Endocrinol.*, **25**, 63 (1939).

[16] Herold, L., *Arch Gynakol.*, **168**, 534 (1939).

[17] Desclin, L., *C.R. Soc. Biol*, **134**, 267 (1940).

[18] Jacobsohn, D., *Acta Physiol. Scand.*, **19**, 10 (1949).

[19] Gomez, E. T., *J. Dairy Sci.*, **22**, 488 (1939).

[20] Harris, G. W, and Jacobsohn, D, *Proc. Roy. Soc.*, B., **139**, 263 (1952).

[21] Benson, G. K., and Cowie, A. T., *J. Endocrinol*, **14**, 54 (1956).

[22] Jacobsohn, D., and Westman, A., *Acta Physiol. Scand.*, **9**, 284 (1945).

[23] Donovan, B. T., and van der Werff ten Bosch, J. J., *J. Physiol.*, **137**, 410 (1957).

[24] Benson, G. K., and Folley, S J., *J. Endocrinol*, **18**, 180 (1957).

[25] Tverskoy, G. B., *Fiziol. Zhurn. S S.S.R.*, **46**, No. 6 (1960).

STRUCTURES CORRESPONDING TO TERMINAL BARS AND TERMINAL WEB IN MANY TYPES OF CELLS

By Prof. C. P. LEBLOND, HOLDE PUCHTLER* and Y. CLERMONT

Department of Anatomy, McGill University, Montreal

SURPRISINGLY little is known of the factors influencing the shape of cells. In the intestinal epithelium, two structures were found to have an important role in this respect: the terminal bars, which hold neighbouring cells in close contact, and the terminal web, a layer of fibrils extending across the cell apex between the terminal bars[1]. Interestingly enough, both these structures have the same staining and histochemical properties[1]; in particular, both are stained by successive treatment with tannic acid, phosphomolybdic acid, and amido black (referred to hereafter as the *TPA* technique). The question then arose as to whether cells other than those of the intestinal epithelium contained material with similar staining properties and perhaps with a similar role.

A variety of tissues and organs from male and female adult rats, as well as a few tissues from other animals, were fixed in Carnoy, dehydrated in alcohol and methyl benzoate, sectioned at 2μ and stained by the *TPA* technique[1,2]. A search was then made for structures staining like terminal bars and terminal web.

---

* Fellow of the Damon Runyon Memorial Fund for Cancer Research and of the National Cancer Institute of Canada Present address: Department of Pathology, Medical College of Georgia, Augusta, Ga., U.S.A.

A terminal web which appeared in *TPA* preparations as a single layer extending between the terminal bars was seen not only in the chief cells of the intestinal epithelium (Fig. 1*A*) but also in cells of many other simple epithelia (Table 1, unilayered terminal webs). In all these cells, the terminal web appeared as a thin band located immediately below the apical surface. Using the polarization microscope, Schmidt[3] described a layer just below the striated border of intestinal cells, which exhibited a type of birefringence indicative of the presence of fibrous molecules parallel to the apical surface. Indeed, when sections were cut parallel to the free surface of the intestinal cells and stained with *TPA*, distinct fibrils were often seen within the terminal web.

A systematic survey of the literature revealed that, during the second half of the last century, the terminal web was described by a few authors[4-9], but no name was given to it. This structure was then forgotten, for, to Heidenhain, each unit of the striated border was equivalent to a cilium related to a centriolar granule, and a row of such granules crowded together would appear as a band[10]. This misinterpretation was widely accepted.

Some fifty years later, Sauer[11], who seemed to have been unaware of previous work on the subject, described "a structure which has the appearance of a stained membrane stretched across the end of the cell between the terminal bars" in the ependymal epithelium of amphibian embryos. He stated that this structure is composed of a network of fibrils of such dimension that they are usually not separately visible, and that it may exist in other columnar cells; he proposed the name 'terminal web'. Other authors who observed this structure did not distinguish it from terminal bars (as may be seen, for example, in Figs. 292 and 383 in ref. 12).

The terminal web of the intestinal epithelium was seen in electron microscope pictures of Palade and Porter (quoted in ref. 1) as a filamentous layer extending between the terminal bars and continuous with similar material present in the microvilli of the striated border. Similarly, Palay and Karlin[13] described this terminal web in detail as a dense feltwork of filaments stretched across the cell and from which other filaments extended into the units of the striated border and also into the cytoplasm.

Using the *TPA* technique, a careful examination of the terminal bars was carried out in $2\text{-}\mu$ thick sections of the epithelial cells of the intestine cut parallel to the surface. Under these conditions the terminal bars did not appear to be the uniform rods classically described. Instead, they proved to be composed of juxtaposed granules, giving the appearance of a string of beads. Furthermore, the fibrils of the terminal web were seen to end in these granules. In view of the similarity of the granules with the desmosomes of the Malpighian cells in the epidermis, it was decided to refer to the terminal bar granules by the term 'desmosomes'[14]. Hence, the terminal bar consisted essentially of a series of desmosomes wherein web filaments were confluent.

In the cells of the proximal convoluted tubules of the kidney and the stereociliated cells of the epididymis, cross-sections of the unilayered terminal web appeared finely granulated. In the ciliated cells of the trachea, it was often possible to see a double row of granules connected to the cilia and held within a terminal web ending in desmosomes. Cilia and granules stained with *TPA* and could, therefore, be related to the web.

In the ameloblast, two unilayered webs were present, one at the apex and one at the base of the cell.

In other cell types, the terminal web may be multilayered, each layer being connected with a set of desmosomes. This was the case in the striated ducts of salivary glands (Fig. 1*B*, Table 1).

The terminal bar-terminal web complex is organized quite differently in some cells where fibres attached to the terminal bars extended from the apex of the cell towards the base in a pillar-like fashion. This was observed, for example, in the uterine epithelium. An extreme example of this arrangement was seen in the pillar and outer phalangeal cells of the organ of Corti, where the bundles of tonofibrils forming the pillars proved to stain with *TPA* (Fig. 1*C*).

Another arrangement was exemplified by the goblet cells of the intestinal epithelium or the surface mucous cells of the stomach in which the *TPA*-stained structure was lacy and basket-like, enclosing the mucous droplet (Fig. 1*D*). In addition, these cells had a pillar-like bundle of fibrils going from the terminal bars to the cell base (Fig. 1*D*).

A special type of terminal web was present in some exocrine glands, for example, in the acinar cells of the pancreas (Fig. 1*E*). The apex of the cell had a narrow rectangular surface, supported by a terminal web limited by terminal bars (composed of desmosomes). From these, fibrils extended into the cytoplasm in various directions to form an intricate network which outlined spaces enclosing the zymogenic granules. Such a complex web was not always restricted to the cell apex, but also extended laterally to the regions facing the intercellular canalicules.

Table 1. LIST OF THE CELL WEBS IDENTIFIED SO FAR

- Terminal web
  - Unilayered (Fig. 1*A*)
    - Non-ciliated cells; chief cell of intestinal epithelium. Epithelial cells from: gall bladder, pancreatic duct, seminal vesicle, prostate, coagulating gland, uterus, ascending and descending limbs of Henle's loop, distal convoluted and collecting tubules, lacrimal gland, sweat gland, mammary gland, epididymis, vas deferens, thyroid.
    - Ciliated cells from: bronchus, trachea, ampulla of Fallopian tube, vas deferens.
    - Cells of connective tissue origin: odontoblasts, reticulo-endothelial cells of splenic sinuses (basal plate).
  - Multilayered (Fig. 1*B*)
    - Epithelial cells from: intralobular (striated) and intercalated ducts of sublingual parotid, submaxillary; intralobular duct of pancreas.
    - Ducts of orbital gland, sweat gland.
    - Bile ducts.
    - Surface cell of transitional epithelium.
  - With network (Fig. 1*E*)
    - Glandular epithelial cells of pancreas, serous cells of salivary glands, zymogenic cells of gastric glands, Paneth cells; mucous cells of Brunner's gland.
- Pillar-like web (Fig. 1*C*)
  - Non-ciliated epithelial cells of Fallopian tube.
  - Epithelial cells in stria vascularis of cochlear duct.
  - Supporting cells of the organ of Corti and of the maculæ (Fig. 1*D*).
  - Goblet cells of intestinal and olfactory epithelium.
  - Surface mucous cells of stomach.
  - 'Flame-like' ciliated cells in pancreatic duct.
- Circumferential web
  - Partial (Fig. 1*F*): islets of Langerhans cells, corpus luteum cells.
  - Complete (Fig. 1*G*, 1*H*): parenchymal cells of liver, adrenal cortex and pituitary: sebaceous cell.
- Tubular web (Fig. 1*I*)
  - Spermatid.
- Dispersed web tonofibrils (Fig. 1*J*)
  - Epidermis.
  - Stratified squamous epithelia of tongue, œsophagus, forestomach and vagina.
- Contractile web myofibrils (Fig. 1*K*)
  - Striated muscle fibres of skeletal and heart muscle.
  - Smooth muscle fibres.
  - Myoepithelial cells.

Nature, June 4, 1960, p. 786

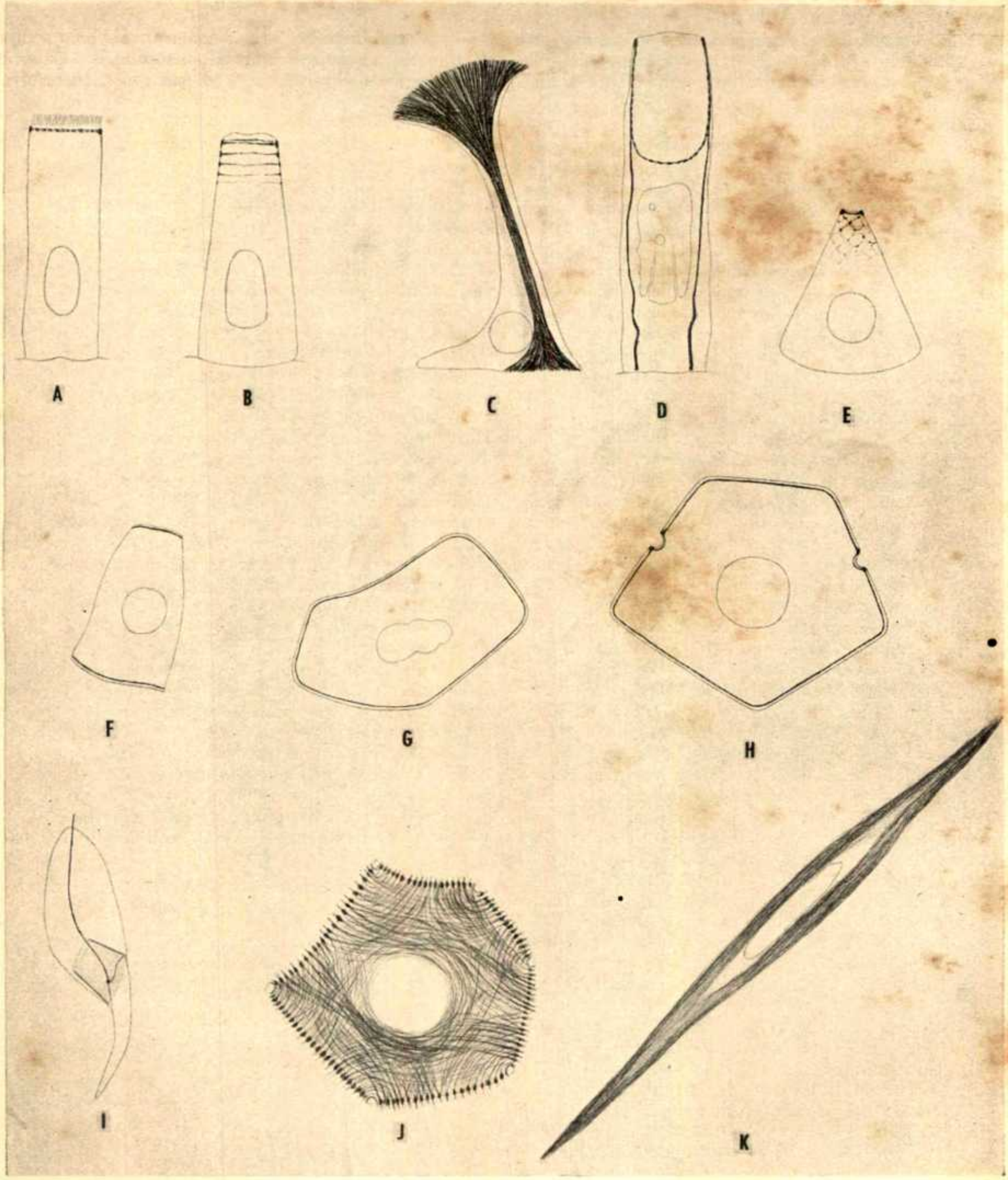


Fig. 1. Diagrammatic representation of various types of 'cell web' as revealed by the tannic acid–phosphomolybdic acid–amido black (*TPA*) technique in 2-μ sections. Cells drawn from rat tissues unless specified

A, chief cell of small intestine epithelium; a fibrous unilayered terminal web is seen at the apex of the cell immediately below the striated border. At the two ends of the web, the terminal bars are seen in cross-section

B, cell from a striated duct of a salivary gland showing a multilayered terminal web. Each layer of the cell web is connected with terminal bars

C, pillar cell of the organ of Corti in which the web filaments are packed into a dense bundle or pillar extending from the base to the apex of the cell

D, surface mucous cell of the stomach (from salamander) with a complex web containing pillar-like fibres as well as a network of fibres arranged as a basket separating the mucous droplet from the cytoplasm. Note that this cell web is attached to terminal bars

E, acinar cell of the pancreas showing a terminal web facing the lumen of acinus. The fibrous web is located between terminal bars, from which a network of filaments extends into the cytoplasm

F, beta-cell of islet of Langerhans showing a partial circumferential web lining two surfaces of the cell (above and below). These surfaces are those which face blood sinusoids

G, cell of sebaceous gland (from horse) showing a complete circumferential web under the cell membrane

H, liver cell with a complete circumferential web. The cell surface is indented in two places (right and left of diagram) so as to make up bile canalicules with the adjacent cells. The circumferential web is attached to bars running longitudinally in the walls of bile canalicules. The cell membrane lining the canalicules is subtended by a hemicylindrical web

I, in spermatids, the caudal tube (also called manchette) constitutes the web. The caudal tube is a transitory structure which appears as the nucleus of the spermatid, elongates to become sickle shaped and disappears before the cell completes its final transformation into a spermatozoon. This sleeve-like structure is located at the base of the nucleus and surrounds centrioles and flagellum

J, cell from the Malpighian layer of the skin (chestnut of the horse) showing intensely stained tonofibrils attached to desmosomes. Since the tonofibrils are distributed throughout the cytoplasm, they are considered as forming a dispersed web

K, smooth muscle fibre with well-stained myofibrils (contractile web)

This was particularly clear in parotid and external orbital glands.

So far, terminal webs have been described in simple epithelial cells. A terminal web may exist in other cell types, for example, in the odontoblast—a connective tissue cell adapted to the elaboration of dentinal matrix. In the spleen, the reticulo-endothelial cells lining the venous sinuses contained a structure described under the name 'basal plate', which extended over the entire base of the cell[15,16]. This stained with *TPA*.

Cells which were not distinctly polarized occasionally contained a *TPA*-staining fibrous layer located immediately below the cytoplasmic membrane. This structure will be referred to as circumferential web. In the cells of the islets of Langerhans, the circumferential web appeared incomplete, as it was clearly seen only at the surfaces in contact with capillaries (Fig. 1*F*). In the cells of the sebaceous glands, the circumferential web clearly extended all around the cell, thus forming a complete lining under the cell membrane (Fig. 1*G*).

The parenchymal cells of the liver also had a complete circumferential web, which reinforced bile canalicules (Fig. 1*H*). When two adjacent cells included a bile canalicule at their interface, each cell provided half the wall of the canalicule, in the form of a hemicylinder composed of cell membrane and underlying web. Junction of the two half-cylinders was ensured by longitudinal bars identical in appearance and staining properties with the terminal bars of epithelial cells, and like them, composed of a row of desmosomes.

The membranous structure described in spermatids under the name caudal tube was composed of longitudinal filaments which stained with *TPA* (Fig. 1*I*). This 'tubular web' extended caudally from the posterior region of the nucleus and enclosed in its cuff-like membrane the centrioles and the proximal part of the flagellum, both of which also stained.

The tonofibrils present in the cells of the Malpighian layers in epidermis and stratified squamous epithelia stained well with *TPA*. The bead-like structures or desmosomes which were present along the cell membranes and in which there was a confluence of the tonofibrils also stained intensely (Fig. 1*J*). Therefore, these two structures may correspond to the terminal bar-terminal web complex. The tonofibrils would thus be the web of these cells and, since they were present throughout the cytoplasm, they may be said to make up a dispersed web.

The myofibrils of striated and smooth muscle fibres (Fig. 1*K*) stained with *TPA*. In the case of cardiac muscle fibres (Fig. 1*K*), the myofibrils were seen to terminate in the intercalated disks, which were composed of intensely stained granules similar to desmosomes. Hence, myofibrils were considered to be homologous to the web of other cells and would therefore constitute a contractile web. Myoepithelial cells contained fibrils which were distinctly stained by the *TPA* technique, and would also constitute a contractile web.

Finally, the spindle fibres seen at metaphase during either mitosis or meiosis stained with *TPA*. The centrioles were also well stained, not only when observed at the two extremities of the spindle at metaphase but also at other stages of mitosis and even in resting cells. Perhaps spindle fibres and centrioles could be related to the cell web. Such relation might give significance to the suggestion that towards the end of mitosis the equatorial portion of spindle fibres gives rise to terminal bars[11].

Is it legitimate to link a variety of structures on the basis of similar staining ability ? Before answering this question, it may be recalled that many years ago Zimmermann reported that structures similar to terminal bars were present in many types of cells[17]. It would therefore be reasonable to suppose that the terminal web of the intestinal epithelium also has a counterpart in many cells.

However, when the *TPA* technique was applied to various tissues in a search for structures corresponding to the terminal web, difficulties arose, as the nucleus and various cytoplasmic materials often stained to some extent. It was therefore necessary to define the terminal web as precisely as possible. In the epithelial cells of the intestine this structure exhibited three characteristic features : (1) it stained by the *TPA* technique ; (2) it stained with iron hæmatoxylin and with a series of histochemical stains indicating the presence of basic proteins (somewhat different from usual basic proteins and particularly from collagen), but there was no reaction for carbohydrates, fats or nucleic acids ; (3) when the terminal web was cut parallel to the plane of section, it was often possible with the *TPA* or iron hæmatoxylin techniques to distinguish fine fibrils. (Since electron micrographs of this structure showed it to be composed of fine filaments too minute to be resolved by the light microscope[13], these filaments must be arranged in bundles which appear as fibrils after *TPA* staining.)

The various types of web listed in Table 1 stained with *TPA* and tended to be fibrillar in appearance ; furthermore, those that have been analysed histochemically (as will be reported elsewhere by Holde Puchtler) gave the histochemical reactions of basic proteins. Hence, it was concluded that these various forms represented different structural arrangements of the same cell organelle, for which we propose the name 'cell web'.

It has been pointed out that, when sections of intestinal epithelium were cut parallel to the cell surface, the terminal bars of the epithelial cells were not uniform rods, but rather rows of juxtaposed granules, referred to in the present work as 'desmosomes'. The desmosomes had exactly the same staining (*TPA*, iron hæmatoxylin) and histochemical properties (being composed of basic proteins) as the cell web itself. Investigation of many cell types often showed structures with the same characters as the terminal bars of the intestinal epithelium. This was true not only of the terminal bars seen in simple epithelia at one (Fig. 1*A*) or several levels (Fig. 1*B*) but also of the longitudinal bars seen along bile canalicules and intercellular canalicules in exocrine acini, and of the intercalated disks in cardiac muscle fibres. All these structures were composed of rows of desmosomes with the same properties as the individual desmosomes of the epidermal prickle cells. The fact that the histochemical properties of desmosomes were identical to those of the web itself suggested that at least part of the desmosomes would arise from aggregation of web filaments in certain areas of the cell membrane.

There were a few cells, particularly connective tissue and blood cells, in which neither web nor desmosomes were distinguishable. However, a faint *TPA* staining of fibrillar structures could be seen occasionally. For example, mature plasma cells contained a sharply staining centriole from which fibrils radiated. Furthermore, whenever cells divided, all of them, including connective tissue cells, showed *TPA* staining of centrioles and spindle fibres, which, therefore, may be related to web filaments. Would connective tissue cells and blood cells have a web too scanty for adequate staining ? If so, the web might well be present in all cells of the rat. Whatever the answer to this question may eventually be, it was clear that a large majority of the cells in this species contained a cell web. Furthermore, preliminary observations suggested that structures corresponding to the cell web were present in other mammals and in other animal groups, making up structures that in protozoa and other cells have been described as resulting from cortical or ectoplasmic differentiation[20].

What are the functions of cell web and desmosomes ? *A priori*, the two main factors influencing the shape of a cell are its relation with neighbouring elements and the structural qualities of its intracellular components. Since, in the intestinal epithelium the desmosomes connect each cell with its neighbours, while the cell web functions as a support for the cell apex[1], these structures must play a part in maintaining cell shape.

Similar observations may be made in tissues other than simple epithelia. In liver cells, the desmosomes and web are located so as to account for the well-known rigidity of bile canalicules[19]. In the ear, the stiff pillars of Corti are composed of densely packed web fibrils. The tubular web (caudal tube) of the spermatids, as a result of its firmness, may be seen to push the cytoplasmic membrane aside. In contrast, the cells with little or no stainable web—leucocytes and connective tissue cells—have no definite shape. It is concluded that, while more proof of the rigidity of the web is required, perhaps by testing with micro-dissection needles, circumstantial evidence favours a role of this web in giving firmness and shape to the cell.

In conclusion, the cell contains a fibrillar system —for which we propose the name 'cell web'—which stains with the *TPA* technique (tannic acid, phosphomolybdic acid and amido black) and is arranged in a characteristic manner in any given cell type. In simple epithelia, the cell web predominates in the apical region of the cell, where it is arranged in single or multiple layers of fibrils, which join the granules composing the terminal bars. (These granules are referred to as desmosomes.) In many parenchymal cells—liver, adrenal, etc.—the web makes up a complete lining under the cell membrane and its fibrils enter desmosomes, which build up structures similar to terminal bars. In stratified epithelia, the web is believed to consist of the well-known tonofibrils which enter individual desmosomes, and in muscular tissues, of the myofibrils which, in cardiac muscles at least, join the desmosomes of intercalated disks. A cell web has been seen in many other cell types (for example, spermatids and reticulo-endothelial cells of spleen). It is suggested that the fibrils of the cell web are endowed with a fair degree of firmness, and combine with the desmosomes in shaping the cell.

[1] Puchtler, Holde, and Leblond, C. P., *Amer. J. Anat.*, **102**, 1 (1958).
[2] Puchtler, Holde, *J. Histochem. Cytochem.*, **4**, 439 (1956).
[3] Schmidt, W. J., *Z. Zellforsch.*, **33**, 1 (1943).
[4] Brettauer, J., and Steinbach, S., *Sitzgsber. Akad. Wiss. Wien Math.-naturwiss. Kl.*, **23**, 303 (1857).
[5] Billroth, Th., *Arch. Anat. Physiol. u. Wiss. Med.*, 159–177 (1858).
[6] Eimer, Th., *Virchows Arch.*, **48**, 119 (1869).
[7] Thanhoffer, L. v., *Pflügers Arch.*, **8**, 391 (1874).
[8] Edinger, L., *Arch. Mikrosk. Anat.*, **13**, 651 (1877).
[9] Paneth, J., *Arch. Mikrosk. Anat.*, **31**, 113 (1888).
[10] Heidenhain, R., *Pflügers Arch.*, **43** (Supp.), 1 (1888).
[11] Sauer, F. C., *J. Morphol.*, **61**, 563 (1937).
[12] Greep, R. O., "Histology" (Blakiston Co., New York, 1954).
[13] Palay, S. L., and Karlin, L. J., *J. Biophys. Biochem. Cytol.*, **5**, 363 (1959).
[14] See Bennett, H. S., comments in discussion of ref. 2.
[15] Jolly, J., and Chevalier, P., *C.R. Soc. Biol.* (Paris), **67**, 585 (1909).
[16] Mangubi-Kudrjavtzewa, Anna, *Anat. Hefte*, **39** (H3), 697 (1909).
[17] Zimmermann, K. W., *Arch. Mikrosk. Anat.*, **52**, 552 (1898).
[18] Zetterqvist, H., "The Ultrastructural Organization of the Columnar Absorbing Cells of the Mouse Jejunum" (Aktiebolaget Godvil, Stockholm, 1956).
[19] Elias, H., "Res. in the Service of Med." (Searle and Co.), **37**, 1 (1953).
[20] Levi, G., "Tratto di Istologia". Unione Tipografico-Editrice Torinese (Torino, 1954).

DETECTION AND ESTIMATION OF A FACIAL ECZEMA TOXIN, SPORIDESMIN

By G. R. RUSSELL
Ruakura Animal Research Station, Hamilton, New Zealand

THE disease of sheep known in New Zealand as facial eczema is now believed to be due to the presence on the pasture of a fungus, *Sporidesmium bakeri*[1]. The hepatotoxic principle has been isolated and crystallized[2]. Following the results of Synge and White, spots of the toxin were chromatographed on paper in water solvent and sprayed with sulphur-reacting reagents. Of those tried, only the azide-iodine reagent[3] showed a positive reaction. This reagent has now been developed in two ways—as a spray for chromatograms, and as a titration reagent for the toxin.

Run in a descending water solvent, the toxin appears to streak, possibly due to adsorption on the paper, and this may be even more pronounced if the applied spot is an impure extract. Consequently a variety of different solvent systems was tried, and finally the method adopted was to run a descending chromatogram on Whatman No. 4 paper, using methanol/water (50/50) as a solvent. This system does not entirely preclude streaking of the toxin spot, but it does reduce streaking when crude extracts are chromatographed. An azide-iodine reaction with lowered iodine content (0·005 N iodine in 0·1 N potassium iodide, containing 1·5 per cent sodium azide) has been found most satisfactory for detection of the spot. The paper is dried and sprayed with this reagent, when the toxin appears as a white spot on a brown background. After a few minutes the paper is oversprayed with 1 per cent aqueous starch solution, which reveals the white spots against a blue background, slowly fading to a permanent brown colour.

When running several chromatograms of toxic extracts in this manner it appeared that there was some relationship between the amount of toxin present and the size of the spot on the chromatogram. A standard solution of sporidesmin (with carbon tetrachloride of crystallization) in alcohol was prepared. Chromatograms of this were run, with levels of toxin applied at the origin ranging from 0·25 µgm. to 5 µgm., and over this range there was a distinct increase of spot size with the amounts present.

Using this chromatogram as a standard it has been possible to estimate approximately the amount of toxin present in a sample by visual comparison of the spot size using known amounts of toxin on the same paper. The R_F of the pure toxin is 0·88, while the spots appearing in samples are usually of lower R_F 0·81, and sometimes streaking. It is sometimes necessary to run a preliminary chromatogram with an unknown sample to get some idea of the percentage of toxin present, as the toxin spot must be within the range of the standards.

It was considered that catalysis of the iodine–azide reaction by the toxin might be utilized as the basis of a titration method for estimation of the toxin. Reagents were prepared of 0·01 N iodine in potassium iodide solution containing 3 per cent sodium azide[4] and 0·01 N sodium arsenite. The sodium arsenite solution was used in a Conway microburette. Samples of the pure toxin in alcohol solution were put into small dishes, evaporated and excess iodine–azide solution added. The dish was sealed with a ground-glass lid, and after 5 min. the unreacting iodine was titrated with sodium arsenite, using starch indicator. The titrations were carried out in duplicate, and blanks always titrated. Using 0·5 ml. of azide–iodine reagent there was a straight-line relationship between the amount of toxin added and the iodine consumed by the azide–iodine reaction, within the range up to 5 µgm. toxin. When higher amounts of toxin are required to be titrated, greater excess of the iodine–azide solution is required. Titration carried out with iodine solution without azide present shows that uptake of iodine by the toxin is insignificant under these conditions.

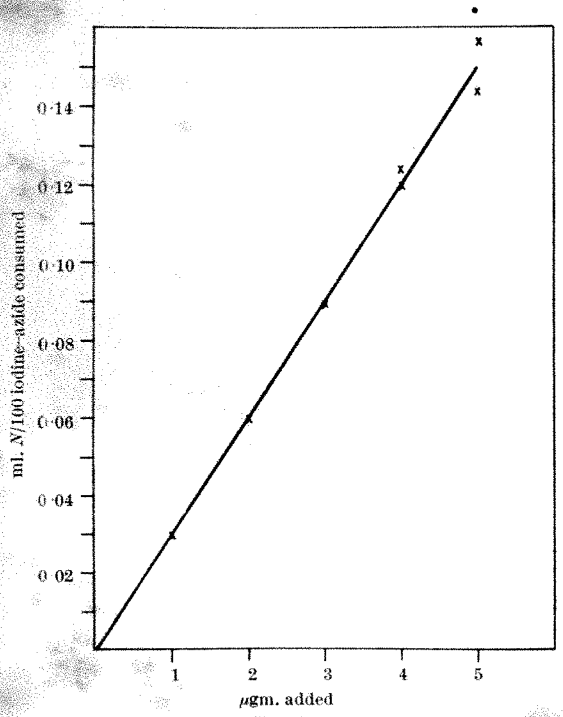


Fig. 1. Titration of toxin

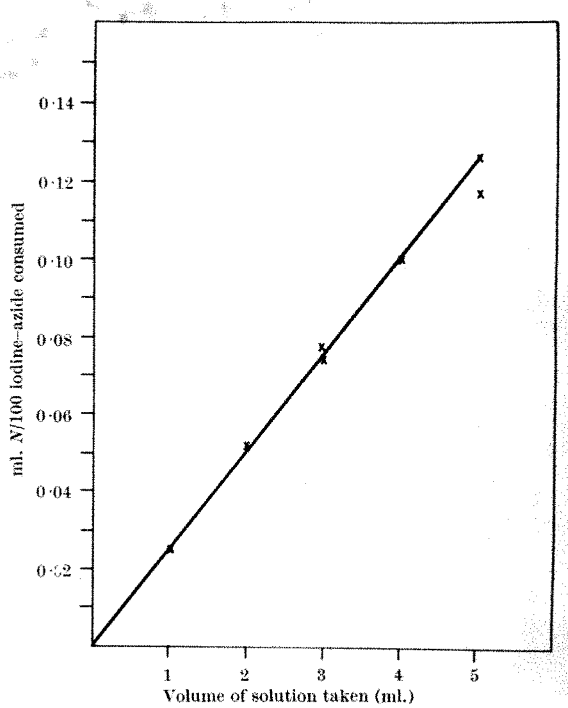


Fig. 2. Titration of spore extract (10 mgm./ml. ethanol)

Methanol extracts of spores at the petroleum ether wash stage of purification[2] were made up in alcohol solution and the insoluble material allowed to settle out. Aliquots of this solution were titrated as above, and the iodine consumption appeared to be proportional to the amount of extract added. It therefore appears that even in these crude extracts, a measure of the iodine consumption by the azide–iodine reaction may be used to estimate the amount of toxin present. The following is a typical example of a toxic extract of spores; 10 mgm. of the extract at the petroleum ether wash stage was made up to 1 ml. in alcohol. Chromatography of aliquots of this solution showed that the only azide–iodine reacting spots present were due to the toxin, and it was estimated by the comparative method that the extract is 4 per cent toxin.

Titration of a series of aliquots of this solution, using information from Figs. 1 and 2, indicates that the extract is 4·2 per cent toxin. This result is in good agreement with the level of toxicity obtained by biological tests, carried out by colleagues in these laboratories (based on production of keratitis of rabbit's eye, injury to HeLa cells and characteristic biliary lesions produced in the liver of rabbits).

The results of this suggests that the method so far used may be applicable to the detection and estimation of the toxin in many media, and work is in progress to estimate toxin in pasture.

A more complete study of the catalysis of the azide–iodine reaction by the toxin will be made in the future.

---

[1] Thornton, R. H., and Percival, J. C., *Nature*, **183**, 63, (1959).

[2] Synge, R. L. M., and White, E. P., *Chem. and Indust.*, **49**, 1546 (1959).

[3] Chargaff, E., Levine, C., and Green, C., *J. Biol. Chem.*, **175**, 67 (1949).

[4] Feigl, F., "Spot Tests: Organic Applications", **2**, 164 (Elsevier, 1954).

LETTERS TO THE EDITORS

MATHEMATICS

Analysis of Accelerated Motion in the Theory of Relativity

CONVENTIONAL treatments of accelerated motion in the theory of relativity have led to certain difficulties of interpretation. Thus, Crampin, McCrea and McNally[1] mention the lack of uniformity in the correspondence of events as depicted by the transformation of Born and Biem. Again, Donahue and Leffert[2] and Moller[3] discuss certain reversals in the apparent gravitational field of an accelerated body. I have found[4] that these difficulties may be avoided by simpler analysis based on the use of restricted conformal transformations. In the conformal theory the velocity of light remains constant even for experimenters in accelerated motion.

The problem considered is that of rectilinear motion with a variable velocity v. I introduce two co-ordinate systems, A, (x,t) and B, (x',t'). The motion takes place along the x or x' axis.

The correspondence between the xt and $x't'$ systems may be expressed quite simply by the transformation:

$$\begin{aligned} x' + t' &= F(x + t) \\ x' - t' &= G(x - t) \end{aligned} \tag{1}$$

The velocity is given by:

$$v = \frac{g - f}{g + f} \tag{2}$$

Here f and g are the derivatives of F and G with respect to their arguments $x \pm t$. I now suppose that A, (x,t) is an inertial system, and in order to satisfy the relation of equivalent scale in the vicinity of B, I apply the boundary condition:

$$fg = 1 \text{ along } x' = 0 \tag{3}$$

If the motion of B is given then this relation, together with equation (2), is sufficient to determine the functions F and G. As determined in this way, this transformation becomes tangent to instantaneous Lorentz transformations all along the path of B and in the case of uniform velocity reduces to the Lorentz transformation everywhere.

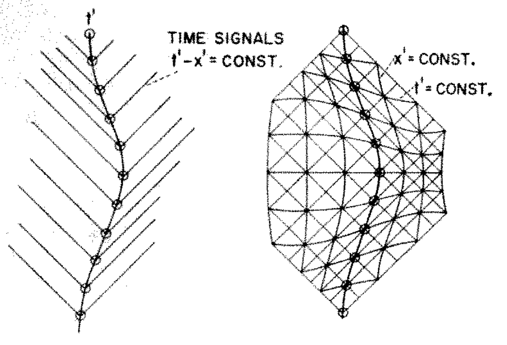


Fig. 1. A system of conformal co-ordinates associated with non-uniform motion

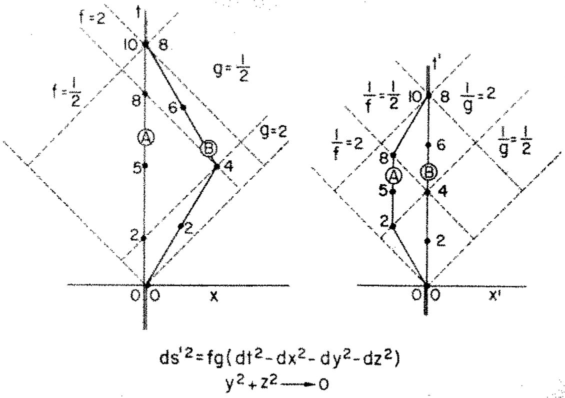

t
f=2
10
8
$g=\frac{1}{2}$
$f=\frac{1}{2}$
8
6
A
B
g=2
5
4
2
2
0
0
x
t'
$\frac{1}{f}=\frac{1}{2}$
10
8
$\frac{1}{g}=2$
$\frac{1}{f}=2$
8
6
$\frac{1}{g}=\frac{1}{2}$
A
B
5
4
2
2
0
0
x'
$ds'^2=fg(dt^2-dx^2-dy^2-dz^2)$
$y^2+z^2 \longrightarrow 0$

Fig. 2. Example showing application of restricted conformal transformations

Fig. 1 shows how such $x't'$ co-ordinates may be constructed graphically with the aid of periodic time signals originating in the B system. Such signals generate a family of outgoing waves, represented by the characteristic lines $t \pm x =$ constant. If these lines are now extended backward, a corresponding family of incoming signals will be represented. Intersections of the characteristic lines may then be identified with the events of synchronization of the various clocks of the B system.

Extension of the theory of relativity by conformal transformations in four dimensions was considered many years ago by Bateman[5]. It seems that the group $C4$ admits only restricted motions, and of these the Lorentz transformation alone maintains equality in the scale relation. Therefore, we do not speak of a conformal transformation of the whole space. However, by restricting attention to a narrow cylindrical region around the x-axis, conformal mappings can be employed locally, so that:

$$ds'^2 = fg(dt^2 - dx^2 - dy^2 - dz^2) \tag{4}$$

for $y^2 + z^2 \rightarrow 0$.

Fig. 2 illustrates a simple example of the type discussed in connexion with the clock paradox. At $t = 0$, B starts away from A at the velocity 3/5. At $t = 5$, B reverses its motion and returns. Values of f and g in various regions are indicated between characteristic signal lines. The condition of local scale equivalence, $fg = 1$, results in a 20 per cent reduction of the elapsed time along the path of B. In addition to the time discrepancy, there appears also a discrepancy in the relative spatial displacements.

ROBERT T. JONES
National Aeronautics and Space Administration,
Ames Research Center,
Moffett Field, California.

Jan. 20.

[1] Crampin, Joan, McCrea, W. H., and McNally, D., *Proc. Roy. Soc.*, A, **252**, 156 (1959).

[2] Leffert, C. B., and Donahue, T. M., *Amer. J. Phys.*, **26**, No. 8 (1958).

[3] Moller, C., *Amer. J. Phys.*, **27**, No. 7 (1959).

[4] Jones, Robert T., "Extending the Lorentz Transformation to Motion with Variable Velocity", *NASA* Memo 7-9-59*A* (1959).

[5] Bateman, H., *Proc. Lond. Math. Soc.*, ii, **8**, 223 (1910).

GEOPHYSICS

Anisotropy of Susceptibility and the Natural Remanent Magnetization of Some Welsh Slates

In order to investigate the effect of the deformation associated with mountain building upon the anisotropy of susceptibility and the natural remanent magnetization of rocks, approximately a hundred specimens were prepared for measurement from some fifty samples of Lower Palæozoic Welsh slates cleaved during the Caledonian orogeny. The anisotropy in fields of less than two œrsted was determined with a transformer bridge[1] and the natural remanent magnetization with an astatic magnetometer. The results showed that the cleavage is a plane of high susceptibility, and that the remanent vector is parallel to it. In some of the slates it appears that the direction of natural remanent magnetization has been controlled by the anisotropic susceptibility, and in others that the pattern of anisotropy and the natural remanent magnetization have been aligned with the cleavage independently. I am indebted to Dr. J. C. Belshé and Dr. R. W. Girdler, with whose help the susceptibility work was begun.

It was only possible to measure the direction of natural remanent magnetization of the specimens from four sites, the remainder being too weakly magnetized. Without exception the vectors lay close to the cleavage plane; fifty of the fifty-six measured were within 20° of it and twenty-six within 5°. Figs. 1*a* and 1*b* are equal-area projections showing the direction of natural remanent magnetization relative to the field orientation of the rocks. In the first plot (Fig. 1*a*) the mean directions of natural remanent magnetization of the specimens from three of the sites have been joined by great circles to their respective cleavage planes. The scatter about these mean directions is small, for example, the radius of the cone of 90 per cent probability (α), and the Fisher precision factor (k)[2] were 8° and 29 respectively for the Dolgelley slates. The mean directions are related to the cleavage and therefore distinct for each site, but they are nevertheless in the same general direction as previous workers have found in the nearest rocks of Devonian age[3]. The natural remanent magnetization of these slates is due to pyrrhotite. In contrast, the remanent vectors of the Bethesda slates (Fig. 1*b*) have neither a small scatter nor directions comparable to any suggested for British rocks. Their magnetization is due to hæmatite. The remanence of the Bethesda slates is almost unaffected by alternating-current demagnetization up to fields of about 400 œrsted, while the magnetization of the pyrrhotite-controlled specimens is wiped out by fields of 250 œrsted.

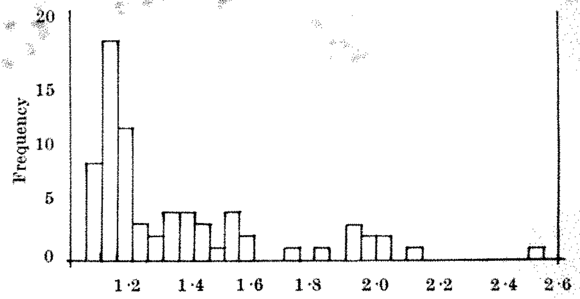


Fig. 2. Histogram of anisotropy ratios of Welsh slates

Fig. 2 is a histogram of the anisotropy ratios found in the slates. Defining the P factor as the ratio of maximum to minimum susceptibility, we see that no P factor of less than 1·05 was observed while values between 1·1 and 1·2 were the most common. The ferromagnetic mineral in those specimens with P factors greater than 1·4 was shown by X-ray analysis and Curie-point determination to be invariably pyrrhotite. The anisotropy of the Welsh slates exceeded that of the few uncleaved sedimentary and igneous rocks which were collected alongside them for comparison.

To consider the relation between the pattern of anisotropy and the cleavage, we now compare the direction of minimum susceptibility and the pole to the cleavage plane (Fig. 3). The similarity of these two directions demonstrates that the maximum intermediate plane of the susceptibility magnitude ellipsoid is approximately parallel to the cleavage plane. The anisotropy of the slates will be due either to shape effect or to crystalline anisotropy of the ferromagnetic minerals. If it is caused by the former then there will be preferred orientations of the long axes of grains of intrinsically isotropic susceptibility. If it is caused by the latter the ferromagnetic grains must have preferred crystallographic orientations. Either possibility is easy to imagine in a slate and both are observable in various minerals, particularly the micas.

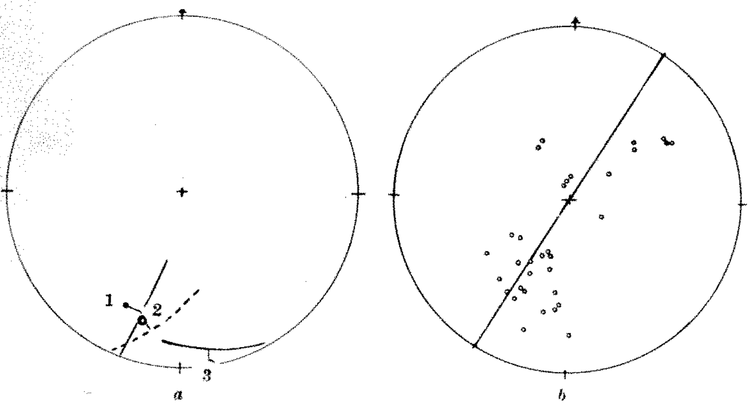


Fig. 1. The direction of natural remanent magnetization and the orientation of the cleavage. (*a*) Slates from Barmouth (1), Talsarnau (2) and Dolgelley (3). (*b*) Cambrian slates from Bethesda. Upper hemisphere poles and great circles, ○ ⁄ ; lower hemisphere poles and great circles, ● ⁄

In reflected light the pyrrhotite in the markedly anisotropic slates can be seen to be in the form of platey grains lying parallel to the cleavage plane. However, the anisotropy of the slates is not likely to be due to shape because the susceptibility of the pyrrhotite is too small for the effect of the anisotropic demagnetizing field to be observed[4]; powders of this pyrrhotite have a susceptibility of 8×10^{-3} e.m.u./cm.^{3}. Since pyrrhotite is known to have an easy plane of magnetization and a difficult direction normal to the plane, the observed anisotropy of the slates

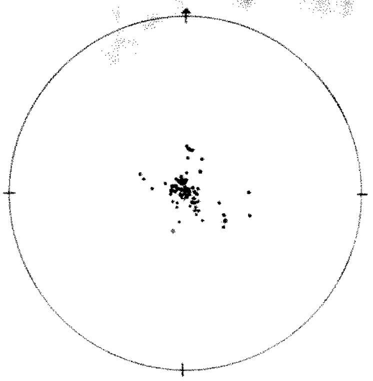


Fig. 3. Equal area projection of the minimum susceptibility directions with the cleavage plane horizontal. Pole to the cleavage, ⊕

could be due to an alignment of the high-susceptibility basal planes parallel to the cleavage. This explanation was confirmed by further examination of the optically uniaxial pyrrhotite in reflected light. In sections cut parallel to the cleavage the grains are predominantly almost isotropic, while in sections perpendicular to cleavage they invariably show distinct anisotropism and moreover they extinguish parallel to the plane of the plates. Hence the platey grains represent the common tabular habit of pyrrhotite, and therefore there is an alignment of the basal planes parallel to the cleavage and this causes the slates to be magnetically anisotropic.

The thermo-remanent magnetization of anisotropic substances has been shown to be deflected from the ambient external field towards the direction of high susceptibility[4,5]. Three specimens of the Crogenon slates, which have pyrrhotite, were given a thermo-remanent magnetization and a mean deviation of 30° recorded. Since the Curie-point of pyrrhotite is 320° C., which may have been exceeded during the metamorphism associated with the Caledonian orogeny, it is possible that the natural remanent magnetization had a thermal origin and is parallel to a component of the Devonian geomagnetic field in the basal planes of the pyrrhotite. Such a mechanism of magnetization does not account for the direction of the natural remanent magnetization of the Bethesda slates because their anisotropy is too small to produce the necessary deviation from the ambient field. Thus we must look to some more direct effect of the stress environment which produced the cleavage.

The magnetic susceptibility of slates is then distinctly anisotropic. The pattern of anisotropy and the direction of natural remanent magnetization are related to the cleavage and were, therefore, determined either directly or indirectly by the stress environment during metamorphism. It is important to note the possible indirect effect of stress demonstrated, for example, by the anisotropic Ballachulish slates in which it is known[6] that the pyrrhotite formed after the slates were cleaved. The mere presence of a foliation such as a cleavage or bedding plane can cause anisotropy if secondary pyrrhotite forms. The effect of anisotropic susceptibility upon magnetization is sufficient to account for the direction of natural remanent magnetization in the slates with pyrrhotite, but not of those with hæmatite. Thus it has been possible to explain the nature of the anisotropic susceptibility of some of the slates in terms of re-crystallization controlled by past stress environments and it should not be difficult to extend this work. However, the nature of the remanent magnetization and the means by which the stress controls its direction are still uncertain.

M. D. Fuller

Department of Geodesy and Geophysics,
Madingley Rise, Madingley Road,
Cambridge.

[1] Girdler, R. W., thesis, University of Cambridge (1959).
[2] Fisher, R. A., *Proc. Roy. Soc.*, A, **217**, 295 (1953).
[3] Creer, K. M., *Phil. Trans. Roy. Soc.*, A, **250**, 111 (1957).
[4] Uyeda, S., *et al.*, *J. Geophys. Res.* (in the press).
[5] Grabowski, M. A., and Brotskaya, C. Yu, *Bull. Acad. Sci. U.S.S.R.*, Geophys. Ser., **8**, 977 (1958).
[6] Neumann, H., *Miner. Mag.*, **29**, 234 (1950).

PHYSICS

Structure of High-Rank Coals deduced from Helium Densities

Wandless and Macrae[1] were the first to show that a relationship exists between the true density of coals and their hydrogen content. Franklin[2] extended this work, and on plotting the specific volume (1/*d*) of a number of coals found that an extrapolation of the straight line drawn through the points, to zero hydrogen content, did not pass through the point for graphite (Fig. 1). For this reason she proposed the hypothesis that the structure of coals is "markedly different from that of graphite". This is in disagreement with the generally accepted theory that coal molecules are basically fused, polynuclear aromatic

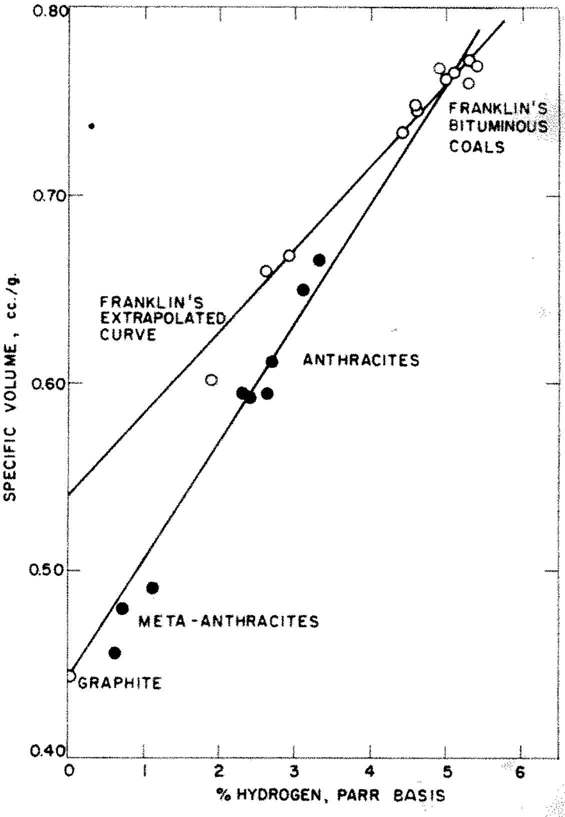


Fig. 1. Specific volume of coals versus percentage hydrogen

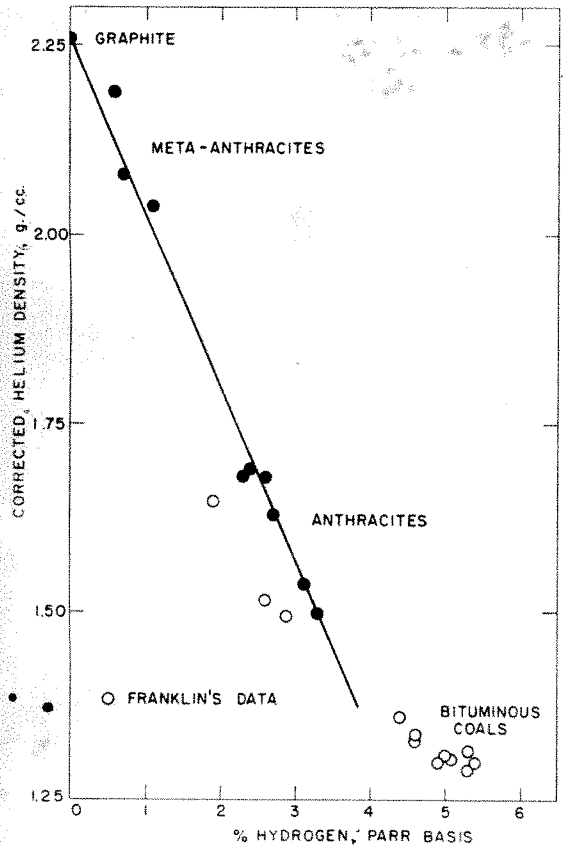


Fig. 2. Density of coals versus percentage hydrogen

structures, that is, islets of small graphitic monolayers which may or may not be associated vertically, and to which various aliphatic groupings are attached. This is suggested in van Krevelen and Chermin's[3] plot of density of coals versus carbon content, in which the density of graphite is considered to be "the true limit" of coalification.

If coals, especially those of high rank, are composed of molecules which are basically related to graphite, then the hydrogen atoms present in these coals should decrease the density of the coals in proportion to the amount of hydrogen present. To test this hypothesis, we have determined the helium densities of three meta-anthracites and six anthracites (Table 1). These were corrected for mineral matter by the method of Wandless and Macrae[1] and the corrected densities plotted against hydrogen content in Fig. 2. The specific volumes of these coals are also plotted in Fig. 1. It will be observed that density gives a closer correlation than specific volume for the high-rank coals. On the other hand, specific volume gives a fair correlation that extends into the bituminous coal region. In either case, it will be observed that graphite constitutes the end-point of these plots, and that there is no reason to assume that high-rank coals have a carbon structure basically different from that of graphite.

Table 1. HELIUM DENSITIES AND ANALYSES OF COALS

Coals	Analysis, Parr basis % H	% C	% S	Helium density (gm./c.c.) d, uncorr.	d, corr.*
Meta-Anthracites					
Rhode Island No. 1	0·6	97·1	0·47	2·330	2·08
No. 2	0·7	97·6	0·08	2·191	2·19
Michigan†	1·1	96·5	0·30	2·100	2·04
Anthracites, Penna.					
Eastern Middle,					
No. 1	2·3	95·5	0·46	1·722	1·68
No. 2	2·4	93·7	0·48	1·753	1·69
Western Middle,					
No. 1	2·6	93·9	0·45	1·824	1·68
No. 2	3·1	92·7	0·66	1·609	1·54
Northern Field	2·7	92·9	0·56	1·664	1·63
West Southern Field	3·3	93·2	0·78	1·542	1·50

*Corrected for mineral matter following Wandless and Macrae (ref. 1).

† Pre-Cambrian algal coal, reputed to be the oldest known coal in the world.

The equation for the line drawn through the densities of the high-rank coals in Fig. 2 is $y = 2 \cdot 26 - 0 \cdot 23x$, where y is density and x is the percentage hydrogen. As will be observed in Fig. 2 this correlation must not be extended too far down the coal series. Coals having hydrogen contents greater than about 3·5 per cent tend to have densities greater than the equation predicts. No doubt this is due to the increasing amount of oxygen and other atoms introduced along with hydrogen into the lower rank coals, and on this basis the density of these coals should not be expected to correlate with their hydrogen content as the only variable affecting density.

A further test of the reliability of the equation above can be made with three high-rank coals investigated by Dulhunty and Penrose[4]. The hydrogen contents of these coals are 2·0, 3·1 and 3·6 per cent. These values give calculated densities of 1·800, 1·547 and 1·432 respectively, which compare favourably with the observed densities of 1·804, 1·512 and 1·430 in the same order.

Fairly good densities of coals so far as the bituminous rank may be calculated using the equation for the line drawn through the specific volumes of the coals in Fig. 1. The equation for this line is $y = 0 \cdot 442 + 0 \cdot 064x$; where y is the specific volume and x is the percentage hydrogen. By calculating the specific volume of a coal with this equation, the density is easily obtained as the reciprocal.

T. S. POLANSKY
H. J. DONALD
C. R. KINNEY

Department of Fuel Technology,
Pennsylvania State University,
University Park, Pennsylvania.

---

[1] Wandless, A. M., and Macrae, J. C., *Fuel*, **13**, 4 (1934).

[2] Franklin, R. E., *Fuel*, **27**, 46 (1948).

[3] van Krevelen, D. W., and Chermin, H. A. G., *Fuel*, **33**, 79 (1954).

[4] Dulhunty, J. A., and Penrose, R. E., *Fuel*, **30**, 109 (1951).

Effect of Carrier Gas on the Sensitivity of Thermal Conductivity Detectors

THE sensitivity of thermal conductivity detectors is proportional to the variation of the wire temperature (t) with the volume fraction (x) of the vapour in the carrier gas. Ray[1] has shown that for small values of x:

$$dt/dx = a(k_1 - k_2)/k_1^2 \qquad (1)$$

where k_1 and k_2 are the thermal conductivities of carrier gas and vapour, respectively, and a is a constant depending on the geometry of the detector cell and the square of the wire current. This equation, and the conclusion drawn by Ray from it, has led to a discussion[2-6] of the merits of carrier gases of high and low thermal conductivity with respect to the sensitivity of thermal conductivity detectors.

It should be noted, however, that Ray's equation is valid only when the thermal conductivity of the mixture satisfies the linear relation $k_m = (1 - x)\, k_1 + xk_2$. In general, thermal conductivities of mixtures are not a linear function of the composition, although quite often, at high dilutions, a linear relation can be obtained by substitution of an effective k_2 for k_2 (ref. 7). However, the value of this effective k_2 depends on the choice of the carrier gas.

It is also possible to replace the linear k_m versus x relation by a more widely applicable empirical equation[8]. This would lead to very complicated formulæ. Instead, we will consider another extreme relation, for example, $1/k_m = (1 - x)/k_1 + x/k_2$ (refs. 9 and 10). Application of this equation gives:

$$\mathrm{d}t/\mathrm{d}x = a(k_1 - k_2)/k_1 k_2 \qquad (2)$$

In contrast with equation 1, equation 2 predicts a higher sensitivity of the detector for carrier gases of high thermal conductivity.

Table 1. EXPERIMENTAL AND CALCULATED DETECTOR SENSITIVITIES (MILLIVOLTS PER VOLUME FRACTION) FOR METHANE IN HYDROGEN AND NITROGEN ($x \sim 0{\cdot}025$)

i (m.amp.)	Hydrogen			Nitrogen		
	Exp.	Eq. (1)	Eq. (2)	Exp.	Eq. (1)	Eq. (2)
30				0·28	0·3	0·2
60				2·25	2·5	2
90				8·6	8·5	6
100	11	4	22	12	12	9
120				21	21	15
150				53	45	35
200	91	33	175			
250	180	65	350	372	265	195
400	790	275	1,430			

Thermal conductivities at the average cell temperature were taken from Berl, W. G., "Physical Methods in Chemical Analysis", 2 (New York, 1931). The temperature was calculated by using the equation for the heat balance in the detector cell.

Table 2. EXPERIMENTAL AND CALCULATED DETECTOR SENSITIVITIES FOR PROPANE IN HYDROGEN AND NITROGEN ($x \sim 0{\cdot}025$)

i (m.amp.)	Hydrogen			Nitrogen		
	Exp.	Eq. (1)	Eq. (2)	Exp.	Eq. (1)	Eq. (2)
30				0·42	0·3	0·4
60				4·4	2·5	3·5
90				15·4	8	11·5
100	20·8	4·5	45	23	11	15
120				37	18	25
150	75	15	155	69	35	45
200	176	35	375	154	75	100
225				195	100	140
250	340	70	730	207	125	165
275				207	150	200
300	564	125	1,260	142	180	220
400	1,390	295	2,950			

Tables 1 and 2 show some experimental sensitivity values, obtained with a four-wire thermal conductivity detector (wire thickness 0·003 cm.; wire length 12 cm.; wire resistance at 0° C. 16·3 ohm; temperature coefficient of the platinum wires 0·0037; detector temperature 25° C.).

The sensitivities (E/x) are expressed in mV. per volume fraction of the vapour. In addition to the experimental values, sensitivities were calculated using equations 1 and 2. A direct comparison between the experimental and calculated values can be made when $\mathrm{d}t/\mathrm{d}x$ is converted into $\mathrm{d}E/\mathrm{d}x$ by means of an approximate equation for the out-of-balance voltage of the bridge,

$$\mathrm{d}E/\mathrm{d}x = \tfrac{1}{2}\, i\, R_0 \alpha\, \mathrm{d}t/\mathrm{d}x \text{ (ref. 7)}$$

where i is the total bridge current, R_0 the resistance of the filaments at 0° C. and α the temperature coefficient of these resistances.

Up to a total bridge current of 250–300 m.amp. (the current should not exceed this figure when nitrogen is used as a carrier gas), the system methane – nitrogen gives higher sensitivities than the system methane – hydrogen, while for propane higher sensitivities are obtained when hydrogen is used as a carrier gas. It is interesting to note that for the propane – nitrogen system the sensitivity reaches a maximum at a current of about 250 m.amp.

The agreement between the experimental values and the sensitivities calculated with both (1) and (2) is rather poor. In our opinion this clearly illustrates the difficulty of predicting sensitivities from k_1 and k_2 without knowing the exact value of the thermal conductivity of the mixture. Although in most cases a calculation of sensitivities will be impossible, our experiments confirm the view[2-6] that the highest sensitivity values can be obtained by employing a carrier gas of high thermal conductivity.

Note added in proof. A. B. Littlewood, in a recent communication (*Nature*, 184, 1631; 1959), gives a semi-empirical method of calculating sensitivities from molecular dimensions.

C. BOKHOVEN
A. DIJKSTRA

Staatsmijnen in Limburg,
Central Laboratory,
Geleen, The Netherlands.

[1] Ray, N. H., *Nature*, **182**, 1663 (1958).
[2] Schmauch, L. J., and Dinerstein, R. A., *Nature*, **183**, 673 (1959).
[3] Wiseman, W. A., *Nature*, **183**, 1321 (1959).
[4] Eden, M., Karman, A., and Stephenson, J. L., *Nature*, **183**, 1322 (1959).
[5] Scott, B. A., and Williamson, A. G., *Nature*, **183**, 1322 (1959).
[6] Fredericks, E. M., Dimbat, M., and Stross, E. H., *Nature*, **184**, 54 (1959).
[7] Keulemans, A. I. M., "Gas Chromatography", second ed., 85 (Reinhold Pub. Co.).
[8] Lindsay, A. L., and Bromley, L. A., *Indust. Eng. Chem.*, **42**, 1508 (1950).
[9] Brokaw, R. S., *Indust. Eng. Chem.*, **47**, 2398 (1955).
[10] Lehman, H., *Chem. Technik*, **9**, 530 (1957).

METALLURGY

Reaction between Copper and Solid Oxygen condensed at Very Low Temperatures from a Gas Discharge

IN recent years numerous studies[1] have been carried out on the short-lived reactive species formed in an electric discharge after trapping and storing them on a low-temperature surface. This communication is concerned with the interaction between the discharge products of oxygen and the metal surface upon which they have been trapped at a low temperature. Copper was chosen as the metal to study because it is frequently used as a condensing surface. Also some data are available on the low-temperature (77° K.) oxidation of copper by molecular oxygen[2,3] and on the reaction of oxygen discharge products with copper at elevated temperatures[4].

Both single crystal and polycrystalline specimens of 99·99 per cent copper were studied. Their surfaces were specially prepared so that they were clean,

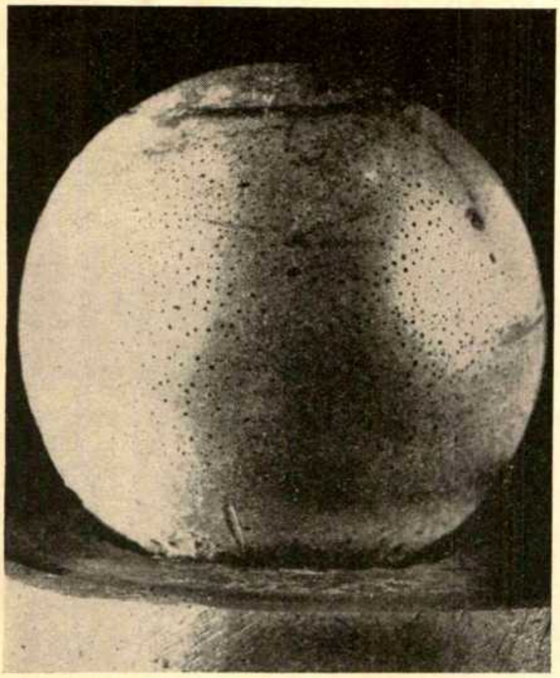


Fig. 1

strain-free, and smooth[5]. Some preliminary experiments were carried out in which a single-crystal sphere at 4·2° K. was placed in the path of a stream of ordinary tank oxygen which had been passed through a 2,450-Mc. electrodeless discharge to dissociate it partially. Small specks of a reaction product could be detected visually (Fig. 1). These were later identified as cupric nitrate by X-ray diffraction, indicating that the tank oxygen contained small amounts of nitrogen. The random distribution of the reaction product on the surface of the spherical single crystal rules out orientation effects. When oxygen of 99·998 per cent purity was used, no reaction could be detected visually.

Most of the experiments were carried out in an apparatus in which the copper specimen, after annealing in hydrogen at 450° C., could be cooled to a desired temperature (usually 4·2° K.) and the thickness of films formed on its surface measured using an ellipsometer[6].

Oxygen was deposited on the bare metal surface, and the thickness of the gas film was measured with the ellipsometer. When discharge products were desired, the oxygen stream was first passed through the microwave generator wave-guide before impinging on the metal surface. After warm-up of the copper specimen to room temperature, ellipsometer readings were again taken.

It was found that, under these particular experimental conditions (Dewar pressure during deposition, about 2×10^{-5} mm. mercury; inlet pressure of oxygen, 0·15–0·7 mm. mercury), molecular oxygen had no effect at any temperature up to 300° K. When the pure oxygen was passed through the microwave discharge, however, a film of reaction product of about 20 Å. thickness formed if the copper surface was at 4·2° K. during deposition. The films formed on all surfaces studied ({100}, {110}, and {111}) were of the same thickness, and this thickness was not increased by subsequent runs. Deposition of extraneous material was ruled out by the fact that no film was found on warm-up on an adjacent gold surface employed as a control. The discharged oxygen had no effect on copper at 40° K. or higher. Further, if a thin film (400 Å.) of molecular oxygen was placed on the copper surface at 4·2° K. and discharged oxygen condensed on top of this, no reaction was observed. Finally, since ozone is formed as one of the discharge products, a check was made to see if it was responsible for the reaction observed by depositing pure ozone on the copper at 4·2° K. As with molecular oxygen, no reaction was observed.

It appeared, then, that a reaction took place on the surface between 4° K. and 40° K., forming a product that is solid at room temperature. The species responsible for the reaction observed is probably atomic oxygen, and the reaction product, an oxide.

The concentration of the trapped oxygen atoms is very low, probably of the order of tenths of a mole per cent[7]. Most of these would recombine at a temperature between 4·2° and 40° K., where they have sufficient mobility, rather than react with the metal surface. The formation of an oxide film may be due to a reaction between the condensed molecular oxygen and the copper surface. The activation energy for this reaction could be provided by the local heating produced by recombinations of oxygen atoms. Further work is in progress on the system described here and on other metals and gases.

We wish to acknowledge the assistance of Dr. G. J. Minkoff of the Imperial College of Science and Technology, London, in carrying out the preliminary experiments while a guest worker at the National Bureau of Standards.

This work was carried out under the National Bureau of Standards Free Radical Research Program, supported by the Department of the Army.

JEROME KRUGER
WILLIAM J. AMBS

National Bureau of Standards,
Washington 25, D.C.

[1] Franklin, J. L., and Broida, H. P., "Ann. Rev. Phys. Chem.", **10**, 145 (1959).

[2] Rhodin, jun., T. N., *J. Amer. Chem. Soc.*, **73**, 3143 (1951).

[3] Rhodin, jun., T. N., *J. Amer. Chem. Soc.*, **72**, 5102 (1950).

[4] Dravenieks, A., *J. Amer. Chem. Soc.*, **72**, 3761 (1950).

[5] Kruger, J., *J. Electrochem. Soc.*, **106**, 847 (1959).

[6] Kruger, J., and Ambs, W. J., *J. Opt. Soc. Amer.* (in the press).

[7] Zwanzig, R. W., Fourth Internat. Symp. on Free Radical Stabilization. Sponsored by the National Bureau of Standards (1959).

ENGINEERING

High-Temperature Creep of Graphite

Davidson and Losty[1] have proposed a logarithmic equation to describe the creep behaviour of synthetic graphites in the temperature-range 1,300–2,000° C. Analysis of results obtained at this laboratory by Martens, Jaffe and Button[2,3] indicates that this equation also gives a good description of graphite creep at higher temperatures, up to 3,000° C. However, there are appreciable differences in the relation of creep to temperature and stress in the two temperature ranges.

Short-time tensile creep data in the temperature-range 2,400–3,000° C. have been obtained for several commercial grades of synthetic graphite using test specimens with a 0·25-in. diameter by 1-in. long gauge section. Heating was accomplished in an automatically controlled graphite tube furnace in a helium

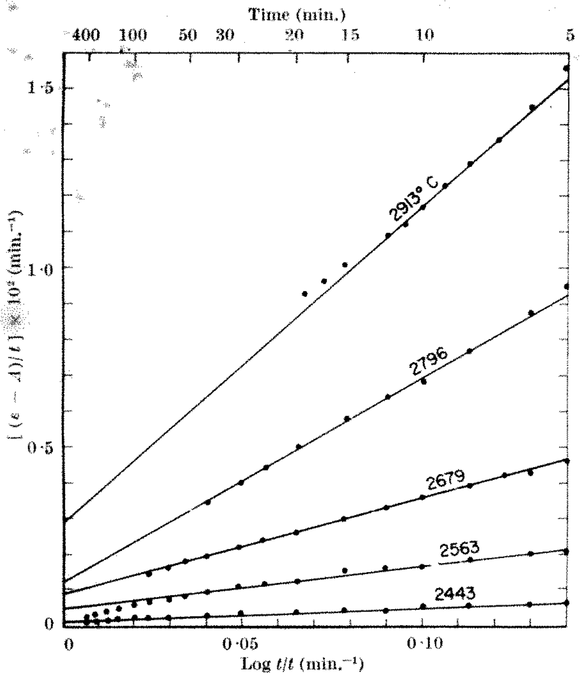


Fig. 1. Creep of *H3LM* graphite plotted according to equation 1. Stress 2,000ψ, parallel to the grain

atmosphere. Tests were generally run to fracture, or 400 min., whichever occurred first. The results discussed here were obtained on specimens cut from one block each of Great Lakes Carbon Co. *H3LM* and Speer Carbon Co. 3499. (The data analysed here were obtained from blocks designated 0401 and 0106 in refs. 2 and 3.) All tests were made on specimens as machined without any preliminary heat treatment, unless otherwise noted. Further details of the creep measurement techniques have been described elsewhere[2,3].

The equation found by Davidson and Losty is of the form:

$$\varepsilon = A + B \log t + Ct \qquad (1)$$

Here, ε is the creep strain, t is time, and A, B and C are constants for each test. Some representative results, plotted on co-ordinates which give a straight line if equation 1 is obeyed, are shown in Fig. 1. The results plotted are for times greater than 5 min. It is evident that the fit is quite good. The points tend to fall above the best straight line at short times and below it at long times. The short-time deviations, which were observed in all the results, may arise in part from errors in the estimation of the A values and from strain measurement errors. The deviations from linearity at long times (for example, the 2,563° C. curve, Fig. 1) cannot be ascribed to these errors. Steady-state creep-rates (C values) determined from the final portion of the creep curves agree with those determined by drawing a tangent to the elongation versus time curve, whereas rates obtained from a linear fit to the early part of the curve (as in Fig. 1) are higher. This behaviour was characteristic of the *H3LM* graphite, but was not generally observed in the 3499 material. This phenomenon apparently reflects a change in the condition of the material which is brought about by the creep deformation. The nature of this change is not understood.

The constants B and C were both found to be Arrhenius functions of the temperature:

$$B = B_0 \exp(-\Delta H_B/RT) \qquad (2a)$$

$$C = C_0 \exp(-\Delta H_C/RT) \qquad (2b)$$

where B_0 and C_0 are functions of the applied stress, R is the gas constant, T is the absolute temperature, and ΔH_B and ΔH_C are observed activation energies. This agrees with the results of Davidson and Losty. The activation energies obtained here for B and C, in that order, were: 112 and 106 kcal./mole from the initial portion of the creep curve, *H3LM*; 70 and 180 kcal./mole for the final part of the curve, *H3LM*; and 81 and 204 kcal./mole for 3499. These values are appreciably higher than those obtained by Davidson and Losty (20–50 kcal./mole). Recent experiments have indicated that, for some blocks of commercial graphite, the creep behaviour is altered by heat treatment at 2,800° C. prior to testing at lower temperatures. Therefore, the energy-values obtained here are best regarded as apparent activation energies. Preliminary results indicate that equation 1 still holds following heat treatment, but the observed activation energies are somewhat lower for some blocks. Both B and C were found to be approximately proportional to the square of the initial applied creep stress over the range 600–3,100ψ at 2,565° C. This differs from the results of Davidson and Losty, who found a linear dependence on stress in the 1,300–2,000° C. range.

Some observations were also made on the creep recovery phenomena. In these experiments, the load was removed after a total creep strain of 5–20 per cent and the strain recovery observed at the same temperature as the creep. In some cases the temperature was increased for periods of ½–1 hr. during recovery. This accelerated the rate of recovery but did not increase significantly the total amount of recovered strain. The amount of recoverable strain ranged from one-tenth to one-third of the total creep elongation. For both the as-received and the pre-annealed specimens, the recoverable strain was generally less than one-half of the transient creep strain (the $B \log t$ term in equation 1). This contrasts with the results of Davidson and Losty, who found that the transient creep strain was completely recoverable. The larger total creep strains employed in the present investigation may contribute to this difference in behaviour.

A sigmoidal curve is obtained when the strain recovery is plotted against the logarithm of the time after removal of the load. A description in terms of a superposition of relaxation processes with a broad spectrum of relaxation times is indicated to account for the curvature in this plot at very short and very long times. However, the recovery behaviour can be approximated by a linear logarithmic time dependence, consistent with the use of equation 1 to describe the creep behaviour. Such a description deviates significantly from the observed results only at very short and very long times (for example, < 2 min. and > 200 min. at 2,680° C.).

Equation 1 is compared with two other creep equations, applied to the analysis of high-temperature creep of graphite, in a paper published elsewhere[3].

Grateful acknowledgment is made to L. D. Jaffe and H. E. Martens for helpful discussions and to King Titus for assistance with the computations.

This communication presents the results of one phase of research carried out at the Jet Propulsion Laboratory, California Institute of Technology, under

Contract *NAS w*-6, sponsored by the National Aeronautics and Space Administration.

D. B. Fischbach

Jet Propulsion Laboratory,
California Institute of Technology,
Pasadena, California.

[1] Davidson, H. W., and Losty, H. H. W., *Nature*, **181**, 1057 (1958); "Mechanical Properties of Non-Metallic Brittle Materials", edit. by Walton, W. H., 219 (Butterworths Scientific Publications, London, 1958).

[2] Martens, H. E., Jaffe, L. D., and Button, D. D., Progress Rep. 20-373, Jet Propulsion Lab., Calif. Inst. Tech., *Trans. Amer. Inst. Mech. Eng.* (in the press).

[3] Martens, H. E., Button, D. D., Fischbach, D. B., and Jaffe, L. D., Progress Rep. 30-18, Jet Propulsion Lab., Calif. Inst. Tech.; in Proc. Fourth Conf. on Carbon (Pergamon Press, London) (in the press).

CRYSTALLOGRAPHY

Mosaic Texture of Graphites

Crystal sizes in graphitic carbons are commonly in the μ or sub-μ range. The average dimensions of the crystallites (that is, the parallel-layer groups of condensed aromatic ring networks) in any particular material are usually deduced from measurements of the widths of X-ray powder diffraction maxima. Although the measurements are complicated by the presence of stacking disorders, techniques exist[1] for eliminating the effects due to these. The dimensions thus obtained are: *La* the average diameter of layer-network over which there is considerable perfection, *t* the average height of parallel-layer group over which the stacking is fully ordered, *Lc* the total height of the group irrespective of the presence of disordered (turbostratic) stacking. With crystallite dimensions greater than about 200 Å. the accuracy of the determination depends very considerably, and to an extent increasing rapidly with crystal size, on the corrections for extraneous (instrumental, absorption, etc.) line-broadening effects. Nevertheless, for good natural graphites the crystallite dimensions are consistently found to be not more than a few thousand Å. (ref. 2 and Steward, E. G., and Cook, B. P., unpublished work). For artificial graphites the dimensions are usually less than 1000 Å. (refs. 2,3,4 and Steward, E. G., and Cook, B. P., unpublished work).

Recent considerations[5] of the graphitization process in anthracites, pyrolytic and evaporated carbons suggest that current views on graphitization are unnecessarily restricted by attaching too great an ultimate and exclusive importance to dimensions measured in the above manner: the concept of larger mosaic '*M*' units has been suggested. Kuroda[6] has used electron diffraction to study cokes and has recently reported evidence of the presence of substructure with preferred orientation. Further evidence in support of the general concept could also be deduced from the more recent electron microscope studies by Dawson and Follett[7], who have reported crystal layer-sizes of about 3000 Å. in a graphitized coke for which X-ray diffraction had given *La* values of less than 800 Å.

Visual examination of crystal flakes of natural graphites clearly reveals a highly oriented mosaic structure. Such flakes may have dimensions of several mm., but X-ray diffraction measurement would indicate parallel-layer group dimensions much smaller than this. That the '*L*' dimensions deduced from the X-ray diffraction broadening arise from the sub-structure may be demonstrated quite simply by the X-ray diffraction Laue method. Fig. 1*a* shows a Laue pattern taken with an X-ray beam of 50μ diameter, approximately normal to a flake selected from a sample of natural graphite. The pattern is seen to approximate to that of a single crystal. However, the spots show break-up typical of a mosaic crystal and it is the diffraction broadening of the individual reflexions within the spot-clusters which is dependent on the size of the mosaic sub-blocks (that is, the parallel-layer groups) and which is the diffraction broadening normally recorded in the 'powder method'. The well-modulated *10* reflexions and the sixfold symmetry of these indicate that there is little stacking disorder of layer-planes within the parallel-layer groups and that there is strong preferred orientation of the *a*-axes of the various parallel-layer groups comprising the mosaic: the weak intensity of *0002* reflexions indicates that the layer-planes are essentially perpendicular to the X-ray beam.

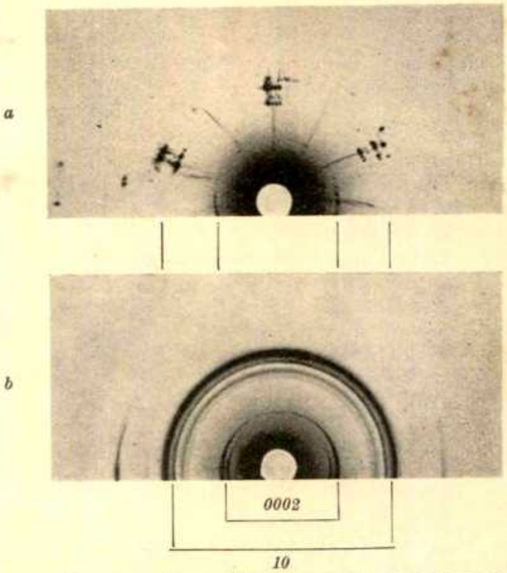


Fig. 1. Laue-type X-ray diffraction photographs of graphitic carbon flakes: 50μ beam approximately normal to flakes. (Copper radiation.) *a*, Natural (Ceylon) graphite; *b*, petroleum coke: graphitized at 2,700° C.

It is logical that a similar mosaic condition exists to different extents in graphitic carbons generally. This is illustrated in Fig. 1*b*, which shows the Laue pattern obtained with the 50μ beam, from a thin flake of graphitized coke: the selected flake was not necessarily typical of the whole coke. The intensity of the *0002* reflexion relative to that of the *10* reflexions again indicates a mosaic formed by strong preferred coplanar orientation, parallel to the surface of the flake, of the *La* areas: the pronounced arcing of the weak *0002* reflexions is due to the flake being somewhat cylindrically curved about an axis approximately normal to the beam. The extensive modulation of the *10* band into the component 3-dimensional $10\bar{1}0$ and $10\bar{1}1$ reflexions shows that turbostratic stacking is not appreciable: the circumferential arcing of spots to form smooth rings is therefore indicative of a large number of small (*La*) units and of lack of preferred orientation of the *a*-axes of these within the above mosaic planes.

These simple experiments thus demonstrate by X-ray diffraction methods the existence one would expect of mosaic units in graphitic carbons. In such a material the particles will not necessarily have a uniform *L* : *M* size relationship and there will also be different types of boundary between the L volumes comprising an M mosaic. In some circumstances there may be a condition where $L = M$ and the particle would then be an unoriented agglomerate of crystallites.

The texture will, of course, vary profoundly from one carbon to another. In a well-crystallized (for example, natural) graphite there will be considerable 3-dimensional near-parallel alignment of layer-groups to form mosaics closely approximating to single crystals. Larger misorientations between the mosaic sub-blocks, particularly in the Ma plane, would in part account for the limited ultimate crystalline development in other so-called 'graphites'.

Thus, while X-ray diffraction has the unique ability to reveal the size of the basic crystalline unit in carbons, further parameters need to be recognized when assessing the general crystalline texture of such materials and when considering their physical properties.

E. G. Steward
B. P. Cook

Research Laboratories,
The General Electric Co., Ltd.,
Wembley, England.

[1] Houska, C. R., and Warren, B. E., *J. App. Phys.*, **25**, 1503 (1954).

[2] Bacon, G. E., A.E.R.E. *M/R* 2702, Unclassified Report, 14 (1958).

[3] Franklin, R. E., *Acta Cryst.*, **4**, 253 (1951).

[4] Bowman, J. C., Proc. First and Second Conf. on Carbon, 59 (University of Buffalo, 1956).

[5] Steward, E. G., and Cook, B. P., *Z. Krist.* (in the press).

[6] Kuroda, H., *Bull. Chem. Soc., Japan*, **32**, 728 (1959).

[7] Dawson, I. M., and Follett, E. A. C., *Proc. Roy. Soc.*, A, **253**, 390 (1959).

Crystal Structure of Adenosine-5′-phosphate

Adenylic acid, or adenosine-5′-phosphate, is a nucleotide of particular biochemical interest. It is not only a component of ribonucleic acid, but also forms a part of the structure of many coenzymes and, as the di- and tri-phosphate, it is frequently involved in metabolic processes. Spencer[1] has reviewed the information at present available on the constituent components of the nucleotides from crystal structure analysis. In addition to the references cited by Spencer, one may also mention the brief note of Brown *et al.*[2] on a single projection of adenosine-3′-phosphate and the paper by Alver and Furberg[3] on the structure of cytidine-3′-phosphate. No nucleoside-5′-phosphate has been solved previously.

The unit cell parameters for adenylic acid are $a = 12{\cdot}77$ Å., $b = 11{\cdot}82$ Å., $c = 4{\cdot}88$ Å., $\beta = 92°\ 19'$, space group $P2_1$. Unidimensionally integrated data were collected on a Wiebenga-type camera using copper radiation.

The structure was solved by three-dimensional Patterson superposition methods based on identification of the phosphorus peak in the Harker section at $v = \frac{1}{2}$. It has been refined in projection on (010) and along [001] to R values of 13·7 per cent and 13·4 per cent respectively. Fig. 1*A* is an F_0 synthesis showing $e(x,y)$ at the present state of refinement, and Fig. 1*B* is a perspective drawing of the molecule.

It may be noted here that the ribose ring is puckered in such a way that carbon 3′ is about 0·5 Å. out of the approximate plane formed by the four remaining atoms of the ring, lending further support to Spencer's hypothesis that the preferred conformations of the ribose ring are those with either atom 2′ or 3′ out of the plane.

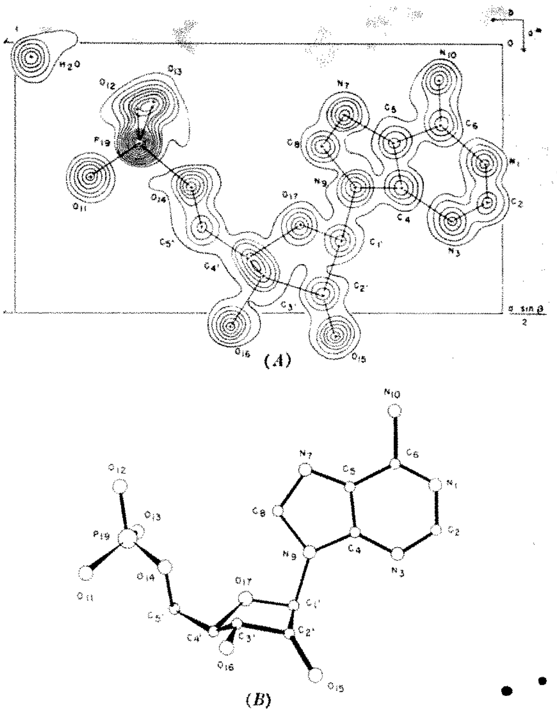


Fig. 1. (*A*) Fourier synthesis showing projection of electron density along [001]; contours at intervals of 2 e/Å.². (*B*) Perspective drawing of the adenylic acid molecule

The structure is being refined further with full three-dimensional data, and a complete account will appear elsewhere.

J. Kraut
Department of Biochemistry,

L. H. Jensen
Department of Anatomy,
University of Washington,
Seattle 5, Washington.

[1] Spencer, M., *Acta Cryst.*, **12**, 59 (1959).

[2] Brown, D. M., Fasman, G. D., Magrath, D. I., Todd, A. R., Cochran, W., and Woolfson, M. M., *Nature*, **172**, 1184 (1953).

[3] Alver, A., and Furberg, S., *Acta Chem. Scand.*, **13**, 910 (1959).

Crystal Structure of Tetraphenyl*cyclo*butadiene Iron Tricarbonyl

There has been much recent interest[1-5] in the possible existence of the *cyclo*butadiene ring system in transition metal complexes, and a crystal structure determination[6] has verified that Criegee and Schröder's $C_8H_{12}NiCl_2$ is indeed tetramethyl *cyclo*butadiene nickel dichloride. The present investigation similarly verifies the conjecture[4,5,7] that the compound $Fe(CO)_3(C_6H_5C_2C_6H_5)_2$ of Hübel *et al.*[4] is tetraphenyl*cyclo*butadiene iron tricarbonyl.

The yellow crystals, supplied by European Research Associates, are monoclinic with $a_0 = 8{\cdot}93$ Å., $b_0 = 18{\cdot}73$ Å., $c_0 = 14{\cdot}10$ Å., $\beta = 92{\cdot}6°$, with four molecules per cell, and have extinctions corresponding to space group $P2_{1/c}$. Diffraction intensities were obtained by the stationary crystal–stationary counter technique[8] at rates as high as 500 a day using a General Electric *XRD*-5 spectrometer equipped with single-crystal orienter and scintillation counter. A total of 2,306 reflexions, all the reflexions with $\lambda^{-1} \sin\theta \leqslant 0{\cdot}481$, were measured with a molybdenum $K\alpha$ source; of these, the strongest 1,100 have been used in the work so far.

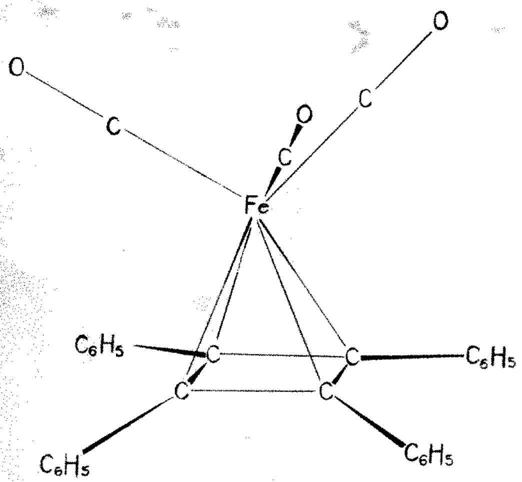


Fig. 1

The three-dimensional Patterson function clearly indicated the correct Fe—Fe vectors. Three-dimensional superposition based on the Fe position and recorded by means of the zero contour of the minimum function led to the correct structure except for two carbon atoms, one missing and one badly misplaced. An electron-density map then revealed the complete structure, and two further cycles of Fourier refinement have resulted in only relatively small further adjustments. The present agreement between observed and calculated structure factors is good, with discrepancy index (for the 1,100 reflexions used) of $R = 0 \cdot 145$. Further refinement is in progress.

The molecular structure is shown in Fig. 1. The *cyclo*butadiene ring is square planar to within the errors of the present determination of atomic positions, which, from the planarity and symmetry of the phenyl rings, linearity of the Fe—CO groups, and approximate agreement of the bond-lengths with standard values, are judged to be about 0·1 Å. Relative to an axis through the iron atom and the centroid, x, of the $(C_6H_5)_4C_4$ group, the $(CO)_3$ constellation has three-fold symmetry to within about 3° (with angles x-Fe—CO of about 120°) and the $(C_6H_5)_4$ constellation has fourfold symmetry to less than 5° except for twisting and bending of the phenyls out of the mean C_4 plane. The twists, all of the same hand in any one molecule, are about 30°, 30°, 30°, and 60°, and the bends, all away from the $Fe(CO)_3$, average about 10°. The phenyl of 60° twist is *trans* to a carbonyl. The intermolecular packing is generally good, but whereas no consistent intramolecular explanation is apparent for the asymmetry of phenyl twist, this irregularity does seem to correspond to certain irregularities in the packing.

R. P. Dodge
V. Schomaker

Union Carbide Research Institute,
P.O. Box 324, Tuxedo, New York.

[1] Longuet-Higgins, H. C., and Orgel, L. E., *J. Chem. Soc.*, 1969 (1956).
[2] Criegee, R., and Schröder, D., *Annalen der Chemie*, **623**, 1 (1959).
[3] Schrauzer, G. N., *J. Amer. Chem. Soc.*, **81**, 5307 (1959).
[4] Hübel, W., Braye, E. H., Clauss, A., Weiss, E., Krüerke, U., Brown, D. A., King, G. S. D., and Hoogzand, C., *J. Inorg. Nucl. Chem.*, **9**, 204 (1959).
[5] Hübel, W., and Braye, E. H., *J. Inorg. Nucl. Chem.*, **10**, 250 (1959).
[6] Dunitz, J. D., Mez, H. C., and Shearer, H. M. M., paper presented at the Seventeenth Int. Cong. Pure and App. Chem.
[7] Brown, D. A., *J. Inorg. Nucl. Chem.*, **10**, 45 (1959).
[8] Furnas, jun., T. C., "Single Crystal Orienter Instruction Manual", p. 81.

CHEMISTRY

Gaussian Wave Functions for the Hydrogen Molecule

Some time ago, Boys[1] showed that the troublesome potential energy integrals which arise in the quantum mechanical treatment of molecular problems are easily evaluated when the electronic wave function is expressed in terms of Gaussian functions:

$$\psi = \sum_k C_k \exp\left\{ - \sum_j a_j^k \mid r_j - \alpha_j \mid^2 \right\} \qquad (1)$$

(C_k, a_j^k are constants, α_j^k are constant vectors and r_j is the position vector of the j^{th} electron), and in terms of derivatives of such functions. The most complicated integrals can be reduced to expressions containing elementary functions and error functions (or derivatives of error functions).

Recently, Boys[2] showed that this is also true when correlation terms such as $\sum_j \sum_i g_{ji}^k \mid r_j - r_i \mid^2$ are added to the exponent of (1); while one of us[3] found independently that the potential energy integrals associated with Gaussian functions of the very general type:

$$\psi = \sum_k P_k \exp\ (- Q_k) \qquad (2)$$

(where Q_k is any positive definite quadratic form and P_k a polynomial in the electron co-ordinates) can be reduced to quadratures.

Gaussian functions of the form (1) have been used by Meckler[4] in calculations for the oxygen molecule. The more general functions which result from the addition of correlation terms are of interest because inter-electronic correlation is not easily taken into account when conventional wave functions (based on atomic orbitals) are used.

As a first step in the examination of wave functions of the form (2) we have carried out calculations for the ground-state of the hydrogen molecule. The wave functions were of the form:

$$\psi = \sum_{k=1}^{n} C_k \left[\varphi_k^+ (1,2) + \varphi_k^+ (2,1) + \varphi_k^- (1,2) + \varphi_k^- (2,1)\right]$$

$$\varphi_k^\pm = \exp\{-a_k (x_1^2 + y_1^2) - b_k (x_2^2 + y_2^2) - 2g_k (x_1x_2 + y_1y_2) - c_k (z_1 \pm \alpha_k)^2 - d_k (z_2 \pm \beta_k)^2 - 2h_k (z_1 \pm \alpha_k) (z_2 \pm \beta_k)\} \qquad (3)$$

which corresponds to electron orbitals of cylindrical symmetry with correlation and with 'floating' centres. The energy was minimized with respect to the parameters $C_k, a_k, b_k, c_k, d_k, \alpha_k, \beta_k, g_k, h_k$ at the equilibrium internuclear distance. Table 1 lists the binding energies obtained for $n = 3$, 4, 6 and 8.

Table 1

$n =$	3	4	6	8
No. of independent variable parameters	26	35	53	71
D (eV.)	4·30	4·42	4·52	4·58

The omission of the correlation parameters (g_k, h_k) led to poorer results (4·07 for $n = 3$ and 4·35 for $n = 8$).

The binding energies obtained with $n = 6$ and $n = 8$ are, so far as we know, higher than any other calculated values except those of James and Coolidge[5] (4·70); and it is worth noting that these authors used elliptical co-ordinates which are not suitable when the molecule contains more than two centres.

In spite of the large number of variable parameters the computing times (on a 'Mercury' electronic computer) were relatively short: the evaluation of a typical matrix element, for example:

$$\int \varphi_{k^+}(1, 2)\, H\varphi_{k^-}(2, 1)\, d\tau$$

required less than 0·2 sec., the calculation of the energy for a given set of parameters varied from 13 sec. for $n = 3$ to 63 sec. for $n = 8$, and the corresponding total computing times were approximately 2 hr. and 14 hr. respectively.

A full account will be published elsewhere. Further work is in progress.

We wish to express our thanks to the director and staff of the London University Computer Unit for enabling us to use the facilities of the Unit.

J. V. L. Longstaff
K. Singer

Department of Chemistry,
Royal Holloway College,
Englefield Green, Surrey.

[1] Boys, S. F., *Proc. Roy. Soc.*, A, **200**, 542 (1950).
[2] Boys, S. F. (unpublished work).
[3] Singer, K. (unpublished work).
[4] Meckler, A., *J. Chem. Phys.*, **21**, 1750 (1953).
[5] James, H. M., and Coolidge, A. S., *J. Chem. Phys.*, **1**, 825 (1933).

Non-Equilibrium Theory of Gas-Liquid Chromatography

In a gas-liquid chromatographic column the assumption of equilibrium demands that the rate constants for solute transfer between the gas and the liquid phases must be infinitely large and the flow-rates extremely small. In practical columns neither of these conditions is ever fulfilled; the kinetic rate constants are finite, and the use of extremely slow flow-rates is out of the question because of undesirably long retention times and pronounced longitudinal diffusion in the gas phase which enhances band broadening. This has led various workers to advance theories which take account of the effect of non-equilibrium conditions on band structure and column efficiencies[1–4]. Of particular importance is the van Deemter theory[4], which uses the driving force concept to describe the departure from equilibrium in terms of resistances to mass transfer in the gas and the liquid phases. The hypothesis of interfacial equilibrium involved in the theory is one the validity of which cannot be demonstrated directly by experiment. The existence of equilibrium at the interface would mean that if the concentration in the liquid phase at the interface is specified, the concentration in the gas phase at the interface is the same as if the two phases had been in contact for an indefinite length of time. Owing to continuous flow of carrier gas it is scarcely likely that the molecules once evaporated from the surface will get to the same spot again, and this, obviously, introduces conceptual difficulties regarding the nature of dynamic equilibrium at any point within the column. A natural consequence of the assumption of interfacial equilibrium is that once the diffusing molecules strike the interface, they pass into the other phase without experiencing any resistance at the interface itself. On the contrary, discrepancies between the calculated and observed rates of absorption suggest that there should be resistance to mass transfer at the interface[5–7]. From the point of view of the theory of absolute reaction-rates, there are sound theoretical grounds for postulating the existence of interfacial resistance. One can imagine an energy barrier which may involve the formation of an 'intermediate-activated state'; of all the molecules which strike the boundary surface only those which have the required energy of activation for diffusion surmount the energy barrier while the rest rebound into the gas phase, and furthermore the orientation of molecules may play a part.

A more general theory of the chromatographic process, which takes into account the whole gamut of diffusion processes and is not restricted to equilibrium conditions, has been worked out. The absorption and desorption processes are described by the simple laws of kinetic theory which can handle problems outside the domain of equilibrium in a fairly direct manner. The solution of the partial differential equations, when interpreted in terms of the first and second moments of the residence-time distribution-functions, leads to the following expressions for the retention time (t_R) and the height equivalent to a theoretical plate (H):

$$t_R = \frac{L}{u}\left(1 + \frac{a_2}{a_1}\frac{k_1}{k_2}\right) \qquad (1)$$

and:

$$\overbrace{H = \underbrace{\underbrace{2\lambda dp}_{\text{Apparent diffusion}} + \underbrace{2\gamma\,\frac{D_1}{u}}_{\text{Molecular diffusion}}}_{\text{Longitudinal diffusion}} + \underbrace{\frac{2}{3}\,\frac{\frac{a_2}{a_1}\cdot\frac{k_1}{k_2}\cdot d^2_{f_1}}{\left(1+\frac{a_2 k_1}{a_1 k_2}\right)^2}\cdot\frac{u}{D_1}}_{\text{Resistance to mass transfer}}}^{\text{GAS PHASE}} + \overbrace{2\,\frac{\frac{a_2}{a_1}\left(\frac{k_1}{k_2}\right)^2}{\left(1+\frac{a_2 k_1}{a_1 k_2}\right)^2}\,\frac{a_2}{k_1\sigma}\cdot u}^{\text{Interfacial resistance to mass transfer}} + \overbrace{\underbrace{\frac{2}{3}\,\frac{\frac{a_2 k_1}{a_1 k_2}\cdot d^2_{f_2}}{\left(1+\frac{a_2 k_1}{a_1 k_2}\right)^2}\cdot\frac{u}{D_2}}_{\text{Resistance to mass transfer}} + \underbrace{2\,\frac{a_2 k_1}{a_1 k_2}\cdot\frac{D_2}{u}}_{\text{Longitudinal diffusion}}}^{\text{LIQUID PHASE}} \qquad (2)$$

where a_2/a_1 is the ratio of the area of cross-section of the liquid to that of gas phase, d_{f_1} and d_{f_2} are the 'effective depths' of the gas and liquid phases, k_1 and k_2 are absorption and desorption-rate constants respectively, σ the surface area per unit column length, and the rest of the letters have the same meaning as described in van Deemter's theory.

The theoretical basis for the above expressions is too lengthy to be given here. Although diffusion in the liquid phase normal to the interface is of primary importance, the general treatment of the problem demanded the inclusion of diffusion parallel to the interface which is represented by the last term in equation 2. In gas-liquid chromatography, the resistance to mass transfer in the gas phase is usually assumed to be negligible as compared with that in the liquid phase. The resistance at the interface may be an important factor in the design of chromatographic columns particularly at high flow-rates and low specific surface areas. We are at present investigating the possibility of evaluating the expression for interfacial resistance.

I wish to express my thanks to the Directors of "Shell" Research, Limited, for their kind permission to publish this communication. I am also grateful to Mr. A. J. Davies for many helpful discussions.

M. A. KHAN

"Shell" Research, Ltd.,
Thornton Research Centre,
P.O. Box 1,
Chester.

[1] Glueckauf, E., and Coates, J. I., *J. Chem. Soc.*, 1315 (1947).
[2] Lapidus, L., and Amundson, N. R., *J. Phys. Chem.*, **56**, 984 (1952).
[3] Glueckauf, E., *Trans. Farad. Soc.*, **51**, 34 (1955).
[4] van Deemter, J. J., Zuiderweg, F. J., and Klinkenberg, A., *Chem. Eng. Sci.*, **5**, 271 (1956).
[5] Emmert, R. E., and Pigford, R. L., *Chem. Eng. Prog.*, **50**, 87 (1954).
[6] Danckwerts, P. V., and Kennedy, A. M., Inst. Chem. Eng., Symp. on Gas Absorption (1954).
[7] Vivian, J. E., and Peaceman, D. W., *Amer. Inst. Chem. Eng.*, **2**, 437 (1956).

A Rapid Method for Qualitative Analysis of Volatile Mercaptan Mixtures

THE recently developed technique of flash exchange gas chromatography[1,2] has proved valuable for the determination of trace quantities of volatile aldehydes, ketones and acids. This approach has now been extended to the qualitative analysis of volatile mercaptans[3,4] by use of the exchange reaction between mercuric mercaptides and toluene-3,4-dithiol.

Mercuric mercaptides[5–7] (3–5 mgm.) are introduced into a glass capillary melting point tube and an equal weight of warmed (liquid) toluene-3,4-dithiol added. The tube contents are centrifuged to produce a slurry of mercaptides in toluene-3,4-dithiol. The open end of the tube is placed in the sample port of a gas chromatography unit and the lower part of the tube is heated at 245–260° for 15 sec. in an oil-bath. The exchange reaction takes place and C_1–C_4 saturated mercaptans flash into the unit for separation and identification.

In Table 1 are tabulated the retention times for mercaptans regenerated in the exchange reaction. The reaction is slow and only the highly volatile mercaptans escape the reaction mixture in sufficient amount to give good detector response (heating *n*-pentyl and *n*-hexyl mercaptides with toluene-3,4-dithiol produces no definite peaks).

Table 1. RETENTION TIMES FOR MERCAPTANS (*R*SH) REGENERATED FROM MERCURIC MERCAPTIDES WITH TOLUENE-3,4-DITHIOL

R	Retention time (min.) ¼ in. × 10 ft. Carbowax 1540, 80° *	Retention time (min.) ¼ in. × 5 ft. Apiezon *M*, 60° †
H	no reaction	
CH_3	3·6	1·3
C_2H_5	4·8	2·3
iso-C_3H_7	5·1	3·3
n-C_3H_7	7·9	5·4
iso-C_4H_9	10·5	9·4
sec.-C_4H_9	8·6	8·4
tert.-C_4H_9	5·2	4·3
n-C_4H_9	13·9	12·9

* Flow-rate of helium, 35 ml./min. † Flow-rate of helium, 50 ml./min.

No evidence was found for the thermal decomposition of mercuric mercaptides to disulphides[7] under the conditions of the exchange reaction. Alkyl sulphide–mercuric chloride complexes react with toluene-3,4-dithiol to produce the sulphide along with small amounts of the corresponding mercaptans. Lead mercaptides give a much slower rate of reaction with toluene-3,4-dithiol than the mercuric mercaptides.

We wish to acknowledge the helpful interest of Prof. Arthur Furst (Stanford University) in providing several potential exchange reagents.

JOHN F. CARSON
WILLIAM J. WESTON
JACK W. RALLS*

Western Utilization Research and Development Division,
Agricultural Research Service,
U.S. Department of Agriculture,
Albany,
California.

* Collaborator employed by the National Canners Association, with which this work was conducted co-operatively.

[1] Ralls, J. W., Abstracts of the 135th National Meeting, American Chemical Society, Boston, Mass., 12 (April 5–10, 1959).
[2] Ralls, J. W., *Anal. Chem.*, **32**, 332 (1960).
[3] Carson, J. F., and Wong, F. F., *J. Org. Chem.*, **22**, 1725 (1957).
[4] Jacot-Guillarmod, A., and Cuchini, P., *Helv. Chim. Acta*, **42**, 713 (1959).
[5] Challenger, F., and Greenwood, D., *Biochem. J.*, **44**, 87 (1949).
[6] Dateo, G. P., Clapp, R. C., MacKay, D. A. M., Hewitt, E. J., and Hasselstrom, T., *Food Res.*, **22**, 440 (1957).
[7] Reid, E. E., "Organic Chemistry of Bivalent Sulfur", **1**, 143 (Chemical Publishing Company, Inc., New York, 1958).

Coloured Sulphur Deposits at Low Temperatures

F. O. RICE obtained green, purple and black deposits by chilling sulphur vapour at liquid-air temperature[1]. Several parameters of the experiments, predominantly the vapour temperature, determine the colour. With the help of equilibrium data of the vapour composition[2] Rice has concluded that the yellow deposits arise from cyclo-S_8, green ones from catena-S_8 and purple to black ones from S_2.

In the course of a series of investigations on unstable low-temperature deposits we have chosen the sulphur system as a model. A summary of our results follows[3].

Each apparatus consisted of four units in series: (1) sulphur reservoir with large liquid surface at temperature ν_S° C.; (2) heated quartz-tube designed for multiple collisions of sulphur molecules with the wall at ν_f° C.; (3) molecular beam defining orifice;

Table 1

ν_s ° C.	ν_f ° C.	ν_t ° C.	mgm. S/cm.² min.	Colour of deposit approximately 10μ thick Reflected light	Transmitted light
160	200	−188	0·3	yellowish-green	
160	275	−188	0·3	dark green	red brown
160	300	−188	0·3	blue green	red
160	380	−188	0·3	violet	yellow red
105	600	−188	0·01	green	reddish
145	600	−188	0·2	dark green	red
200	600	−188	1·6	violet	yellow red

(4) target (ice, sodium chloride, potassium bromide, quartz, aluminium, copper) in high vacuum at temperature ν_t° C. The experiments were performed under near equilibrium and widely varied conditions, for example, ν_s and sulphur vapour pressure, ν_f, ν_t, (liquid helium, hydrogen, air, ethylene, solid carbon dioxide, room temperature), residual gas-pressure, rate of sulphur deposition.

Coloured deposits (other than yellow ones) are formed at $\nu_f > 250°$ C., $\nu_t < -100°$ C., and at a target ambient pressure sufficiently low for essentially collision-free flow of molecules from orifice to target. The deposits have a rough surface and sandy texture below − 100° C.

Table 1 shows the correlation of colour with ν_f and rate of deposition.

Ultra-violet and visible spectra of green deposits are continuous with a maximum absorption at 507 mμ.

In the infra-red all the deposits lower the transmission considerably in the range 1–25μ, probably due to scattering. Coloured deposits exhibit a strong absorption-band at 14·96μ = 668·5 cm.$^{-1}$ (Fig. 1*a*) with a half-width of ∼ 7 cm.$^{-1}$. This band grows linearly with deposit thickness (Fig. 1*b*), does not change in 150 hr. at − 190° C., but vanishes according to a first-order rate law with $t_{\frac{1}{2}}$ = 57·7 hr. at − 104° C. (Fig. 1*c*), and (extrapolated) $t_{\frac{1}{2}}$ = 18 min. at −78° C. Deposits which have been above − 78° C. do not redevelop infra-red absorption or colour on re-freezing to − 190° C.

This infra-red band is without any doubt due to the unstable sulphur form (method of purification and other arguments[3]). There is no measurable qualitative correlation of infra-red spectrum with colour. In matrix experiments with xenon (Xe : S = 500) only green deposits are formed with the same band at 668 cm.$^{-1}$.

At a micro-wave frequency of 9,500 Mc./sec. no paramagnetic resonance is observed with 3·2 mgm. of green sulphur deposit at − 188° C. in the cavity between 2,000–7,000 gauss (line width 100 gauss). An upper limit of 0·01 per cent detectable 'free spins' relative to the deposited number of S-atoms follows from this observation (measurements by Mr. F. Waldner, Physics Institute of the University of Zurich).

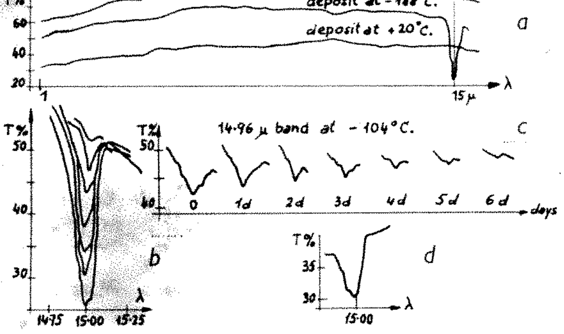


Fig. 1

Deposits of different colour have an electrical resistivity of 2 × 10^6 Ω cm. at − 188° C. compared with 10^{18} Ω cm. for normal sulphur. No photosensitivity with near ultra-violet and visible light is observed.

At room temperature deposits on sodium chloride formed below − 100° C. can be removed as coherent, shiny films which collapse elastically to a fortieth of their surface-area. They are 30 per cent soluble in carbon disulphide 2 hr. after warming up.

The experiments with a xenon matrix demonstrate the existence of trapped S_2, since this is the only sulphur constituent of the molecular beam. The infra-red absorption at 668·5 cm.$^{-1}$ must, therefore, be attributed to an induced vibrational transition of S_2 in the asymmetrical quasi-solid environment which has not been communicated before. There is a shift of 53 cm.$^{-1}$ from the fundamental ω_0 = 721·6 cm.$^{-1}$ in the gaseous state[4]. This fact and a barely visible fine-structure (Fig. 1*d*) are also characteristics of induced absorptions in liquid or solid oxygen[5]. S_2 is also responsible for the green colour of the xenon matrix. With the deposits of pure sulphur alone additional colours and a not very much stronger infra-red band are observed than in the very dilute S_2–Xe matrix. This can be understood by the following argument. S_2 molecules arrive at the target with enough kinetic energy to align themselves, combine, and form unoriented chains of variable length before attaining the target temperature. All these S_n-chains (n = 3, 4 . . . 8 . . .) together essentially show continuous infra-red absorption in the range studied. They form a 'self-matrix' which traps S_2 molecules at a concentration which is dependent on the parameters of deposit-formation, but which is constant under specified conditions.

Whereas this mechanism accounts for the transformation of most of the S_2 molecules on the target, the explanation of the different colours must start from the observation that no direct relation of the molecular composition of the deposits with colour exists. Infra-red absorption attributable to S_3 or S_4 . . . or S_8 . . . is not detected since no band, except at 14·96μ, shows up clearly. Therefore the colour must be due to the physical pattern of aggregation of the sulphur on the target, that is, to selective scattering at polymer-clusters of roughly equal diameter[6]. Their size (∼ 1000 Å.) depends on the rate of deposition or vapour temperature (Table 1). Reflected and transmitted light have complementary colours in agreement with this interpretation. Above − 100° C. the clusters combine and merge into a film covering the target evenly. The rough surface changes to a shiny one. Trapped S_2 molecules are set free to add to longer chains. On freezing again no S_2 absorption or colour-changes are detectable. The result of the paramagnetic resonance measurements is consistent with these interpretations[7]. The biradical character of the chains is probably responsible for a much lower electrical resistivity, the electrons in antibonding π-orbitals being largely delocalized along the chains.

This work has been supported in part by the Schweizerischer Nationalfonds, project *A* 92. We

wish to thank Profs. J. Dunitz, E. Miescher and K. Wieland for discussions.

B. Meyer
E. Schumacher

Institute for Inorganic Chemistry,
University of Zurich.
April 27.

[1] Rice, F. O., and Sparrow, C., *J. Amer. Chem. Soc.*, **75**, 848 (1953). Rice, F. O., and Ditter, J., *ibid.*, **75**, 6066 (1953). Schenk, P. W., *Z. angew. Chemie*, **65**, 325 (1953). Freund, T., *J. Chem. Phys.*, **21**, 180 (1953).

[2] Braune, H., Peters, S., and Neveling, V., *Z. Naturforsch.*, **6**, *a*, 32 (1951); **7**, *a*, 486 (1952).

[3] Extensive publication of method, data and interpretation in *Helv. Chim. Acta*; see also, Meyer, B., thesis, Zurich (1960).

[4] Herzberg, G., "Molecular Spectra and Molecular Structure of Two-Atomic Molecules" (New York, 1950).

[5] Crawford, M. F., and Dagg, J. R., *Phys. Rev.*, **91**, 1569 (1953). Smith, A. L., Keller, W. E., and Johnston, H. L., *ibid.*, **79**, 728 (1950). Welsh, H. L., Crawford, M. F., MacDonald, J. C. F., and Chisholm, D. A., *ibid.*, **83**, 1264 (1951). Bass, A. M., and Broida, H. P., *J. Opt. Soc. Amer.*, **47**, 163 (1957).

[6] Coloured sulphur dispersions: V. Weimarn, P. P., *Kolloid-Z.*, **20**, 278 (1917). Kenyon, A. S., and La Mer, V. K., *J. Colloid Sci.*, **1**, 71, 79 (1946). La Mer, V. K., and Barnes, M. D., *ibid.*, **2**, 349, 361 (1947); **4**, 163 (1949).

[7] Cf. Gardner, D. M., and Fraenkel, G. K., *J. Amer. Chem. Soc.*, **78**, 3279 (1956). Ingram, D. J. E., "Free Radicals", 219 (Butterworth, 1958). Jen, C. K., Foner, S. N., Cochran, E. L., and Bowers, V. A., *Phys. Rev.*, **112**, 1169 (1958). Meyer, H., O'Brien, M. C. M., and van Vleck, J. H., *Proc. Roy. Soc.*, A, **243**, 414 (1958).

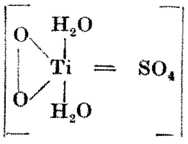
Nature of the Colour-forming Species in Peroxy Titanium Sulphate

Although titanium is determined colorimetrically in aqueous sulphuric acid medium in presence of excess of hydrogen peroxide, the nature of the colour-forming species is not known definitely. Schwarz[1] suggested that the colour was due to the peroxo–disulphato titanate anion $[O_2Ti(SO_4)_2]^{2-}$. On the other hand, Jahr[2] and later Gastinger[3] considered that the colour of the compound was due to the peroxy titanyl cation $[TiO_2\ aq.]^{2+}$, and suggested the following equilibrium in solution:

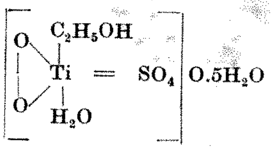
$$\underset{\text{Coloured}}{[TiO_2\ aq.]^{2+}} + H_2O = \underset{\text{Colourless}}{[TiO\ aq.]^{2+}} + H_2O_2 \qquad (1)$$

Schaeppi and Treadwell[4] attributed the colour to O_2TiSO_4 or $[O_2Ti(SO_4)_2]^{2-}$, whereas Babko and Volkova[5] represented the coloured complex ion as $[Ti(H_2O_2)]^{4+}$. Mori, Shibata, Kyuno and Ito[6] regarded the coloured species as $[TiO_2\ aq.]^{2+}$ or $[Ti(OH)_2(H_2O)(H_2O_2)]^{2+}$, assuming the co-ordination number of titanium to be four. Thus, a variety of constitutions has been proposed to explain the colour-forming species of the titanium complex, based on the investigations carried out in dilute sulphuric acid medium, but the complex has not been isolated so far.

We prepared a concentrated solution of peroxy titanium sulphate by the reaction of a freshly prepared titanium hydroxide with a cooled mixture of the calculated quantity of sulphuric acid and excess of hydrogen peroxide. The solution, when evaporated at 25° C. by passing dry air through it, gave a red-coloured solid peroxy complex of the composition $TiO_2SO_4.3H_2O$. The best sample prepared so far was 95 per cent pure, the balance being $TiOSO_4.3H_2O$. The complex contained a true peroxy group as shown by Riesenfeld Liebhasky test. It is amorphous and highly soluble in water and in absolute alcohol, but hydrolyses on dilution with water. The hydrolysis of the compound in aqueous solutions is prevented by dilute sulphuric acid. From various physico-chemical studies the solid compound is assigned the structure (I):



(I)



(II)

The compound in dilute sulphuric acid has an absorption maximum at 410 mμ, as also observed by Reeves and Jonassen[7], while in absolute alcohol it is at about 390 mμ. The compound when dissolved in absolute alcohol is found to have the structure (II). The molecular weight as determined by the cryoscopic method in 1 *N* sulphuric acid gives a value of 178, instead of the theoretically calculated value of 230. This shows a dissociation of the complex in solution to the extent of 28 per cent at about − 2° C. To find out the exact nature of the dissociation of the complex, electromigration, conductivity and spectrophotometric investigations were carried out on the complex. The compound in 2 *N* sulphuric acid medium showed very little electromigration towards the cathode, which is in agreement with the finding of Schaeppi and Treadwell[4]. This indicates that the complex has practically zero charge. This observation was confirmed by a conductivity experiment, from which it was found that the conductivity of a 0·5 *M* solution of peroxy titanium sulphate was practically the same as that of the solvent. Thus the coloured complex is probably dissociated into two neutral molecules:

$$TiO_2SO_4 + H_2O = TiOSO_4 + H_2O_2 \qquad (2)$$

This type of dissociation was confirmed spectrophotometrically by the molar ratio method. It was found that the dissociation of the complex ($0{\cdot}325 \times 10^{-3}\ M$) in 1·6 *N* sulphuric acid, in accordance with equation (2), was 40 per cent, whereas in 6·8 *N* sulphuric acid it was 33 per cent, both at 25° C. All studies show that the coloured compound in dilute sulphuric acid medium dissociates mainly according to equation (2).

The present work does not support the observation of Reeves and Jonassen[7] that the sulphate ligand takes no part in complex formation. Further, there is no evidence so far of the formation of the complex ions suggested by Schwarz[1] and by Babko and Volkova[5].

The coloured complex, represented by the structure (I), satisfies the normal co-ordination number of six for titanium. This is also supported by the fact that the two co-ordinated molecules of water are difficult to remove, when the solid complex is subjected to evacuation for a long time, whereas the third water molecule is more easily removed. The complex gives off ozone and oxygen on keeping, indicating the presence of the strained triangular ring of the peroxy group of the complex. The sulphate group occupying two co-ordination positions[8] in the complex is likely to facilitate its hydrolysis in dilute aqueous solutions, forming mainly hydrated titanium peroxide and sulphuric acid.

We thank Prof. M. R. A. Rao for helpful discussions on the subject.

C. C. PATEL
M. S. MOHAN
Department of Inorganic and Physical Chemistry,
Indian Institute of Science,
Bangalore-12.

[1] Schwarz, R., *Z. anorg. allgem. Chem.*, **210**, 303 (1933).

[2] *FIAT* Review of German Science, Inorganic Chemistry, Part 3, 170 (1948).

[3] Gastinger, E., *Z. anorg. allgem. Chem.*, **275**, 331 (1954).

[4] Schaeppi, Y., and Treadwell, W. D., *Helv. Chim. Acta*, **31**, 577 (1948).

[5] Babko, A. K., and Volkova, A. I., *Zhur. Obschei. Khim.* (*J. Gen. Chem.*), **21**, 1949 (1952); *Chem. Abs.*, **46**, 3445*a* (1952).

[6] Mori, M., Shibata, M., Kyuno, E., and Ito, S., *Bull. Chem. Soc., Japan*, **29**, 904 (1956).

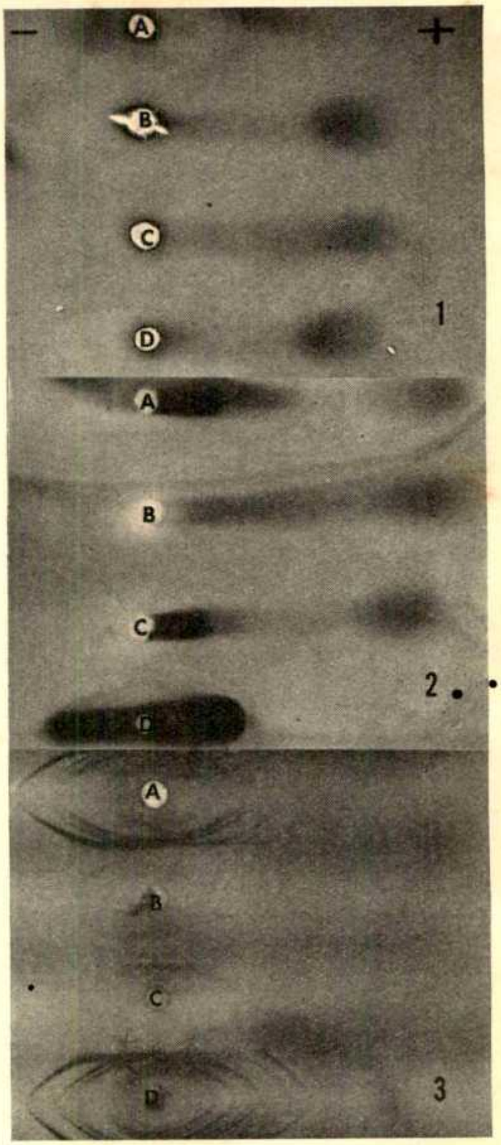
[7] Reeves, R. E., and Jonassen, H. B., *J. Amer. Chem. Soc.*, **76**, 5354 (1954).

[8] "Chemistry of the Co-ordination Compounds", edit. by Bailar, J. C., 29 (Reinhold Pub. Corp., 1956).

BIOCHEMISTRY

Mucopolysaccharides of Serum and Pleural Fluid

THE use of paper electrophoresis has enabled several investigators to establish the presence of acid mucopolysaccharide components in various tissue extracts[1,2] and urine[3]. Two such substances, staining with toluidine blue, were found in human aortic tissue[4]; concentrated human urine contained three components which stained with alcian blue[5]. The latter all appeared to migrate more rapidly than the albumin fraction, with the fastest component having the same mobility as chondroitin sulphate *A*. In the present work, which is primarily concerned with the electrophoretic characteristics of various body fluids in agar, a component was noted in the perchloric–phosphotungstic acid precipitate of both serum and pleural fluid which possessed staining and electrophoretic properties similar to those of acid mucopolysaccharide in urine.



Figs. 1–3. Electrophoretic properties in agar of serum, pleural fluid and urinary acid mucopolysaccharide. Fig. 1 was stained with alcian blue and azocarmin; Fig. 2 with α-naphthol-phenylenediamine; Fig. 3, immunoelectrophoresis with rabbit anti-human serum placed in troughs adjacent and parallel to the separated fractions. Untreated serum: 1,*A*, 3,*D*; acid precipitated serum: 1,*B*, 2,*A*, 3,*C*; acid precipitated urine: 1,*C*, 2,*B* untreated pleural fluid: 2,*D*, 3,*A*; acid precipitated pleural fluid: 1,*D*, 2,*C*, 3,*B*

The method of Winzler *et al.*[6] was used for the precipitation of mucoproteins from fresh normal human serum, normal urine, and from pleural fluid obtained from a patient ill with cholecystitis. To 2·0 ml. of each specimen was added 8·0 ml. 0·75 *M* perchloric acid. In 10 min. the precipitate which appeared in the serum and pleural fluid was removed by filtration; the urine sample remained clear. 2 ml. of 5 per cent phosphotungstic acid in 2 *N* hydrochloric acid were added to the filtrates and acidified urine, the tubes were centrifuged, the sediments washed twice with the phosphotungstic acid and resuspended in 2·0 ml. veronal buffer, *p*H 8·6, 0·03 ionic strength. Electrophoretic separation was carried out at refrigerator temperature with techniques similar to those described by Zak and Jarkowski[7] and by Crowle[8]. Slides (2 × 3 in.) were coated with 2 per cent 'Ionagar' (Oxo, Ltd., London) and dried at 37° C. Plastic tape was cut into strips approximately 3 mm. wide and layered on the long edges of the slides. Filter paper wicks were placed at each end and 4·0 ml. melted 1 per cent agar in the veronal buffer was poured between the taped edges. A 'Plexiglas' matrix with four holes was lowered until it rested on the tape strips. Following a period of 20 min. in a refrigerator, the agar was removed from the holes by vacuum suction. One 0·01 ml. of each sample was placed in separate holes by capillary pipette. A solution of orange *G* was added to a sixth hole located near an edge of the matrix and close to the cathode-end of the slide. Current (9 V./cm.) was applied until the orange *G* moved 2·0 cm., which required approximately 20 min. The matrix was removed and the slides fixed and stained for mucopolysaccharides[5], lipoprotein or mucoprotein[9] components.

The characteristics of mucopolysaccharide present in perchloric–phosphotungstic acid precipitated serum and pleural fluid were quite similar to those of acid-treated urine as shown in Fig. 1. The substance appeared to migrate 2–3 times faster than the albumin fraction and stained with both alcian blue and α-naphthol-phenylenediamine reagent. The specificity of the former dye for acid mucopolysaccharide was shown by Heremans et al.[5] and the present experiments confirm their observation. The alcian blue stained only the fast-migrating material (Fig. 1) whereas the major substance of the treated serum and pleural fluid appeared to be mucoprotein (Fig. 2), which resembled the immuno-electrophoretic fraction *X* of de Vaux St-Cyr[10]. This was confirmed by extending the period of electrophoresis until the indicator dye had migrated the full length of the slide. The mucoprotein fraction then appeared to have a mobility similar to α_1-globulin of untreated serum. Proteins and lipoproteins were apparently removed by the isolation procedures; only the untreated serum (Fig. 1*A*) and pleural fluid (not shown) counterstained with azocarmin and with oil red *O*. Immuno-electrophoresis (Fig. 3) suggested that the mucopolysaccharides were not antigenic in the rabbit since precipitation did not occur in the corresponding area of migration. However, this apparent lack of antigenicity may be due to alteration of the material during acid precipitation or to a difference in complexity of the substance as it existed in the serum which was used to immunize the animal. Indeed, the fast-migrating mucopolysaccharide was not detectable in untreated serum (1, *A*) or pleural fluid. Within the necessary limitation placed on the extent of separation, all fractions of the latter two specimens appeared to contain mucoprotein (2, *D*). Following acid precipitation, the α_1-globulin was the only main serum fraction staining with the dye. This suggested that the mucopolysaccharide represented prosthetic groupings split from the mucoproteins of other serum fractions during acid treatment. Although the present evidence indicated this possibility, it may be emphasized that concentration of the samples was not attempted and, therefore, the existence of 'free' mucopolysaccharide cannot be excluded since the concentration may be below the limits of detectability. Regardless of the origin, it would appear important to gain further information concerning the biological properties of the isolated mucopolysaccharide.

The use of agar in electrophoretic studies such as these offers certain advantages over paper methods. Separation of the various components is accomplished more rapidly without loss of detail, and the apparatus is of very simple design. The elimination of elution procedures prior to immunological investigation also favours the present method.

These investigations were supported by a grant (*E*-2653) from the National Institutes of Health, Bethesda.

C. W. Fishel

Department of Microbiology,
University of Colorado Medical Center,
Denver,
Colorado.

---

[1] Bassiouni, M., *J. Clin. Path.*, 7, 330 (1954).

[2] Rienits, K. G., *Biochem. J.*, 53, 79 (1953).

[3] Boyce, W. H., Garvey, F. K., and Norfleet, C. M., *J. Clin. Invest.*, 33, 1287 (1954).

[4] Dyrbye, M., Kirk, J. E., and Wang, I., *J. Geront.*, 13, 149 (1958).

[5] Heremans, J. F., Vaerman, J. P., and Heremans, M. T., *Nature*, 183, 1606 (1959).

[6] Winzler, R. J., Devor, A. W., Mehl, J. W., and Smyth, I. M., *J. Clin. Invest.*, 27, 609 (1948).

[7] Zak, B., and Jarkowski, T. L., *Clin. Chem. Acta*, 3, 494 (1958).

[8] Crowle, A. J., *J. Lab. Clin. Med.* (in the press).

[9] Grabar, P., in "Methods of Biochemical Analysis", 7, edit. by Glick, D. (Interscience, London, 1959).

[10] de Vaux St-Cyr, C., Courcon, J., and Grabar, P., *Bull. Soc. Chim. Biol.*, 40, 579 (1958).

A New Technique for studying the Quantitative Aspects of Cytochemical Reactions and its Application to the Feulgen Reaction

Quantitative microspectrophotometry of cytochemically stained substances in cellular structures should be based on a knowledge of the stoichiometry of the reactions involved and the conditions influencing it. Thus far independent chemical analysis of individual cellular structures to study the quantitative relation between colour and amount of stained substance in general is not possible. This relation can be studied on a macro-scale by incorporating the substance in a kind of artificial section or model system which makes it possible to carry out the staining procedure under cytochemical conditions. For this purpose thin cellulose films were chosen. The extinction of the film after the staining procedure is proportional to the mass of the stained substance per unit area in the film. This mass is proportional to the amount of cellulose in the same area, provided the substance is uniformly distributed.

Since the cellulose films can be made of reasonable strength this amount of cellulose per unit area can be found by punching out pieces of known diameter in the measured region and weighing the dried punches. If no loss of substance occurs during preparation and staining of the model system the mass of stained substance per punch weight can be derived from the calculated composition of the film as a whole.

If an analysis method for the substance is known or can be developed this method can be used to analyse individual punches directly at the end of the staining procedure. Such analysis makes the method independent of initial irregular distribution or irregular loss of the substance in different areas of the film. Another advantage of the use of cellulose films is their favourable optical properties, which permit the study of spectra of the incorporated substance down to 230–240 mμ.

To demonstrate the value of this system, deoxyribonucleic acids were incorporated in a cellulose film.

The model system was prepared from a solution of deoxyribonucleic acid in viscose spread in a thin layer on a glass plate. This layer was dried somewhat at 60° C. and converted in a cellulose film in which deoxyribonucleic acid was quantitatively incorporated through the action of a mixture of 3 vol. methanol and 1 vol. formic acid. The films were fixed overnight in a mixture of 30 per cent formaldehyde and methanol (1/9 v/v). After having been kept in methanol for some days, the films were subjected to the Feulgen reaction (hydrolysis for 12 min. at 60° C. in 1 *N* hydrochloric acid). The stained films as well as their appropriate controls were cut into small strips. These strips were transferred to a spectrophotometer cell filled with *o*-xylene and were held mechanically in a stretched position. After the measurement of the extinction a round piece of each strip was punched out in the region that had been traversed by the light beam. The dried punches were weighed and analysed for inorganic phosphorus after digestion in a perchloric acid–hydrogen peroxide mixture. The standard deviation of the mean of the values of phosphorus content per mgm. dry cellulose of the unstained punches could be kept within 1 per cent.

The result of an experiment in which films of various concentrations of deoxyribonucleic acid were used is given in Fig. 1. From each film strips were cut,

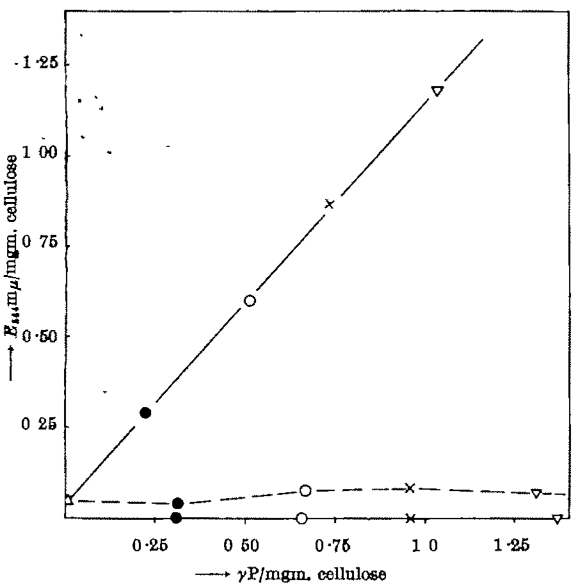


Fig. 1. Schiff-stained deoxyribonucleic acid–cellulose membranes. ———, Hydrolysis; – – – –, no hydrolysis. The phosphorus content of the unhydrolysed and unstained membranes ($E <$ 0·005) are plotted on the abscissa. The dry weight of the punches (diam. 5·49 mm.) varied between 0 55 and 0 80 mgm.; their thickness in xylene was found to be in the range 60–80μ

which were stained omitting the hydrolysis procedure. The results show that a linear relation exists between the deoxyribonucleic acid content after staining and the value of the extinctions measured. This linearity is not influenced by the formaldehyde treatment and in general is independent of the way in which the films are prepared from the viscose layer. Since the points in the graphs are based on mean values from five to six punches, an impression of the accuracy of the method can be gained from the standard deviations for the quotient $E/\gamma P$ of the individual punches, given in Table 1. These results give further proof of the validity of the Feulgen reaction as a quantitative method for deoxyribonucleic acid.

Table 1

Groups of punches*	γP/mgm dry cellulose (calculated)	Mean $E_{546}/\gamma P$
●	0·321	1 12 ± 0 085† (6)‡
○	0 70	1 10 ± 0 088 (6)
×	1 00	1 13 ± 0 083 (5)
▽	1·40	1 10 ± 0 02 (6)

* See Fig. 1. † Standard deviations. ‡ Number of punches.

Cytophotometry of Feulgen-stained cell nuclei in general is carried out on an empirical basis, working with arbitrary units of deoxyribonucleic acid content within a certain experiment[1]. Based on the hypothesis of the constancy of the amount of deoxyribonucleic acid in cell nuclei within one species, macro-analysis of suspensions of cell nuclei in this particular case could be used to some extent to investigate the stoichiometric relations involved, as was done by Ris and Mirsky[2]. The use of an artificial section may facilitate the study of the factors influencing the stoichiometry of the Feulgen reaction. Such studies may contribute to the solution of the problem if the deviations from the constancy hypothesis, still found by microspectrophotometry of Feulgen-stained nuclei, are based on real variations in deoxyribonucleic acid content.

The system seems suitable for testing the behaviour of other aldehyde reagents instead of the Schiff reagent in the Feulgen reaction. In this respect we investigated the behaviour of the blue thionine–SO_2 aldehyde reagent reported previously[3]. These studies show a similar linear relation between extinction (at 590 mμ) and deoxyribonucleic acid amount as was found for the Schiff reagent.

Investigations with the aid of the model system may facilitate the finding of staining conditions that reflect to some extent the positions of the aldehyde groups in the apurinic acids from several types of deoxyribonucleic acid.

Since its value has now been proved for the Feulgen reaction it appears reasonable to extend the method to compounds other than deoxyribonucleic acid for which a study of the stoichiometric relation cannot be based on a constancy hypothesis.

In its present form the method is limited to the investigation of quantitative cytochemical behaviour of alkali-stable substances. Removal of the excess alkali from the viscose just before mixing and film formation seems possible. In addition other cellulose derivatives with film-forming potentialities are known to exist so that the present limitations appear to be surmountable.

Part of this work has been published as a thesis for a Ph.D. degree by one of us[4].

Full details will be published elsewhere. We wish to thank Miss J. Allaart for technical assistance.

P. VAN DUIJN
J.-P. PERSIJN

Biochemical Section,
Pathological Laboratory,
University of Leyden.

---

[1] Leuchtenberger, C., "General Cytochemical Methods", edit. by Danielli, J. F., 1 (Academic Press, Inc., New York, 1958).

[2] Ris, H., and Mirsky, A. E., *J. Gen. Physiol.*, 33, 125 (1950).

[3] van Duijn, P., *J. Histochem. and Cytochem.*, 4, 55 (1956).

[4] Persijn, J.-P., thesis, Leyden (1959).

Biological Significance of Peptide containing Hydroxyproline during the Development of Carrageenin Granuloma

ALTHOUGH it is generally accepted that free hydroxyproline cannot be utilized for the synthesis of collagen[1–3], we have demonstrated in previous papers a close interrelation between the level of free hydroxyproline in tissues of rats[4], or in the body of chicken embryos[5], and the rate of collagen synthesis (after cortisone administration). In a recent paper Green and Lowther[6] presented proofs that the formation of protein-bound hydroxyproline proceeds by way of 'activated' proline which is hydroxylated during the incubation in granuloma slices to form 'activated' hydroxyproline. The possibility of such a hydroxylation of proline *in vitro* has been demonstrated recently[7]. Some hypotheses dealing with collagen synthesis presume in connective tissue the presence of peptide with hydroxyproline, the biochemical existence of which has not yet been proved. In an ultrafiltrate of extracts from bovine embryonic tissues homogenates (subcutis, growth-zone of bones) we found repeatedly several peptides containing hydroxyproline. Their chromatographic and other biochemical characteristics will be published elsewhere (Kobrle, V., and Chvapil, M.).

In this study are presented further findings concerning the biological significance of peptide or peptides containing hydroxyproline.

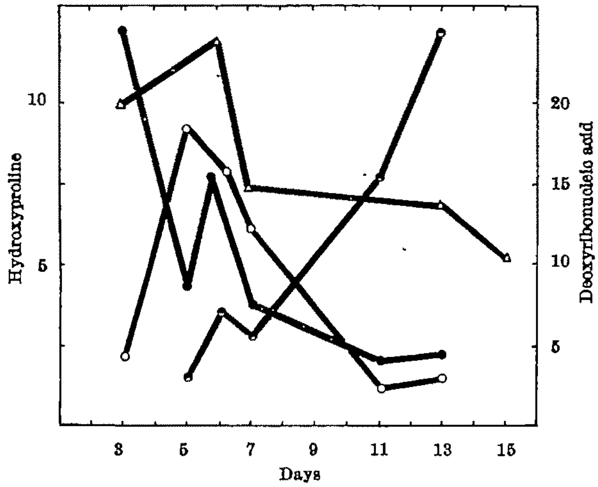


Fig. 1. Changes in free and peptide hydroxyproline, total tissue hydroxyproline and deoxyribonucleic acid concentration during the development of carrageenin granuloma. ○, Peptide hydroxyproline; ●, free hydroxyproline; ◒, total tissue hydroxyproline; △, deoxyribonucleic acid. Results are presented in μgm./100 mgm. of dry substance

For this reason carrageenin granuloma in guinea pigs was produced by the usual technique[8] under simultaneous penicillin and streptomycin treatment. On individual days of the development of the granuloma until the fifteenth day, the tissue was collected, homogenized with the aid of air as fluid and with a Potter and Elvehjem apparatus, extracted 60 min. with $0{\cdot}14\ M$ sodium chloride. The whole homogenate was centrifuged at 15,000g; the proteins in the supernatant were separated by means of ultrafiltration in metal pressure ultrafilter using a membrane supplied by Nojax Cellulose Casinas, Visking Corp., Chicago. The absence of proteins in ultrafiltrate was always re-examined. An aliquot of the ultrafiltrate was hydrolysed ($6N$ hydrochloric acid, 140° C., 3 hr.). In hydrolysed and non-hydrolysed parts of the filtrate we determined colorimetrically the amount of hydroxyproline[9], and the total amount of imino-groups[10] polarographically. In an aliquot of the whole homogenate we determined after acid hydrolysis the total hydroxyproline[9], and in another aliquot the amount of deoxyribonucleic acid[11]. Two independent series of experiments were carried out with similar results.

Results of a second series of experiments are summarized in Table 1 and Fig. 1.

It is evident that in the first days of granuloma development there occurs an accumulation in tissue of peptide containing hydroxyproline which forms 20–65 per cent of total filtrable hydroxyproline. It is worth mentioning that the changes in peptide–hydroxyproline follow the changes in amount of deoxyribonucleic acid in tissues. In good agreement with the findings of Jackson[12], the maximum of collagen accumulation is 7–10 days.

The level of free hydroxyproline in granuloma tissue diminishes at first, and then alters simultaneously with peptide.

The presence and the amount of peptide with hydroxyproline in an ultrafiltrate does not depend on whether the tissue homogenate was heat-treated (100°, 10 min.) or not. For this reason we exclude the possibility that peptide hydroxyproline is the source of collagen degradation by some tissue enzymes.

We suppose, therefore, that the accumulation of peptides containing hydroxyproline in their molecule in carrageenin granuloma is connected with early collagen protein synthesis, or stimulated collagen production bound on the presence of fibrillogenic connective tissue cells. The interrelation of free hydroxyproline and peptide–hydroxyproline is not yet quite clear. The elucidation of these questions is the task of further studies.

Table 1

	Duration of experiment (days)					
	3	5	6	7	11	13
Free hydroxyproline*	12·4	4·4	8·04	3·84	1·94	2·27
Peptide hydroxyproline	2·2	9·3	8·05	6·18	1·16	1·58
Percentage of peptide-hydroxyproline†	15	68	50	60	37	40
Total tissue hydroxyproline		162	374	289	780	1,235
Deoxyribonucleic acid	2,020	1,550	2,380	1,720	973	1,480

* Results are presented in μgm /100 mgm. of dry substance.
† Percentage of peptide-hydroxyproline is calculated from total ultrafiltrable hydroxyproline.

M. Chvapil
B. Čmuchalová

Institute of Industrial Hygiene and
Occupational Diseases in Prague,
Karlovo nam. 33, Praha 2,
Czechoslovakia.

---

[1] Stetten, M. R., *J. Biol. Chem.*, **181**, 31 (1949).
[2] Fitton Jackson, S., and Smith, R. H., "Recent Advances in Gelatine and Glue Research" (Pergamon Press, London, 1957).
[3] Boucek, R. J., Noble, L., and Woessner, jun., J. F., in "Connective Tissue, Thrombosis and Arteriosclerosis", edit. by Page, E. H., 193 (Academic Press, Inc., New York, 1959).
[4] Chvapil, M., *Physiol. Bohemoslov.*, **7**, 391 (1958).
[5] Chvapil, M., *Physiol. Bohemoslov.*, **8**, 186 (1959).
[6] Green, N. M., and Lowther, D. A., *Biochem. J.*, **70**, 56 (1959).
[7] Chvapil, M., and Hurych, J., *Nature*, **184**, 1145 (1959).
[8] Robertson, W. V., and Schwartz, B., *J. Biol. Chem.*, **201**, 689 (1953).
[9] Stegeman, H., *Z. physiol. Chem.*, **311**, 41 (1958).
[10] Chvapil, M., and Zahradník, R., *Physiol. Chem*, **307**, 217 (1957).
[11] Colowick, S. P., and Kaplan, N. O., "Methods in Enzymology", **3**, 680 (Academic Press, Inc., New York, 1957).
[12] Jackson, D. S., *Biochem. J.*, **65**, 277 (1957).

Flavonoid Compounds in the Inflorescence of *Helichrysum arenarium*

In a previous paper[1] we reported the isolation and identification of three crystalline compounds from the inflorescence of *Helichrysum arenarium*. We isolated from the alcoholic extract the salipurposide, naringenin-5-glucoside (5,7,4′-trihydroxyflavanone-5-glucoside), $C_{21}H_{22}O_{10}\cdot 2H_2O$, m.p. 219–224°, yield 0·25 per cent, acetyl derivative m.p. 174–177°. Until then, this flavanone glucoside had been found only in *Salix purpurea* and *Acacia floribunda*.

We also isolated the apigenin (5,7,4′-trihydroxyflavone), m.p. 346°, yield 0·03 per cent (triacetyl derivative m.p. 179·5–181·5°, dimethyl derivative m.p. 155–156°), which occurs in dried flowers in a free state. After hydrolysis with dilute sulphuric acid of a syrupy fraction, which could not be obtained in crystalline state, we isolated the kæmpferol (3,5,7,4′-tetrahydroxyflavone) $C_{15}H_{10}O_6$, m.p. 276–278°, yield 0·1 per cent; triacetyl-derivative m.p. 177°.

Now we have obtained evidence that kæmpferol occurs in *Helichrysum arenarium* as a glucoside.

Using paper partition chromatography we have shown, besides salipurposide, the presence of still two other flavonoid compounds. (Whatman No. 3 circular-paper chromatography, ethyl acetate–formic acid–water, 10 : 2 : 3, $R_F = 0{\cdot}84$, $R_F = 0{\cdot}77$.) One compound could be isolated in pure state, $C_{21}H_{20}O_{11}$, m.p. 171–175°, R_F = 0·84, yield 0·1 per cent (calc. C, 56·25; H, 4·50; found: C, 55·89; H, 4·54) and identified with kæmpferol-3-glucoside (astragaline). This substance hydrolysed with acid gives a compound with m.p. 278–280°, R_F = 0·87 (Whatman No. 1, *n*-butanol–acetic acid–water, 4 : 1 : 5) identified with kæmpferol, and glucose identified by paper chromatography (R_F = 0·18) and its osazone.

By methylation and thereafter hydrolysis a crystalline compound, m.p. 148–149°, identical with 5,7,4′-trimethylkæmpferol was isolated. This provides evidence of location of the glucosidic linkage at position 3.

Our R_F value distinctly differs from the observed one by Hörhammer[2], R_F = 0·67, in the same solvent system.

The simultaneous occurrence in the same plant of three grades of oxidation of the flavonoid nucleus—flavanone, flavone, flavonol (naringenin, apigenin, kæmpferol)—is interesting. One may suggest the possibility of biosynthesis of apigenin from naringenin and of kæmpferol from naringenin or apigenin.

Analogous oxidations were realized by iodine, selenium dioxide and hydrogen peroxide *in vitro*.

The results of pharmacological study now under investigation will show if the flavonoid compounds which we have isolated are responsible for the cholagogue activity observed for the drug.

The crude extract, containing apigenin as major compound, showed in preliminary trials cholagogue activity, and another, containing salipurposide and kæmpferol-3-glucoside, showed a spasmolytic activity and a feeble cholagogue one (A. Szadowska, Department of Pharmacology, Med. Academy; more extensive results will be published elsewhere).

Z. I. JERZMANOWSKA
J. T. GRZYBOWSKA
Organic Chemistry Department,
Medical Academy,
Łódź, Poland.

[1] Jerzmanowska, Z., and Grzybowska, J., *Acta Pol. Pharm.*, 15, 13 (1958).

[2] Horhammer, L., Wagner, H., and Gotz, H., *Arch. Pharm.*, 291, 44 (1958).

PHYSIOLOGY

Improvement of the Intravenous Glucose Tolerance Test

GLUCOSE is carried to its metabolic sites directly by plasma water and only indirectly by red blood cells. Accordingly, the intravenous glucose tolerance test would convey greater information if it were reported in terms of plasma glucose concentration. Yet whole blood is currently used in such determinations. Whole blood contains glucose in both red blood cells and plasma, and since the transport between them is moderately slow the concentrations are generally different when blood glucose-levels are rapidly changing. For example, if plasma water glucose concentration is suddenly raised from 100 to 200 mgm. per cent, data of Bowyer and Widdas[1] indicate that it would take 17 min. for the glucose concentration in the red blood cell water to reach 190 mgm. per cent.

Slow transport brings into question interpretations based upon a simple exponential model for the intravenous glucose tolerance test[2]. For if the glucose concentration curve for the whole blood is a simple exponential function, and if slow transport occurs, then the plasma glucose curve cannot be a simple exponential function. The complex shape of the plasma glucose concentration curve can best be understood in terms of a model shortly to appear[3].

This complex model depends upon inferences about plasma glucose concentrations, because experimental data are not available. The utility of the model would be materially enhanced by direct experimental determinations of plasma glucose concentrations during the intravenous glucose tolerance test. Such determinations could readily be obtained by immediate refrigeration and prompt centrifugation of blood samples to retard transfer. Such refrigeration could be obtained by drawing the blood through polyethylene tubing immersed in ice water. The difficulties of intra-arterial cannulation can be obviated by using venous blood after warming the arm.

JOHN C. SEED
Wellcome Research Laboratories,
Tuckahoe, New York.
Department of Anesthesiology,
Memorial Center for Cancer and Allied Diseases,
New York.
FORMAN S. ACTON
Department of Electrical Engineering,
Princeton University,
Princeton, New Jersey.
ALBERT J. STUNKARD
Department of Psychiatry,
University of Pennsylvania,
Philadelphia.

[1] Bowyer, F., and Widdas, W. F., *J. Physiol.*, 141, 219 (1958).

[2] Amatuzio, D. S., Stutzman, F. L., Vanderbilt, M. J., and Nesbitt, S., *J. Clin. Invest.*, 32, 428 (1953). Conard, V., Franckson, J. R. M., Bastenie, P. A., Kestens, J., and Kovacs, L., *Arch. Internat. Pharmacodyn.*, 93, 277 (1953). Hlad, C. J., Elrick, H., and Witten, T. A., *J. Clin. Invest.*, 35, 1139 (1956). Marks, P. A., and Bishop, J. S., *ibid.*, 36, 254 (1957). Macho, L., *Acta Med. Scand.*, 160, 477 (1958).

[3] Seed, J. C., Acton, F. S., and Stunkard, A. J. (in preparation)

Abrupt and Delayed Effects of Insulin on the Distribution Space of Glucose in the Dog

IT has been proposed that insulin increases the permeability of cell membranes of animals to glucose[1]. If this is so, an increase induced by insulin in the volume through which glucose can disperse could occur as a result of the addition of intracellular spaces to those through which glucose is distributed without the added insulin. The method of successive tracer injections[2] provides a means for determining, at each injection time, the amount of glucose which intermixes rapidly with the plasma glucose. From this value the corresponding apparent volume or space of distribution can be calculated, assuming that the concentration of plasma glucose is uniform throughout the volume. In this communication these procedures were used to determine the immediate and later effects of injection of insulin and of infusion of insulin on the glucose distribution space of the dog.

Five experiments were performed on four normal dogs anæsthetized with nembutal. Glucose, uniformly labelled with carbon-14, was injected intravenously through an indwelling polyethylene cannula inserted 3–4 in. into the tibial vein. Samples were withdrawn from the inferior vena cava, which was catheterized via the femoral or saphenous vein. Insulin was given

Table 1. EFFECT OF INSULIN ON LEVEL OF PLASMA GLUCOSE (C, MGM./100 ML.) AND VOLUME OF GLUCOSE (V, PER CENT OF BODY-WEIGHT) IN NORMAL ANÆSTHETIZED DOGS

No. of experiment	Weight of dog (kgm.)	Mode of administration of insulin	Before insulin				Times of injection of ^{14}C-glucose after injection or start of infusion of insulin					
			100 min.		40 min.		23–25 min		60–69 min.		108–114 min.	
			V	C	V	C	V	C	V	C	V	C
1	12·0	Injection, 1 u./kgm.	17·3	115·7	15·7	106·9	*		46·8	30·0		
7A	23·6	Injection, 0·29 u./kgm.	18·0	84·2	14·7	84·2	44·1	26·2	83·3	43·5	24·1	85·4
3	11·5	Infusion, 0·008 u./kgm./min.	23·4	89·1			24·3	63·2	44·4	31·4	30·3	38·7
6	16·9	Infusion, 0·0038 u./kgm./min.	19·8	106·2	22·3	97·4	17·7	55·1	182·3†	33·2	29·0	32·5
7	25·0	Infusion, 0·0018 u./kgm./min.	21·8	77·8	21·6	77·8	20·9	64·0	31·0	55·5	32·0	28·2

* In this experiment volume of glucose was measured at injection time. It was 12·5 per cent of body-weight.

† This determination is based on a specific activity versus time curve of a very poor fit. Therefore it may represent a gross over-estimation of volume of glucose. It is included in order to present unselected results.

either as a single intravenous injection, or as a constant intravenous infusion from a calibrated burette. Glucose was determined by the Somogyi–Nelson method[3]. Specific activity of plasma glucose was measured by preparing glucosazones, the radioactivity of which was measured in a windowless flow-counter. In experiments 1 and 3 (Table 1) Insulin-Toronto was used, whereas in the others crystalline Insulin-Lilly was injected.

Results are shown in Table 1. It can be seen that the injection of insulin resulted in an increase in the apparent glucose volume in all experiments. The effect is a delayed one and is not strictly related to the changes of level of blood glucose. It can be seen in experiments 3 and 6 that, although the level of blood glucose had started to drop, the increase in apparent glucose volume was delayed. In experiment 7A, the level of blood glucose had returned to normal, while the apparent glucose volume was still somewhat above the pre-insulin level. In experiment 1 the glucose volume was determined at the time of insulin injection and was found to be slightly less than the pre-insulin volumes. This is in accord with our earlier findings[2].

The present experiments do not indicate whether the effect of insulin on the apparent glucose volume is a specific one, or whether it results from the hypoglycæmia evoked by insulin. Experiments to elucidate this point are in progress.

In support of the present findings it has been shown that insulin increases the volumes of distribution of galactose and of some pentoses in the eviscerated dog[4], in isolated tissues[5], and in perfused organs[6]. Under certain conditions an accumulation of free glucose in the isolated rat diaphragm was also noted when insulin was added to the incubation medium[7].

The effect of insulin on the apparent glucose space was studied by Drury and Wick[8], who compared two groups of eviscerated-nephrectomized rabbits. One group served as controls, while the other received 10 units kgm./hr. of insulin. No difference in the apparent glucose spaces was found. Each of our experiments with successive tracer-glucose injections was performed on a single dog, so that inter-animal variation was avoided. All our results show an increase in the apparent glucose space during insulin hypoglycæmia, but not immediately after the start of the injection of insulin. The enlarged space appears to exceed that of the extracellular body-water.

This finding modifies the conclusions from earlier experiments, in which attempts were made to determine the effects of insulin on the rates of appearance and disappearance of glucose from the plasma and associated tissue fluids (central compartment). All these methods except one[2] involved the assumption that the glucose space remained constant. The observed increase in the apparent glucose space following injection of insulin leads to an under-estimation of the rate of appearance or an over-estimation of the rate of disappearance of glucose, the extent of which may vary with experimental conditions.

To sum up: the injection or infusion of insulin caused no immediate increase in the apparent glucose space in the normal dog. However, in each of the five experiments, a substantial increase was found 1 hr. or less after the injection, or after the start of the infusion of insulin.

This work was supported by grants from the National Research Council of Canada and the Banting Research Foundation. We thank Dr. C. H. Best for his encouragement and support in this work. The generous gift of glucagon-free crystalline insulin (Lot 499667) by the Eli Lilly Company is gratefully acknowledged. Our thanks are due to Mr. G. Layng for technical assistance.

G. HETENYI, JUN.
G. A. WRENSHALL

Charles H. Best Institute,
University of Toronto.

[1] Levine, R., Goldstein, M. S., Huddlestun, B., and Klein, S. P., *Amer. J. Physiol.*, 163, 70 (1950).

[2] Wrenshall, G. A., and Hetenyi, jun., G., *Metabolism*, 8, 531 (1959).

[3] Nelson, N., *J. Biol. Chem.*, 153, 375 (1944).

[4] Goldstein, M. S., Henry, W. L., Huddlestun, B., and Levine, R., *Amer. J. Physiol.*, 173, 207 (1953).

[5] Kipnis, D. M., and Cori, C. F., *J. Biol. Chem.*, 224, 681 (1957).

[6] Park, C. R., Reinwein, D., Henderson, M. J., Cadenas, E., and Morgan, H. E., *Amer. J. Med.*, 26, 674 (1959).

[7] Park, C. R., Bornstein, J., and Post, R. L., *Amer. J. Physiol.*, 182, 12 (1955).

[8] Drury, D. R., and Wick, A. N., *Amer. J. Physiol.*, 166, 159 (1951).

Effect of Vitamin A on the Cystine Content in Skin of Rats

THIS investigation was undertaken to gain more precise knowledge of the effect of vitamin A on the epithelium. Diets ranging from a small dose to a liberal supply of vitamin A were fed to rats, and the cystine content of their skin was determined.

The analytical results show that the skin of rats on a diet supplemented with only small doses of vitamin A contained less cystine than that of rats which had been fed with a liberal supply of vitamin A.

The current theory[1] of keratin formation includes oxidation of cysteine sulphydryl groups of adjacent polypeptide chains to produce cystine disulphide linkage, the covalent bonds of the latter grouping serving to hold the keratin molecule together and give it rigidity. Since vitamin A deficiency leads to excessive keratinization of epithelium, the possibility that the vitamin A may be concerned in the metabolism of sulphydryl and disulphide linkages deserves scrutiny. This observation led to our investigating the change in cystine content in the skin of rats which had been fed diets supplemented with small doses and large doses of vitamin A, with or without sulphur amino-acids.

The test animals used were rats of the Wistar strain of both sexes, those used for the first experiment weighing 30–35 gm., those for the second, 65–70 gm. They were housed in individual compartments with screen bottoms and fed a vitamin A-deficient ration consisting of powdered rice 92, defatted soybean meal 6, sodium chloride 1 and calcium carbonate 1. In addition, each rat was supplied with 20γ thiamine and 50γ riboflavin daily. The food was made into a paste by adding hot water, and cooked. After a three-week depletion period the animals were transferred to the experimental diets. At the end of four weeks the animals were beheaded. After shaving about 5 cm.^{2} of the back of the neck in the area of the shoulder blades, samples of skin were taken from each animal, dried and defatted with ethyl alcohol–ethyl ether. Weighed samples of it were hydrolysed in 3 *N* hydrochloric acid at 120° C. for 4 hr. The cystine content in the hydrolysate was analysed by the phosphotungstic acid method[2].

The cystine content of skin should be affected by the amount of sulphur amino-acid in the diet. In the first experiment, we investigated the effect of the small dose and the effect of the liberal supply of vitamin A in the diet, with or without a supplement of methionine, on the cystine content of the skin. The four groups of rats were given different diets as described in Table 1.

Table 1. AMOUNT OF SUPPLEMENTS IN EXPERIMENT 1

Group No.	1	2	3	4
Vitamin A per rat daily (γ)	1	100	1	100
DL-Methionine (gm.) per 100 gm. of diet	none	none	0·2	0 2

Rats in Group 1 were dosed with only 1γ of vitamin A per rat daily, which is a low dose. Animals in Group 2 were given 100γ of vitamin A—an ample dose. Groups 3 and 4 were dosed with 1γ and 100γ of vitamin A respectively supplemented simultaneously with methionine. During the four-week feeding period, the amount of diet was restricted to 7 gm. per rat daily the first week and thereafter increased each week by 1 gm. a week.

In the second experiment cystine was used instead of methionine and was given in conjunction only with the lower dosage of vitamin A (Table 2).

Table 2. AMOUNT OF SUPPLEMENTS IN EXPERIMENT 2

Group No.	1	2	3
Vitamin A per rat daily (γ)	1	100	1
L-Cystine (gm.) per 100 gm. of diet	none	none	0·2

Table 3. EFFECT OF VITAMIN A AND METHIONINE ON THE CYSTINE CONTENT OF SKIN

Values shown with mean and standard deviation of six rats in each group

Group No.	1	2	3	4
Supplement to diet	1γ vit. A	100γ vit. A	1γ vit. A + methionine	100γ vit. A + methionine
Body-weight (gm.):				
Initial	36 3 ±2 13	36 5 ±2 50	36·5 ±2·50	36·5 ±3 10
Gain per day	1·86±0·098	1·96±0·120	1·94±0·070	1 98±0·102
Skin: cystine (per cent)	1·36±0 083	1·60±0·102	1·50±0·132	1 68±0 220

Results of the first experiment show that the cystine content of skin of rats dosed with only 1γ of vitamin A is lower than that of rats given a liberal allowance of vitamin A. In the presence of methionine, the cystine content increased both with small and large doses of vitamin A; however, rats with the ample supply of vitamin A showed a higher content of cystine.

The results of the second experiment were essentially similar to those of the first experiment (Table 4).

Table 4. EFFECT OF VITAMIN A AND CYSTINE ON THE CYSTINE CONTENT OF SKIN

Values shown with mean and standard deviation of six rats in each group

Group No.	1	2	3
Supplement to diet	1γ vit. A.	100γ vit. A	1γ vit. A + cystine
Body-weight (gm.):			
Initial	74·8 ±7·54	74·6 ±6·36	74·6 ±8 31
Gain per day	1·89±0·172	2 04±0·189	2·00±0·269
Skin: cystine (per cent)	1·18±0·135	1·53±0·082	1·41±0 205

The cystine content was lower in group 1 and higher in groups 2 and 3, which received an ample supply of vitamin A, and cystine with small doses of vitamin A respectively. The results were in good agreement with the first experiment.

Abdulnabi and Bieri have studied the distribution pattern of amino-acids in the testes and livers and the blood serum of both vitamin A-deficient and normal rats. Paper chromatography did not reveal any difference between the two groups, and the quantitative picture, as obtained by microbiological assay, in general supported the qualitative results. There were, however, three quantitative differences. In the testes of the deficient rats, there was more tyrosine and phenylalanine, whereas in the normal livers there was more threonine than in the livers from the deficient rats.

Our results show that in the skin of the vitamin A-deficient rats there was less cystine than in that of normal rats, suggesting that vitamin A may be involved in the metabolism of cystine and may have an effect on the resistance of epithelium.

TATSUO KOYANAGI
SATORU ODAGIRI

Department of Agricultural Chemistry,
Iwate University,
Morioka, Japan.

---

[1] Lowe, J. S., and Morton, R. A., "Vitamins and Hormones", 14, 97 (1956).

[2] Kassel, B., and Brand, E., *J. Biol. Chem.*, 125, 115 (1938). Kolb, J. J., and Toennies, G., *Anal. Chem.*, 24, 1164 (1952).

BIOLOGY

A Method of staining Sectioned Tissues with Lead for Electron Microscopy

SOLUTIONS of lead are now widely used by some electron microscopists for the production of a general increase in the electron density of cellular constituents in sections of biological material fixed in osmium tetroxide and afterwards embedded in methacrylate or 'Araldite'. Grids bearing the sectioned specimens may be floated face downwards for a few minutes on the surface of weakly ionized lead solutions, for example, lead acetate or 'alkaline' lead hydroxide[1]. During this exposure lead ions become attached to the osmium already deposited on the material during fixation, with a consequent improvement of specimen contrast in the electron beam.

The effective application of these methods of lead impregnation has been somewhat curtailed by the fact that on exposure to air all solutions of lead salts become clouded by the formation of lead carbonate, the insoluble crystals of which are frequently encountered on the surface of sections stained by this method. In order to reduce this contamination attempts can be made to stain the specimens in a nitrogen or carbon dioxide-free atmosphere[2]; but these measures do not entirely eliminate the nuisance.

Successful lead staining without serious disadvantages can be effected as follows: Add 100 c.c. of distilled water to 1 gm. lead hydroxide and bring to the boil. Cool slightly and filter. To the filtrate, which is faintly clouded, add a solution of 2 *N* potassium hydroxide drop by drop until on agitation a completely clear solution remains. This is the staining fluid and probably contains some lead in the form of a plumbite, thus:

$$2KOH + Pb(OH)_2 = K_2PbO_2 + 2H_2O$$

Float the grids face down on a few drops of this solution in a covered watch-glass for 5 min. Then with a pipette replace the staining solution with distilled water and proceed at leisure to remove the grids individually with forceps. Agitate each grid for some 3–4 sec. (only) in a 1 per cent solution of potassium hydroxide and then immediately dip into a large volume of distilled water. Finally blot the grids on to filter paper and allow them to dry. Some experience is required to gauge just the right amount of time for the cleaning of the specimens in the 1 per cent potassium hydroxide (after staining). If this period is inadequate the grids show some contamination by crystals which are, however, readily removed by further immersion in potassium hydroxide. On the other hand, it has been observed that if lavage in the alkali is too prolonged then lead impregnation of the specimen appears to be reduced.

J. D. Lever

Department of Anatomy,
University of Cambridge.

---

[1] Watson, M. L., *J. Biophys. Biochem. Cytol.*, **4**, 727 (1958).

[2] Peachey, L. D., *J. Biophys. Biochem. Cytol.*, **5**, 511 (1959).

5-Hydroxytryptamine in Coelenterates

In an earlier report[1], it was concluded from evidence obtained by pharmacological tests and paper chromatography that 5-hydroxytryptamine was a constituent of the sea-anemones, *Metridium senile* and *Calliactis parasitica*. More 5-hydroxytryptamine-like material was obtainable from *Metridium* tentacles, with their nematocysts, than from body wall which is relatively free of nematocysts. This led to the suggestion that 5-hydroxytryptamine might be a pain-producing factor in these stinging organelles. An independent study[2] of material released on discharge of isolated *Metridium* nematocysts yielded two hydroxyindoles tentatively identified by chromatography as 5-hydroxytryptophan and bufotenine. The identification of 5-hydroxytryptamine in *Calliactis* has now been made quite certain[3,4]. However, the very large amount found in the coelenteric organ of this species and the relatively small amount in tentacles, coupled with the finding of little 5-hydroxytryptamine in *Metridium* and *Anemonia sulcata*, led Mathias, Ross and Schachter[3,4] to conclude that it is unlikely that 5-hydroxytryptamine is associated with nematocysts. Further evidence is now available that this conclusion may not be fully warranted.

With a highly sensitive fluorescence method for the estimation of 5-hydroxytryptamine now available[5], as well as a suitable method for extracting it from tissues[6], it has been possible to confirm and extend our earlier observations on the distribution of a substance like 5-hydroxytryptamine in different parts of *Metridium*. The content of 5-hydroxytryptamine of certain other coelenterates has been estimated by this method.

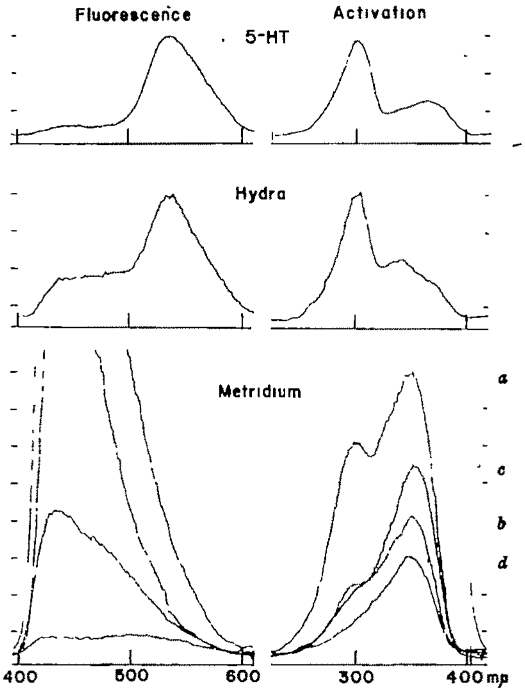


Fig. 1. Fluorescence and activation spectra: 5-HT, 0·1 μgm. 5-hydroxytryptamine/ml. 3 *N* hydrochloric acid; *Hydra*, extract of 0·38 gm. *Hydra oligactis* in 4·2 ml. 3 *N* hydrochloric acid. *Metridium*, (*a*) 0·24 gm. acontia; (*b*) 4·1 gm. body wall; (*c*) 2·8 gm. tentacles (each tissue extracted into 4·5 ml. 3 *N* hydrochloric acid); (*d*) reagent blank

In the presence of 3 *N* hydrochloric acid, there is a fluorescence maximum for 5-hydroxytryptamine at about 540 mμ when activated at 300 mμ (Fig. 1). These are the observed values obtained with the particular spectrofluorometer at our disposal. Bufotenine has a similar fluorescence to that of 5-hydroxytryptamine, but of the coelenterate extracts that we have examined chromatographically only those from *Physalia* tentacles gave an indole spot with an R_F value corresponding to that of bufotenine.

An extract of whole brown *Hydra* contained little interfering substance and gave obvious fluorescence and activation peaks (Fig. 1). Estimations of 5-hydroxytryptamine in one lot of *Hydra* and two lots of *Sagartia*, a small sea anemone, are given in Table 1. Extracts of *Metridium* tissues were found to contain a substance that fluoresces strongly near 430 mμ, thereby obscuring the 540-mμ peak of 5-hydroxytryptamine. Activation peaks were easily

Table 1. 5-Hydroxytryptamine in Coelenterates

Species and part	5-Hydroxytryptamine equivalents μgm./gm. fresh tissue
Hydra oligactis	
Approximately 1,000 whole animals	1·5
Sagartia luciae	
15 whole animals per determination	0·74 1·8
Metridium senile	
Whole animals*	0·04; 0·05; 0·05
Body wall	0·02; 0·05; 0·09
Oral disk and tentacles	0·08; 0·12; 0·17
Tentacles	0·24; 0·47
Acontia	0·60; 0·97; 1·30

* Three extractions and estimations made on the same day on animals maintained in laboratory for several weeks.

distinguished, however, and quantitative estimates were made from them (Fig. 1).

Different parts of *Metridium* were chosen to contain: (1) few nematocysts (body wall); (2) an abundance of nematocysts (tentacles or acontia); (3) a number intermediate between these (oral disk with tentacles). Two or three extractions were made of each of these parts. Some were made on freshly collected *Metridium* and others on animals that had been maintained in the laboratory for some months without feeding. Estimates of the content of 5-hydroxytryptamine of these extracts are given in Table 1. For a given part a range of values was found, attributable, in some measure, to the previous history of the individuals that were utilized. However, it is clear that *Metridium* body wall yielded least 5-hydroxytryptamine while the acontia, rich in nematocysts, yielded nearly 20 times as much as body wall. Other parts were intermediate. As a result of these findings, I am inclined to state, as earlier[1]: "This suggests, but does not prove, that the 5-HT (of *Metridium*) is contained in nematocysts . . .".

Mathias *et al.*[4] say that of several coelenterates they examined, significant amounts of 5-hydroxytryptamine were found only in *Calliactis parasitica*, and by far the highest concentration in "tissues of the coelenteric cavity". Thus far, 5-hydroxytryptamine in invertebrates has been found in venom apparatus and venoms[7], also nervous systems and excretory organs[8]. It would be of much interest to determine in which coelenteric tissue of *Calliactis* the 5-hydroxytryptamine is located. In the meantime it seems that the distribution of 5-hydroxytryptamine in *Metridium* is related to the distribution of nematocysts; but no claim is made that this is a specific (restricted) relationship.

J. H. WELSH

Department of Biology,
Harvard University,
Cambridge 38, Mass.

[1] Welsh, J. H., *Deep Sea Res.*, 3, Supp., 287 (1956).
[2] Phillips, J. H., *Nature*, 178, 932 (1956).
[3] Mathias, A. P., Ross, D. M., and Schachter, M., *Nature*, 180, 658 (1957).
[4] Mathias, A. P., Ross, D. M., and Schachter, M., *J. Physiol.*, 142, 56, P (1958).
[5] Bowman, R. L., Caulfield, P. A., and Udenfriend, S., *Science*, 122, 32 (1955).
[6] Bogdanski, D. F., Pletscher, A., Brodie, B. B., and Udenfriend, S., *J. Pharmacol. Exp. Therap.*, 117, 82 (1956).
[7] Collier, H. O. J., in "5-Hydroxytryptamine", edit. by Lewis, G. P. (Pergamon Press, 1958).
[8] Welsh, J. H., and Moorhead, M., *Science*, 129, 1491 (1959).

Selective Elimination of Single Sense Cells with Methylene Blue

FOR many problems of epigenetics and physiology it is desirable to destroy selectively individual cells within a tissue complex in order to test their functions. Although, in favourable cases, such cell structures as the nucleus have been eliminated, whole-cell destruction often implies damage to the surrounding tissue. Another difficulty of such experiments is the fact that recognition of single living cells within the tissue may be impossible. The use of toxic substances of sufficient specificity to affect the cell type to be eliminated, but without effect on other cells or on the organism as a whole, would solve this problem. A possible avenue of approach seems to be through techniques involving vital or supravital dyestuffs. The actual method must, of course, depend upon the type of cell to be eliminated. The experiments to be described illustrate this method of selective cell elimination by means of a chemical. The cells to be eliminated were single sense cells.

Young pupæ of the wax moth, *Galleria mellonella* L., were used in this work. Ether narcosis of half-hour duration served to immobilize the animals for several hours. Crystalline methylene blue is introduced with the point of a fine iridectomy knife. It dissolves at once in the hæmolymph, which takes a dark blue stain. Through carefully applied pressure, the blue hæmolymph is now distributed in the region to be studied. After ½–1 hr., the sense cells and the nerves are stained and they are now perceptible *in vivo* through the thin cuticle. Generally the nerves are less intensely stained than the sense cells. Body movements of the animals after recovering from narcosis distributed the dyestuff more evenly. After some time all dye will be reduced to its leuco form. Practically all animals survive the operation without showing any defect.

Study of slides from fixed material shows the stain exclusively located in the sense cells, disregarding those cells at the wound which were damaged by the operation. Some of the sense cells are stained light blue, others are dark blue. This difference in staining intensity is shown even by the sense cells of the same sensillum. According to statements in the literature[1], it is to be expected that at least the dark blue cells are destroyed. This is confirmed by histological study. Fig. 1 shows groups of cells

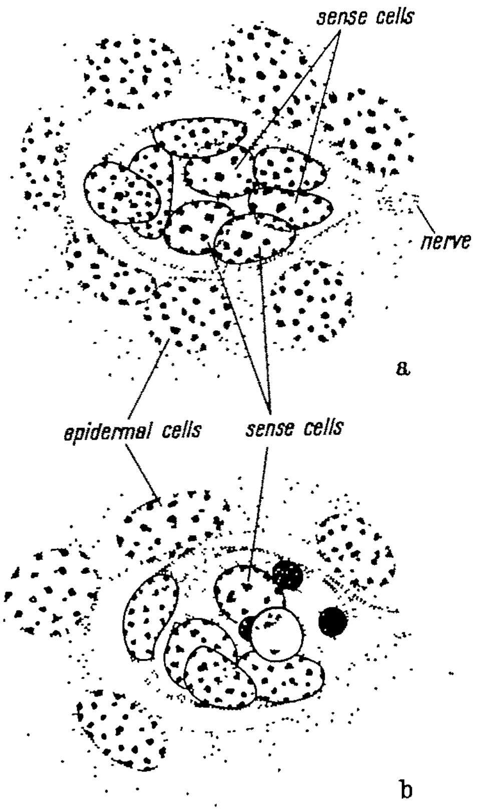


Fig. 1. Cell groups which belong to sensory bristles on the wing of *Galleria*. *a*, A normal cell group; *b*, a cell group in which three sense cells are destroyed by methylene blue. Nuclei which do not belong to the bristle have dotted lines. Pupæ, 25 hr., Bouin-Allan fixed, stained with hæmatoxylin

belonging to sensory bristles on the wing before outgrowth of the bristles themselves. The normal cell complement of such bristles (Fig. 1*a*) consists of eight cells, four of which are sense cells. The others are the trichogen and the tormogen cell and two cells of still unknown function, called *Hilfszellen*[1]. In the group of cells shown in Fig. 1*b*, three sense cells are damaged by methylene blue; two nuclei are pycnotic, one is swollen up like a blister, with clotted chromatin. This pupa was fixed for about 20 hr. after treatment with methylene blue. In animals which were fixed later the sense cells are completely decayed. The fourth sense cell and the four other cells in Fig. 1*b* are not damaged. Such cell groups as in Fig. 1*b* perform their normal function, that is, they give rise to entirely normal bristles, only with a reduced number of sense cells. This indicates that they are physiologically normal.

According to our experience certain prerequisites are necessary whenever a method of selective cell elimination through the use of specific substances is to be applied. (1) It must be possible to localize the toxic substance and to maintain a high concentration for a period of time in the region under study (narcosis; sack-like organs, see below). (2) The substance should be easily distributed (spongy tissue, much hæmolymph). (3) The substance should be implanted in as pure a state as possible, for example, not dissolved in another fluid. Conditions 1 and 2 were fulfilled, in the young pupa, by the extremities, the antennæ and the wings.

By use of the method described it was possible to show that the sense cells exert an influence on the development of the sensilla in the integument of *Galleria*. If this influence is lacking, polyploidization of the trichogen and the tormogen cells does not occur. These results will be reported in detail elsewhere[3].

ULRICH CLEVER

Max-Planck-Institut für Biologie,
Abt. Beermann,
Spemannstr. 34,
Tübingen.

[1] Romeis, B., "Mikroskopische Technik", fifteenth ed. (München, 1948).

[2] Clever, U., *Z. Morph. u. Okol. Tiere*, 47, 201 (1958).

[3] Clever, U., *Wilh. Roux' Arch. Entwickl.-Mech. Org.* (in the press).

A Spring Oat Variety resistant to the Stem Eelworm

RESISTANCE among oat varieties to the stem eelworm, *Ditylenchus dipsaci* (Kühn) Filipjev, was first shown by Goodey[1], who recorded a high degree of resistance in the varieties Grey Winter and Aberystwyth *S*81. Since this record, resistance has been recorded among commercially grown varieties, in Milford (*S*225)[2], in *S*172, Early Grey Winter and Unique[3]. The following is a record of resistance in a new spring oat variety.

An oat variety trial in Denbighshire, conducted jointly by the National Agricultural Advisory Service and the National Institute of Agricultural Botany, had been sown inadvertently in the early spring of 1959 in a field which was later found to be infested with the oat race of stem eelworm. In the trial the varieties were sown in single drill widths 140 yards long in a randomized block lay-out with four-fold replication. Damage by stem eelworm occurred in five of the varieties—Sun II, Civena, Blanche de Wattines, Condor and *V*2661. The remaining variety, number 4757/18/2/19, a form bred by the Welsh Plant Breeding Station, Aberystwyth, showed, apart from a few isolated plants, a high degree of resistance.

The Welsh Plant Breeding Station cereal breeding department gives the pedigree of the resistant variety as a selection from a cross between 01750/11, a mildew-resistant selection developed at the station, and Tama, a crown rust-resistant selection developed at Iowa State College. The variety is to be introduced commercially under the name of Manod (*S*235).

T. GLYN DAVIES

National Agricultural Advisory Service,
Bangor.

[1] Goodey, T., *Helminth. J.*, 15, 203 (1937).

[2] McLeod, K., Golightly, W. H., and Price, C. D., *Agriculture*, 61, 229 (1954).

[3] Jones, J. M., Griffiths, D. J., and Holden, J. H. W., *Plant Pathol.*, 4, 35 (1955).

Foliar Abnormalities, including Repeated Branching and Root Formation, induced by Kinetin in Attached Leaves of *Marsilea*

THE leaf of the water fern *Marsilea* is normally a strictly determinate structure, and even the supply of a wide range of physiologically active substances, to sporelings growing in aseptic culture, has hitherto resulted in no fundamental changes in leaf morphology[1,2]. Some interesting leaf abnormalities have now been obtained, however, following the addition to the culture medium of the cell-division stimulating substance, kinetin[3].

In the investigations outlined here, sporelings of *Marsilea drummondii* were grown aseptically in a liquid medium, consisting of a Knop's solution supplemented by glucose (analytical reagent) at concentrations of either 2 or 4 per cent. Kinetin solutions were added aseptically at various early stages of sporeling development. Resulting changes in leaf morphology were so unusual that the experiments were repeated with several batches of cultures, but all yielded essentially similar results.

In the initial experiment, kinetin was supplied to 10-day old sporelings, at concentrations of 10, 1·0 and 0·1 mgm./litre. The two higher concentrations were toxic, while at 0·1 mgm./litre sporeling development continued, but was markedly abnormal, the new growth consisting of an irregular mass of repeatedly branched structures, some of which were undoubtedly modified leaves. In later experiments, kinetin was added to give concentrations of 0·05, 0·01 and 0·002 mgm./litre. At 0·05 mgm./litre the results were virtually identical with those obtained at 0·1 mgm./litre, but at the two lower concentrations of kinetin less-extreme abnormalities were observed.

In the culture medium containing 0·002 mgm./litre kinetin. development of many of the sporelings was apparently completely normal; but in a proportion of the sporelings leaf development was somewhat affected. Some sporelings produced acicular, non-laminate leaves for a period, before reverting again to normal development, while other sporelings bore leaves with shorter petioles and longer leaf lobes than the corresponding structures of normal leaves.

The most interesting leaf abnormalities were obtained with 0·01 mgm./litre of kinetin. Most sporelings at first produced relatively normal leaves, though with short petioles. The first marked deviation from normal development was the production of several roots from the adaxial surface of some of these leaves, near the junction of lamina and petiole (Fig. 1*e*). The outgrowth of roots from *Marsilea* leaves has not been observed previously, even after the addition of so powerful a root-inducer as 2,4-D [1]. Root formation was usually followed by the appearance of a meristematic outgrowth, which in turn gave rise to a series of abnormal leaves (Fig. 1*d*). After longer exposure to the kinetin solutions the sporelings developed even more striking leaves, showing repeated branching of the leaf segments (Figs. 1*a*, *b*, *c*).

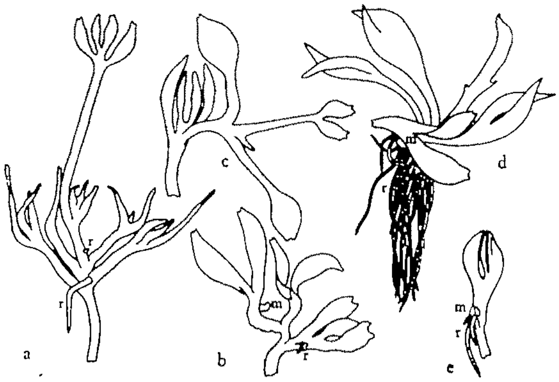


Fig. 1. *Marsilea drummondii* A.Br. Abnormal leaves from sporelings grown in a medium containing 0·01 mgm./litre of kinetin. *m*, Meristem; *r*, roots or root. (All × *c*. 2)

The leaf abnormalities briefly described above would appear to be of both phylogenetic and developmental interest. On the basis of comparative morphological studies, it is apparently generally accepted (for example, Bower[4]) that the strictly quadrifoliate adult leaf of *Marsilea* is derived from an ancestral type with more elaborate structure. The present work indicates that the potentialities of more extended development are still inherent in the *Marsilea* leaf.

Apart from its toxic action at high concentrations, the effects of kinetin appear to be restricted to meristematic tissues. In the present work, kinetin at physiological concentrations had no evident effect on fully developed leaves of *Marsilea* sporelings or on excised leaves of the same cultures. Our results suggest that the limited growth of the leaf meristems of normal plants of *Marsilea* may be due to correlations with other parts of the plant involving a restriction in the supply of cell-division promoting substances similar to kinetin. In any event, the external supply of kinetin disturbs the normal correlations and permits a more prolonged activity of the leaf meristems.

It is hoped to publish further details of this work, including anatomical observations, in a later contribution.

A. Allsopp
Alicja Szweykowska*

Department of Botany,
University of Manchester.

---

* Present address: The University, Stalingradzka 14, Poznan, Poland.

[1] Allsopp, A., *Ann. Bot.*, N.S., **16**, 165 (1952).

[2] Allsopp, A., *Nature*, **173**, 1032 (1954).

[3] Das, N. K., Patau, K., and Skoog, F., *Physiol. Plantarum*, **9**, 640 (1956).

[4] Bower, F. O., "The Ferns", **2** (Cambridge, 1926).

A Comparison of Adhering and Abscising Fruits of Peach treated with N-1-Naphthyl Phthalamic Acid

The search for a thinning spray to be used on peaches has shown that N-1-naphthyl phthalamic acid promotes abscission of peach fruits[1]. This preliminary report compares the size, content of natural auxin, and embryological development of adhering and abscising fruits of Halehaven peach trees sprayed with N-1-naphthyl phthalamic acid at petal fall.

On May 13, 1958, Halehaven peach trees at early petal-fall stage were sprayed with 175 p.p.m. of N-1-naphthyl phthalamic acid. By May 29 heavy fruit drop had started on the sprayed trees. The dropping fruits were comparable in size to those which fell from unsprayed trees a month later. This indicates that N-1-naphthyl phthalamic acid hastens drop.

150 tightly adhering fruits and 150 very loosely adhering fruits (here called abscising) were picked on May 29 from one tree sprayed with N-1-naphthyl phthalamic acid. The loosely adhering fruits probably would have fallen within 24 or 48 hr. had they been left to drop naturally. No differences in colour of the adhering and abscising fruits were observed.

Volume measurements were made on the fruits by water displacement. The ovules were then removed and physical measurements made on twenty of them. Differences in fruit volume, ovule length and weights between adhering and abscising material were not great, but in every category the adhering fruits were larger (Table 1).

Table 1. Comparison between Adhering and Abscising Fruits of Halehaven Peach Trees sprayed with N-1-Naphthyl Phthalamic Acid

	Adhering	Abscising
Volume per fruit (ml.)*	0·22	0·20
Ovule length (mm.)	3·92	3·50
Fresh weight per ovule (mgm.)	6·92	5·85
Dry weight per ovule (mgm.)	0·93	0·91
Indoleacetic acid equivalent (µgm./ovule)	0·00221	0·00031
Indoleacetic acid equivalent (µgm./gm. dry weight)	2·38	0·34
Mean number of cells per embryo	11·1	6·3
Mean number of endosperm nuclei per ovule	155	99

* Volume per fruit at bloom was < 0·22 ml.

Ovules were frozen on dry ice, lyophilized, and bioassayed for auxins using silica-gel column chromatography[2] and the *Avena* first-internode test[3]. Preliminary work with extracts of ovules collected two weeks after bloom from unsprayed Halehaven trees indicated that two growth-promoting substances could be separated. One of very low concentration was eluted in a position similar to ethyl indoleacetate, and another of somewhat higher concentration came out in the indoleacetic acid position (unpublished results). A single determination of extracts of ovules from sprayed trees and subsequent bioassay of the eluted fractions corresponding to the ethyl indoleacetate and indoleacetic acid positions were made. Ovules from both adhering and abscising fruits contained only traces of the growth-promoting substance eluted in the ethyl indoleacetate position, but there was about seven times as much of the substance similar to indoleacetic acid in the ovules from adhering fruits as from those from abscising fruits (Table 1).

Ovules were fixed in a formalin–acetic acid–ethyl alcohol (85 : 5 : 5 per cent) mixture, embedded in paraffin, sectioned at 15 or 20µ, and stained in Heidenhain's hæmatoxylin. In the nine adhering and the thirteen abscising ovules studied, embryos of about 1–23 cells and free nuclear endosperm of about 5–301 nuclei were found. As shown in Table 1, the average number of cells in the embryo and the number of endosperm nuclei of abscising ovules were about 60 per cent of those in the adhering ovules, although these means were not significantly different at the 5 per cent level of probability. In most of the abscising ovules there was more shrinkage of cytoplasm, and less differential staining of many nuclei in embryo and endosperm than in the adhering ovules. In about half the abscising ovules the embryo stained darkly. These changes in staining reaction are interpreted, on the basis of other work on seed abortion, as indicating the beginning of the breakdown of the tissues.

It appears that N-1-naphthyl phthalamic acid causes ovule abortion and abscission in peaches in a manner similar to the action of naphthaleneacetic acid on apples[4]. Whether the primary effect of N-1-naphthyl phthalamic acid is on the endosperm, embryo or some other tissue is still to be determined. While little difference in the size of the fruits and ovules was found in these lots of adhering and abscising fruits treated with N-1-naphthyl phthalamic acid, larger differences were found in the auxin content and in the histological appearance of the embryo and endosperm of each lot of ovules (Table 1). The difference in auxin content of adhering and abscising ovules corresponds to Luckwill's report of lower auxin content in naturally dropping fruits of apples than in adhering fruits[5].

LOYD E. POWELL
CHARLOTTE PRATT

Department of Pomology,
New York State Agricultural Experiment Station,
Geneva, New York.

[1] Edgerton, L. J., and Hoffman, M. V., *Science*, 121, 467 (1955).
[2] Powell, L. E., *Plant Physiol.*, 35, 256 (1960).
[3] Nitsch, J. P., and Nitsch, Collette, *Plant Physiol.*, 31, 94 (1956).
[4] Luckwill, L. C , *J. Hort. Sci.*, 28, 25 (1953).
[5] Luckwill, L. C., *J. Hort. Sci.*, 24, 32 (1948).

Presence of Gibberellin-like Substances in Lettuce Seed

GIBBERELLINS and gibberellin-like substances are being shown to occur in an increasing number of higher plants. Immature seeds of numerous species contain particularly large amounts of these substances[1], but the levels in mature seeds of the same species are much lower[2]. Certain seeds respond very strongly to applied gibberellin, this being particularly evident in certain 'light-requiring' seeds, for example, those of lettuce[3,4] and *Arabidopsis thaliana*[5], in which gibberellin treatment may result in complete germination in the dark. The obvious first step towards understanding the physiological significance of this gibberellin action is to determine whether gibberellin-responsive seeds contain endogenous, gibberellin-like growth regulators. The present communication reports on such studies with mature seeds of lettuce (*Lactuca sativa* L.).

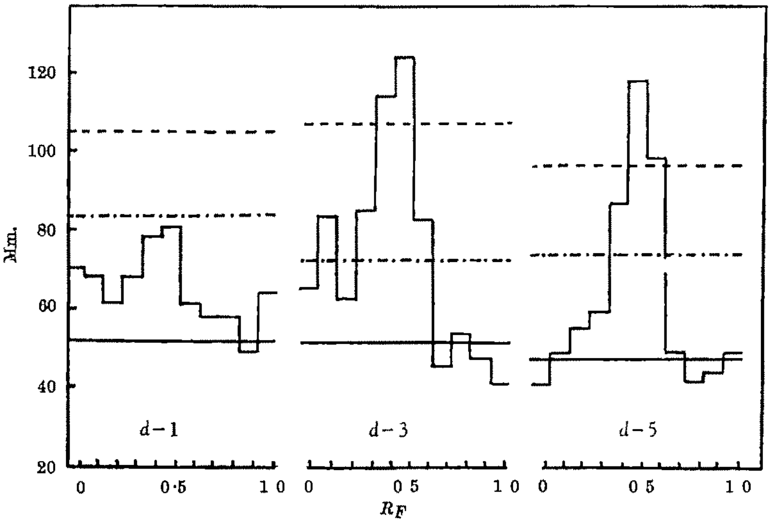


Fig. 1. Histogram of extracts from dry seeds of lettuce, tested for gibberellin-like activity on *d*-1, *d*-3 and *d*-5 dwarf maize. Each test plant was treated with a quantity of extract equivalent to 50 gm. of dry seed. Abscissa, R_F values; ordinate, sum of lengths of first and second leaf sheaths of test plants. ———, Untreated controls; – – – –, 0 01 µgm. gibberellin A_3; -·-·-·-, 0 1 µgm. gibberellin A_3. R_F value of gibberellin A_3, 0 6

The seed used was of the Grand Rapids variety, obtained locally and possessing a pronounced light requirement (at 26°, dark germination about 10 per cent; germination after saturation irradiation with white or red light 95–100 per cent).

The extraction method was that of West and Phinney[6] with some minor modifications; it is largely identical with that used by one of us[7] in similar work with vegetative and photoperiodically induced plants of *Hyoscyamus niger*.

The assay was performed on three monogenic dwarf mutants of maize (*Zea mays* L.), *d*-1, *d*-3 and *d*-5 (ref. 9). The use of these mutants as assay material is essential since their response is highly specific for gibberellins and furthermore permits the recognition not only of quantitative, but also of qualitative, differences in the activities of different gibberellins and gibberellin-like materials. Thus, gibberellins A_1, A_2 and A_3 and numerous gibberellin-like materials from various plants are highly active on all three mutants, but another gibberellin-like material, bean-factor II (ref. 6), probably identical with gibberellin A_5 (ref. 10), while highly active on *d*-3 and *d*-5, is only 5 per cent as active as gibberellin A_3 on *d*-1.

Altogether, three experiments were performed, giving highly consistent results. A representative histogram is shown in Fig. 1. It is evident that there is a zone of pronounced gibberellin-like activity in the R_F region of 0·3–0·6, with a maximum at 0·4–0·5. Furthermore, this activity is much more pronounced on the *d*-3 and *d*-5 mutants than in the *d*-1 test; thus the active material in the extracts shows the activity pattern of bean factor II and not of gibberellins A_1, A_2 and A_3. Some indications of activity were also found in other regions of the chromatograms (for example, at $R_F = 0·1$ on the *d*-3 mutant in Fig. 1); these, however, varied between experiments and thus require further study.

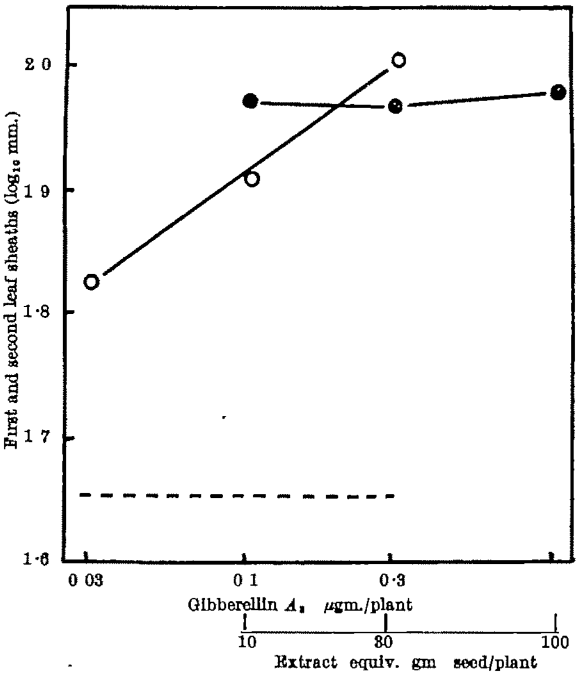


Fig. 2. Growth response of *d*-3 maize seedlings treated with different amounts of gibberellin A_3 (○——○) and of extract from dry lettuce seed (●——●). Broken line, untreated controls

Fig. 2 shows an attempt at a quantitative estimation of the amount of active material. For this experiment, the active zones of the chromatogram shown in Fig. 1 were re-extracted with acetone and the response of *d*-3 mutant seedlings to this extract was compared with their response to different amounts of gibberellin A_3. The response of the seedlings to 0·03 μgm. to 0·3 μgm. of gibberellin A_3 per plant, when plotted as logarithm of growth against the logarithm of dose, follows a straight line, as is characteristic of the dwarf-maize assay in the range of approximately 0·003–3·0 μgm. gibberellin per plant[9]. However, varying amounts of extract, corresponding to 10, 30 and 100 gm. of the original seed weight, all produced responses of practically equal magnitude. This fact indicates that the extracts still contained materials which, with increasing amounts, reduced the response of the plants. Therefore, precise estimations of the quantity of active material are not yet feasible; however, it can be assumed from Fig. 2 that the minimum level is in the order of 0·1–0·3 μgm. per 10 gm. of seeds or 10–30 μgm. per kgm., expressed as equivalents to gibberellin A_3.

It is thus clear that dry lettuce seeds contain gibberellin-like, endogenous growth substances which are physiologically related to bean-factor II and the quantities of which seem to surpass considerably the values reported for other mature seeds[8], although they still seem to be below the levels of activity found in immature seeds.

Gibberellin-like activity was also found in imbibed seeds. It is planned to pursue this matter further, and in particular, to study the gibberellin content in relation to germination.

This work was performed while one of us (A. L.) was on sabbatical leave from the University of California, Los Angeles, and holder of a senior post-doctoral fellowship from the National Science Foundation, Washington, D.C. He wishes to thank the staff of the Hebrew University's Botany Department and its chairman, Prof. M. Evenari, for their hospitality. We are greatly indebted to Dr. B. O. Phinney, University of California, Los Angeles, for supplying seeds of the three maize mutants.

S. BLUMENTHAL-GOLDSCHMIDT
A. LANG*

Department of Botany,
The Hebrew University,
Jerusalem.

---

* Present address: Division of Biology, California Institute of Technology, Pasadena.

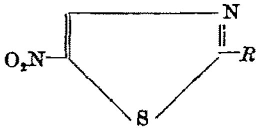
[1] Phinney, B. O., West, Ch. A., Ritzel, M., and Neeley, P. M., *Proc. U.S. Nat. Acad. Sci.*, 43, 398 (1957).
[2] Radley, M., *Ann. Bot.*, N.S., 22, 297 (1958).
[3] Kahn, A., Goss, J. A., and Smith, D. E., *Science*, 125, 645 (1957).
[4] Evenari, M., Neumann, G., Blumenthal-Goldschmidt, S., Mayer, A. M., and Poljakoff-Mayber, A., *Bull. Res. Counc. Israel*, 6*D*, 65 (1958).
[5] Kribben, F. J., *Naturwiss.*, 44, 313 (1957).
[6] West, Ch. A., and Phinney, B. O., *J. Amer. Chem. Soc.*, 81, 2424 (1959).
[7] Lang, A., *Planta* (in the press).
[8] Mitchell, L. C., *J. Assoc. Offic. Agric. Chemists*, 41, 182 (1958).
[9] See Neely, P. M., "The Development and Use of a Bioassay for Gibberellins", doctorate thesis, Univ. of California, Los Angeles (1959).
[10] MacMillan, J., Seaton, J. C., and Suter, P. J., *Proc. Chem. Soc.*, 325 (1959).

MICROBIOLOGY

Specific Inhibition of Obligate Anaerobes

MANY drugs are known which optimally inhibit single groups of micro-organisms (bacteria, fungi, or protozoa), or which inhibit specific types within one of these groups (Gram-positive or Gram-negative bacteria, pathogenic or non-pathogenic fungi). For example, certain antibiotics only inhibit bacteria; the polyene antibiotics only inhibit fungi; fumagillin inhibits protozoa[1]. This list can be extended to include compounds other than antibiotics: crystal violet (Gram-positive bacteria), sodium azide (Gram-negative bacteria). These compounds, possessing taxonomic specificity, are clearly contrasted with non-specific antimicrobial agents such as the halogens, phenols, and quaternary ammonium compounds.

I am concerned here with an antimicrobial activity which appears to transcend major taxonomic boundaries in an unusual fashion. Compounds of the type,



where *R* is a substituted amino group, are selective inhibitors of obligate anaerobes. In particular, I wish to report on the activity of an acetylated piperazine derivative, 1-(5-nitro-2-thiazolyl)-4-acetyl piperazine[2]. Susceptible anaerobes include Gram-positive and Gram-negative bacteria, actinomycetes, and protozoa, but not their aerobic counterparts. This activity may be regarded as a special kind of physiological specificity, which does not appear to have been reported.

All determinations of antimicrobial activity were made under growth conditions optimal for the organ-

Table 1. MINIMUM CONCENTRATIONS OF 1-(5-NITRO-2-THIAZOLYL)-4-ACETYL PIPERAZINE TO INHIBIT THE GROWTH OF ANAEROBIC AND AEROBIC MICRO-ORGANISMS

Anaerobic organism	μgm./ml.	Aerobic organism	μgm./ml.
Trichomonas vaginalis (strain 1)	0·7–1*	*Euglena gracilis*	>1,000
Trichomonas vaginalis (strain *H*)	0·7–1	*Trypanosoma avium*	>1,000
Trichomonas vaginalis (strain *J*)	0·7–1	*Physarum polycephalum*	333
Trichomonas foetus (strain *BR*)	0·7–1	*Lactobacillus casei*	>1,000
Endamoeba histolytica	12–25	*Escherichia coli*†	1,000
Clostridium novyi	1–4	*Proteus vulgaris*	>1,000
Clostridium sporogenes	1–4	*Salmonella typhosa*	333
Clostridium tetani	1–4	*Pseudomonas aeruginosa*	>1,000
Clostridium perfringens	250	*Neisseria catarrhalis*	>1,000
Fusobacterium sp. (human)	1–4	*Staphylococcus aureus*	>1,000
Fusobacterium sp. (guinea pig)	1–4	*Streptococcus faecalis*	>1,000
Fusobacterium sp. (rabbit)	1–4	*Streptococcus pyogenes*	>1,000
Veillonella gazogenes	8–16	*Leptospira icterohaemorrhagiae*	1,000
Desulphovibrio desulphuricans	1–4	*Candida albicans*	>1,000
Spherophorous necrophorous	1–4	*Trichophyton mentagrophytes*	>1,000
Actinomyces bovis	111	*Streptomyces* sp.	>1,000
Treponema pallidum (Reiter strain)	1–4	HeLa strain (Gey)	1,000

* Figures represent range or average of three determinations.

† Engel's porphyrinless mutant of this parent strain sensitive at 111 μgm./ml. (see text).

ism studied. Anaerobic bacteria and *Lactobacillus casei* were grown in Brewer's thioglycollate broth ('Difco') supplemented with 10 per cent of rabbit serum when necessary; trichomonads in Kupferberg's simplified trypticase serum broth; trypanosomes in Diamond's blood broth[3]; *Euglena gracilis* under artificial illumination in acetate–peptone–yeast extract broth; *Desulphovibrio desulphuricans* in Van Delden's broth[4]; and *Leptospira icterohaemorrhagiae* in a semi-solid beef extract–rabbit serum medium. The slime mould *Physarum polycephalum*, maintained in the plasmodial 'animal' phase, was grown on 1·0 per cent oat-meal agar. Malignant human epithelial cells, strain HeLa (Gey), were grown on glass in Hank's balanced salt solution, *p*H 7·0, supplemented with lactalbumin hydrolysate (0·5 per cent), yeast extract (0·1 per cent), calf serum (10 per cent), penicillin (50 units per ml.), and streptomycin (50 μgm. per ml.).

The activity of the piperazine drug is shown in Table 1. The aerobic and facultative organisms were approximately 300–1,000 times more resistant to the drug than the obligate anaerobes, regardless of taxonomic status. When inhibition of an aerobe did occur, as with *Physarum*, *Salmonella*, *Escherichia*, *Leptospira* and strain HeLa cells, a relatively high concentration of drug was required. It is difficult, of course, to state where sensitivity ends and resistance begins, but the broad outline of aerobic resistance and anaerobic sensitivity is apparent. The anomalous response of our strain of *Clostridium perfringens* (250 μgm./ml. for inhibition) suggests further experiments to determine if shifts of susceptibility can occur in a continuously exposed population.

The effect of 1-(5-nitro-2-thiazolyl)-4-acetyl piperazine is microbicidal, since exposed populations are rendered sterile within 24 hr. at the minimum inhibitory concentrations stated. Activity against susceptible anaerobes is independent of *p*H, exogenous protein, and cannot be reversed by twenty times the concentration (on a molar basis) of thiamine, riboflavin, biotin, calcium-D-pantothenate, nicotinamide, pyridoxamine, folic acid, inositol, guanine, adenine, xanthine, hypoxanthine, thymine, or uracil.

An experiment was conducted to determine if the selective inhibition of obligate anaerobes was related to anaerobiosis *per se*, that is, to a sensitivity potentiated by the environment. If this were so, anaerobic growth of the facultative organisms studied (*Staphylococcus aureus*, *Streptococcus faecalis*, *Escherichia coli*, *Shigella dysenteriae*, and *Candida albicans*) might induce sensitivity to this drug. This was not the case. These organisms, grown anaerobically in nutrient broth (alkaline pyrogallol technique), displayed their usual resistance to the piperazine drug.

As indicated in Table 1, a porphyrinless mutant of *Escherichia coli*[5], kindly supplied by Dr. M. S. Engel, of the Oak Ridge National Laboratory, was examined for susceptibility to the piperazine drug. The mutant, capable of growth and respiration with or without exogenous hæm, was ten times more sensitive to this drug than the parent strain. With another member of the nitrothiazole series (R = acetamido) the difference was more striking: inhibition of the parent strain at 250 μgm. per ml., total inhibition of the mutant at less than 1·0 μgm./ml.

An attempt was made to induce sensitivity in the above-mentioned facultative organisms by blocking hæm pigments with potassium cyanide. When these organisms were grown in the presence of the highest concentration of cyanide compatible with growth ($2–10 \times 10^{-3}$ *M* at *p*H 7·2), the usual resistance to the piperazine drug was encountered. Therefore, chemical inactivation of hæm was not equivalent to loss of hæm by mutation.

It should be pointed out that *Desulphovibrio desulphuricans*, which possesses a reversibly oxidizable pigment[6] similar to cytochrome c_3, was as sensitive as anaerobes totally devoid of such pigments (for example, *Clostridium novyi*, *Trichomonas vaginalis*). There is apparently something more fundamental to poisoning by 1-(5-nitro-2-thiazolyl)-4 acetyl piperazine (and perhaps to anaerobiosis) than mere absence or presence of hæm.

In addition to this unique *in vitro* activity, the piperazine drug was effective as an oral trichomonacide in mice. Albino males, carefully screened to weigh 12–15 gm., were infected intraperitoneally with 3×10^6 cells from a 48-hr. culture of *Trichomonas foetus*. Untreated control mice showed 100 per cent mortality usually within 10 days (severe abdominal distension with marked peritonitis). Mice treated once orally with 80 mgm./kgm. of the piperazine drug (3½ min. after infection) showed 100 per cent survival. The acute oral *LD*50 in mice was 1,200 mgm./kgm.; the 50 per cent curative dose (*CD*50) for orally treated mice was about 48 mgm./kgm. of body-weight, as calculated in a dose–response study by the method of Litchfield and Wilcoxin[7]. Further chemotherapeutic studies in animals and man seem warranted, not only for trichomoniasis, but also, indeed, for any infection produced by an obligate anaerobe (for example, amœbic, spirochætal, and clostridial infections).

Compounds of the type described should also prove invaluable in studies designed to elucidate the mechanism of anaerobic growth. Extrapolations and excursions into anaerobiosis in mammalian cells may prove interesting.

I wish to thank Dr. David B. Reisner for supplying the nitrothiazolyl piperazine, for suggesting its antimicrobial evaluation, and for his advice and encour-

agement. The technical assistance of Mr. Harry Jones is gratefully acknowledged.

Herbert N. Prince

Research Department,
Wallace and Tiernan, Inc.,
Belleville, New Jersey.

---

[1] McCowen, M. C., Callender, M. E., and Lawlis, J. R., *Science*, 113, 202 (1951).

[2] Reisner, D. B., and Scudi, J. V. (patent pending).

[3] Diamond, L. S., and Herman, C. M., *J. Parasitol.*, 40, 195 (1954).

[4] van Delden, A., *Centr. Bakt.*, ii, 11, 81 (1904).

[5] Engel, M. S., Stapleton, G. E., and Adler, H. L., *Bacteriol. Proc.*, 118 (1959).

[6] Postgate, J., *Biochem. J.*, 56, xi (1954).

[7] Litchfield, J. T., and Wilcoxin, F., *J. Pharmacol. and Exp. Ther.*, 96, 99 (1949).

BACTERIOLOGY

Physiology of D-Glutamic Acid-requiring Mutants of *Bacillus subtilis*

As reported in a previous paper[1], the *3d* mutant of *Bacillus subtilis K* requires either D-glutamic acid, D-aspartic acid or D-alanine for growth, and the *3a* mutant either D-glutamic acid, D-aspartic acid, L-glutamic acid or L-aspartic acid. This communication is concerned with the cell physiology of these mutants in a medium devoid of D-glutamic acid.

Three media were employed. Minimal medium (*MM*) was prepared as prescribed by Gray and Tatum (L-asparagine was eliminated). The medium lacking the nitrogen components (ammonium chloride and ammonium nitrate) of Gray and Tatum's prescription was termed the *M–N* medium, and the minimal medium supplemented with 100 μgm./ml. of D-glutamic acid the *DG* medium. Cells were precultivated in the supplemented medium for 15 hr. at 30°, and after centrifugation and washing, each 0·1 ml. of the cell suspension was inoculated into 10 ml. of *MM*, *M–N* and *DG* media. Cultivation was in Monod tubes on a shaking machine at 37°.

Fig. 1 (I) shows growth-curves of strain *3d*. The number of viable cells in *MM* medium increased for a while and, after a lapse of 7 hr., decreased rapidly. It was supposed that the rapid lysis observed might have been induced by the unbalanced reproduction between cell wall and cytoplasm. If D-glutamic acid were an essential component of the cell wall, the latter would not be reproduced under the existing conditions, while, because the system concerning the biosynthesis of L-glutamic acid ought to be active in this strain, reproduction of cytoplasm would proceed independently. The residual growth observed in an earlier period of cultivation might be due to the free D-glutamic acid present in the inoculum. This assumption is consistent with the results in Fig. 1 (II), which shows the growth-curves of strain *3a*. It is reasonable that no significant residual growth is observed in *MM* medium, because the biosynthetic pathway of both D- and L-glutamic acids is equally blocked in this strain.

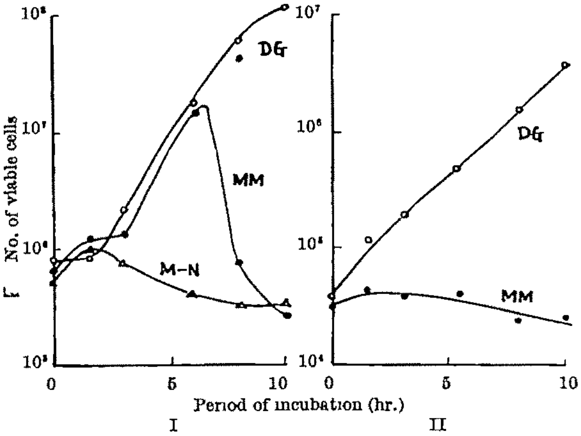


Fig. 1. Growth curves of strains *3d* (I) and *3a* (II) in *MM*, *M–N* and *DG* media

D-Glutamic acid in cell walls was identified as follows: First, washed cells of *Bacillus subtilis K* were ground in a mortar with fine glass beads, and then the cell wall fraction was separated from other parts by differential centrifugation. The sample was washed with sodium chloride solution (1 *M*) and water repeatedly, and 50 mgm. of the dried material was hydrolysed in 5 ml. of 3 *N* hydrochloric acid for 20 hr. at 110°. A small portion of the residue after evaporation was developed on a paper using a mixture of butanol, acetic acid and water (4 : 1 : 2) as solvent. Glutamic acid (D- or L-) was extracted from the corresponding portion of the paper, and added to *MM* medium to test whether strain *3d* could grow in this supplemented medium. As was expected, the strain grew well in the medium. Meanwhile, no growth of the strain *3d* was observed in the *MM* medium supplemented with glutamic acid (D- or L-) from protoplasts of the same bacterium. The protoplasts were prepared by treatment with lysozyme. It is concluded, therefore, that a detectable amount of D-glutamic acid is contained in the cell wall of this bacterium but not in the cytoplasm.

The phenomenon observed above is very similar to that found in diaminopimelic acid-requiring mutant of *E. coli*[2], and, probably, to the lysis of *E. coli* by penicillin treatment[3].

Haruo Momose
Yônosuke Ikeda

Institute of Applied Microbiology,
University of Tokyo.

---

[1] Momose, H., and Ikeda, Y., *Nature*, 186, 567 (1960).

[2] Meadow, P., Hoare, D. S., and Work, E., *Biochem. J.*, 66, 270 (1957).

[3] Lederberg, J., *Proc. U.S. Nat. Acad. Sci.*, 42, 574 (1956).

Effects of Chloramphenicol on the Recovery of Ultra-violet-irradiated *Escherichia coli B*

Doudney[1] has recently shown that the addition of chloramphenicol immediately following the ultra-violet irradiation of *Escherichia coli B* prevents the recovery of the bacteria as indicated by the decrease in viable count, whereas such an addition made after 40 min. incubation with or without nitrogen source, like an incubation in nitrogen-free medium, markedly enhances the recovery. On the basis of these and other pertinent observations, Doudney presented the idea that the synthesis of ribonucleic acid and protein, as required for the resumption of deoxyribonucleic acid synthesis following the temporary inhibition thereof caused by ultra-violet light, and the prevention of subsequent unbalanced growth[2] by inhibiting the synthesis of protein and ribonucleic acid are necessary conditions for the recovery of ultra-violet-irradiated bacteria. Experiments of similar nature made by us, however, do not seem to support such a view.

According to Aronson and Spiegelman[3], the lower concentration of chloramphenicol (20 μgm./ml.) as used by Doudney might be insufficient to block the protein synthesis completely, leading to a different response of bacteria from that observed with higher concentrations of the antibiotic in certain aspects of bacterial physiology. In our experiments a higher concentration (100 μgm./ml.) was employed unless otherwise stated. Further, Doudney used a rather heavy dose of ultra-violet light which reduced the viable count of strain *B* by a factor of more than 10^4. Under such conditions, the recovery of bacteria in a nitrogen-free medium showed a lag of 40 min. or more[1,4]. This agrees with our own observation reported elsewhere[5]. However, even with such a high ultra-violet dose, chloramphenicol added to nitrogen-free medium (0·1 *M* phosphate buffer (*p*H 7·0) – 0 02 *M* glucose) immediately following the irradiation promoted a marked recovery without a noticeable lag, although in *tris*–glucose–salt–casamino acid medium[5] the antibiotic induced the recovery to a smaller extent and with a lag of about 40 min. during which the viable count decreased slightly[5].

When we used a smaller dose of ultra-violet light to yield a survival ratio of around 10^{-3} the recovery in nitrogen-free medium started without delay and chloramphenicol did not significantly affect such a recovery (Fig. 1*B*). Under such conditions of irradiation, chloramphenicol added to *tris*–glucose–salt–casamino acid medium immediately following the irradiation also gave rise to a bacterial recovery without delay, although the recovery was more pronounced when the antibiotic was added after 40 min. incubation in *tris*–glucose–salt–casamino acid medium[5]. That such was not due to the higher concentration of chloramphenicol is illustrated in Fig. 1*A*, in which 20 μgm./ml. of the antibiotic, the concentration employed by Doudney, was also effective in promoting the recovery without lag even when added at 0 min. of incubation. It should be noted that in experiments shown in Fig. 1, the recovery of bacteria in nitrogen-free medium and in growth medium with chloramphenicol followed different kinetics, indicating some difference in the mechanism involved.

The synthesis of deoxyribonucleic acid in our lightly irradiated bacteria showed a lag of about 40 min. in *tris*–glucose–salt–casamino acid medium, while those of ribonucleic acid and protein started without delay, and chloramphenicol added at 0 or 40 min. of incubation, as observed by other workers[1,6] with lower concentrations of the antibiotic, completely inhibited or allowed to a certain extent, respectively, the resumption of deoxyribonucleic acid synthesis.

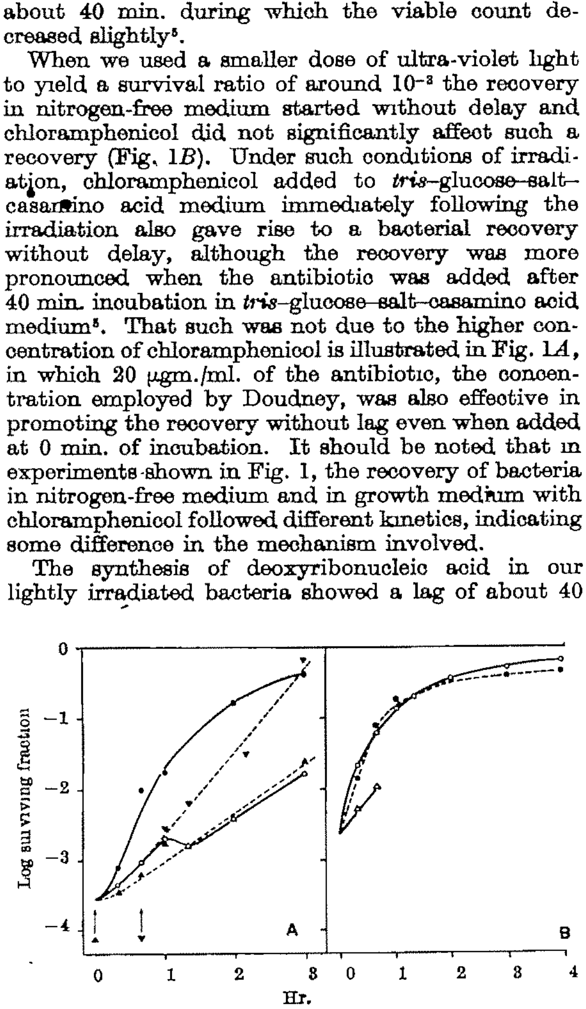


Fig. 1. Recovery of ultra-violet-irradiated *Escherichi coli B* in different media. Bacteria in late logarithmic phase of growth in *tris*–glucose–salt–casamino acid medium were irradiated for 30 sec. at 1 m. distance from Toshiba germicidal lamp (15 W.). *A*. Irradiated bacteria were shaken in *tris*–glucose–salt–casamino acid medium at 37° C. (—○—), with 20 μgm./ml. of chloramphenicol added to it immediately following irradiation (– –▲– – –) or after 40-min. incubation (– –▼– –) as shown by the arrows, or in 0·1 *M* phosphate buffer (*p*H 7 0) + 0 02 *M* glucose (—●—). *B*. They were shaken in 0·1 *M* phosphate buffer (*p*H 7·0) + 0·02 *M* glucose with (– – ● – –) and without (—○—) 100 μgm./ml. of chloramphenicol, or in *tris*–glucose–salt–casamino acid medium (—△—)

The discrepancy between Doudney's and our own observations may be due partly or entirely to the slight difference in experimental conditions or in the strain used. However, our experiments clearly indicate that the inhibition by chloramphenicol of the resumption of deoxyribonucleic acid synthesis does not necessarily prevent the recovery of ultra-violet-irradiated bacteria, and this may be sufficient evidence for ruling out the possibility suggested by Doudney[1]. It was also demonstrated[7] that the unbalanced growth could not be taken as the cause of bacterial death either in thymine-deficient, ultra-violet-irradiated, or mustard-treated *E. coli*. Thus, the possible mechanism of the recovery of ultra-violet-irradiated *E. coli B* is still open to question.

H. OKAGAKI
A. SIBATANI

Cytochemistry Laboratory,
Yamaguti Medical School,
Ube, Japan.

[1] Doudney, C. O., *Nature*, **184**, 189 (1959).

[2] Cohen, S. S., and Barner, H. D., *Proc. U.S. Nat. Acad. Sci.*, **40**, 885 (1954).

[3] Aronson, A. S., and Spiegelman, S., *Biochim. Biophys. Acta*, **29**, 214 (1958).

[4] Doudney, C. O., and Haas, F. L., *Radiation Res.*, **9**, 108 (1959).

[5] Okagaki, H., *J. Bacteriol.*, **79**, 277 (1960).

[6] Harold, F. M., and Ziporin, Z. Z., *Biochim. Biophys. Acta*, **29**, 439 (1958). Diakulić, M., and Errera, M., *ibid.*, **31**, 459 (1959).

[7] Okagaki, H., Tsubota, Y., and Sibatani, A., *J. Bacteriol.* (in the press). Harold, F. M., and Ziporin, Z. Z., *Biochim. Biophys. Acta*, **28**, 482 (1958).

An Association between Capsulation and Phage Sensitivity in *Erwinia amylovora*

DURING a recent outbreak of fire blight in Britain[1,2] more than 150 isolations of the pathogen, *Erwinia amylovora*, have been made in this laboratory. On initial plating of infected material two types of colony are often observed[3]. The dominant type has characteristic markings on 'Yeastrel' peptone agar plates incubated at 30° C. For convenience, strains which form this type of colony are called 'typical'; those forming the second type of colony, which is relatively featureless, and less opaque, are called 'atypical'. Some strains are intermediate in character, even after re-streaking several times. With some such strains the opacity of individual colonies on a single streak plate may show considerable variation, with others, each individual colony appears mottled; marking may or may not be apparent on the more opaque colonies. Some 'typical' strains regularly yield a small proportion of unmarked colonies.

Using the wet indian ink method with a phase-contrast microscope, it was observed that the majority of cells of the 'typical' strains had small but distinct capsules when grown on either 'Yeastrel' peptone agar or a phage-test medium containing 1 per cent glycerol[3]. In contrast, some of the 'atypical' strains showed no capsules (Table 1). The remaining strains showed varying proportions of capsulated and non-capsulated cells. An accurate

Table 1. Colony Form, Capsulation and Phage Sensitivity of 28 Strains of *Erwinia amylovora*

Form of colony at 30° C. on 'Yeastrel' agar	No. of strains	Proportion of capsulated cells	Sensitivity to phages	
			4L and *4S*	23
Typical	2	majority	*Ch*	—
Typical	4	majority	*Ch*	(*c*)
Intermediate	2	many	*Ch*	*C*
Intermediate	1	many	*ch*	*c*
Intermediate	8	few to many	*ch*	*C*
Atypical	4	few to many	*ch*	*C*
Atypical	1	rare	(*c*)*h*	*C*
Atypical	1	few	—	*C*
Atypical	8	rare	—	*C*
Atypical	2	none	—	*C*

Key: *C*, confluent lysis, little background turbidity; *c*, moderate background turbidity; (*c*) heavy background turbidity; *h*, halo

assessment was not possible with this method, because non-capsulated cells tended to clump in the indian ink though they were not agglutinated in normal saline. Also, some intermediate 'atypical' strains showed varying proportions on different occasions. An approximate estimate of the degree of capsulation of each strain was made and the results of two observations were recorded as follows in Table 1: majority (> 75 per cent), many (25–75 per cent); few (< 25 per cent); rare (< 1 per cent).

Crosse[1] has reported the isolation of phages which lyse *E. amylovora*. Since then, further phages have been isolated in this laboratory using the technique described by Crosse and Hingorani[3,4]. Two of these, *4S* and *4L*, give large (about 3·0 mm.) and small plaques (about 1·0 mm.) respectively on 'typical' strains. A third gives small plaques on 'atypical' strains.

The relationship between colony characteristics at 30° C., degree of capsulation and phage sensitivity with 28 strains is shown in Table 1. At one extreme there are the so-called 'typical' strains, the majority of the cells of which appear capsulated. These are lysed by phages *4L* and *4S*, which produce confluent lysis with a little background turbidity; the lysed area is surrounded by a distinct halo which extends on continued incubation. 'Typical' strains are not normally lysed by phage 23 or, if lysis is observed, it is largely obscured by background turbidity. At the other end of the scale are some of the stable 'atypical' strains which appear virtually non-capsulated or which at the most have rare capsulated cells. They are not lysed by phages *4L* and *4S*, but are strongly lysed by phage 23. Various intermediate reactions which have been observed with the remaining strains are also shown. Like capsulation, the reactions may vary slightly from one experiment to another, but the general picture remains the same.

It would appear from these observations that sensitivity to phages *4L* and *4S* depends on the presence of capsules and to phage 23 on the absence of capsules, and that where the culture contains a mixture of capsulated and non-capsulated cells some reaction with both phages can be expected. The strength of the reaction would seem to depend on the relative proportions of each; whether or not lysogenization occurs has not yet been fully investigated. Similar observations have been made by Rakieten, Eggerth and Rakieten[5] with mucoid strains of *Klebsiella, Escherichia* and *Aerobacter*. They found that phages acting on the mucoid strains were mainly type- or strain-specific. In my experience with *E. amylovora*, all strains giving 'typical' colonies (more than 130), whether isolated from *Pyrus, Crataegus, Sorbus* or *Cotoneaster* spp., also two strains in the National Collection of Plant Pathogens (100 and 311), have been sensitive to phages *4S* and *4L*.

The presence of extending halos in the case of reactions with phages *4L* and *4S* and capsulated strains suggests that an enzyme capable of hydrolysing capsules is produced[6,7].

Eve Billing

Department of Bacteriology
(Ministry of Agriculture, Fisheries and Food),
National Agricultural Advisory Service,
Wye, Ashford,
Kent.

[1] Crosse, J. E., Bennett, M. M., and Garrett, C. M. E., *Nature*, 182, 1530 (1958).

[2] Lelliott, R. A., *Agric.*, 65, 564 (1959).

[3] Billing, E., Crosse, J. E., and Garrett, C. M. E., *Plant. Path.*, 9, 19 (1960).

[4] Crosse, J. E., and Hingorani, M. K., *Nature*, 181, 60 (1958).

[5] Rakieten, M. L., Eggerth, A. H., and Rakieten, T. L., *J. Bact.*, 40, 529 (1940).

[6] Humphries, J. C., *J. Bact.*, 56, 683 (1948).

[7] Adams, M. H., and Park, B. H., *Virology*, 2, 719 (1956).

VIROLOGY

Filamentous Structures in Ectromelia Virus-infected Cells

The presence of parallel arrays of thin lamellæ clustered in bundles in the cytoplasm of some tumour cells containing Shope fibroma virus has been depicted by Bernhard *et al.*[1]. Fawcett[2] has observed irregular, coarse bundles of dense filaments in the cytoplasm of virus-containing tumour cells of the Lucké renal adenocarcinoma. Morgan *et al.*[3], reviewing their earlier micrographs of chick chorioallantois infected with fowl pox, found clusters of dense filaments, indistinguishable from those described by Bernhard, in the cytoplasm of ectodermal cells containing virus particles[4]. More recently, Reczko[5] has demonstrated the presence of groups of lamellæ in the epithelial cells of guinea pig peritoneum infected with swine pox virus. In electron micrographs of sections of chick chorioallantoic membranes infected with ectromelia virus, bundles of filaments have been observed in association with intra-cytoplasmic virus inclusion bodies.

Chorioallantoic membranes of 10-day-old White Leghorn embryos were inoculated[6] with a suspension of ectromelia virus so diluted as to give semiconfluent lesions after 72-hr. incubation at 36° C. The inoculum was second-egg passage material derived from infected mouse spleen originally received from Dr. W. C. Cutting of Stanford University. After incubation for 72 hr., membranes were fixed for about 5 min. while still in the eggs with buffered 1 per cent osmium tetroxide containing sucrose[7]. Membranes were excised and fixation continued for another 60 min. Ultra-thin sections of methacrylate-embedded tissue were examined with an RCA *EMU 2-B* electron microscope.

An infected mesodermal cell depicted in Fig. 1 shows a bundle of filaments with discrete virus particles interposed between it and a large virus inclusion body. A portion of the nucleus is seen in the lower left corner. Fig. 2 is a higher magnification showing in greater detail the fine structure of the filaments. The thickness of filaments is 8 mμ on the average, while the length is about 3–4μ. Virus forms, 265 × 200 mμ, with dense inner bodies lie between the bundle of filaments and inclusion body,

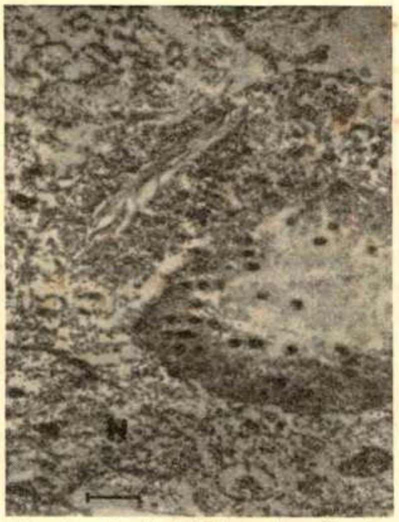


Fig. 1. Mesodermal cell of 72-hr. ectromelia virus-infected chorioallantois. A mitochondrion in a degenerative stage is seen immediately to the right of the nucleus (*N*). The filament bundle appears at the upper left. (In both Figs. 1 and 2, the scale mark represents 1μ.) (× *c*. 7,300)

the periphery of which is shown in the lower right corner.

In the numerous sections studied the filaments have generally been observed to be, at least topographically, in close association with virus forms and with inclusion bodies. In the case of Shope fibroma, the filaments, 7 mμ in diameter, were noted to be closely associated with cytoplasmic masses of virus or precursors of virus and were interpreted as possible by-products of a lipid nature of virus metabolism[1]. Fawcett observed typical virus particles contiguous to the filaments and believed that these might be related in some obscure way[2]. Reczko, noting the consistent location of these formations in the vicinity of developmental forms of the virus in the early stages of infection, concluded that these were probably connected with the process of virus synthesis[5].

The role of these filaments in virus development has not been established. Their presence in the cytoplasm of virus-infected cells has thus far been described for only the five aforementioned agents. It is possible that on careful study these structures will be observed in cells infected with other viruses[8]. Whether they be by-products of virus metabolism, pathological cellular responses to virus invasion, or stages in virus reproduction, will have to await further and more extensive investigation.

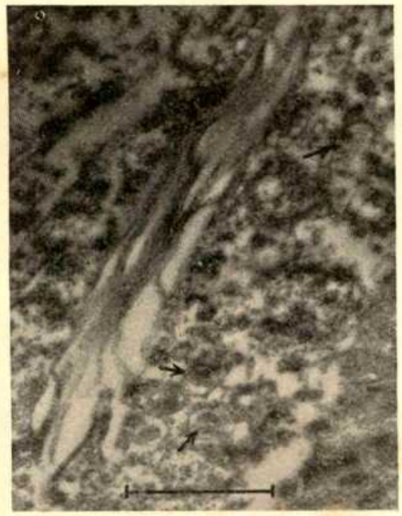


Fig. 2. Higher magnification of portion of infected mesodermal cell showing fine structure of filament bundle and viral forms (arrows) with dense inner bodies. (× 19,600)

BENJAMIN V. SIEGEL

Department of Pathology,
School of Medicine,
University of California,
San Francisco 22.

---

[1] Bernhard, W., Bauer, A., Harel, J., and Oberling, C., *Bull. Cancer*, **41**, 423 (1954).

[2] Fawcett, D. W., *J. Biophys. Biochem. Cytol.*, **2**, 725 (1957).

[3] Morgan, C., Ellison, S. A., Rose, H. M., and Moore, D. H., *J. Exp. Med.*, **100**, 301 (1954).

[4] Morgan, C., Rose, H. M., and Moore, D. H., *Ann. N.Y. Acad. Sci.*, **68**, 302 (1957).

[5] Reczko, E., *Archiv Ges. Virusforsch.*, **9**, 193 (1959).

[6] Siegel, B. V., Smith, M., and Gerstl, B., *Amer. Med. Assoc. Arch. Path.*, **63**, 562 (1957).

[7] Caulfield, J. B., *J. Biophys. Biochem. Cytol.*, **3**, 827 (1957).

[8] Siegel, B. V., Abstr. Seventh Int. Cong. Microbiol., Stockholm, 249 (1958).

An Indicator Plaque-forming System for Demonstration of Interference by Non-cytocidal Strains of Rabies Virus

FIXED strains of rabies virus are known to multiply in chick embryo tissues[1,2]. So far, however, a cytocidal effect of the virus on monolayers of primary chick embryo cell cultures has not been observed. Since chick embryo-adapted strains of rabies virus interfere with infection by homologous virus in animal cells[3], the present investigations were undertaken to demonstrate interference of rabies virus with a superimposed infection of western equine encephalitis virus, which is known to produce cytopathic changes in these cultures.

Monolayers of chick embryo cells in 60-ml. Petri dishes were exposed for 2 hr. to $10^{6\cdot2}$ mouse *LD*50's of a fixed (*CVS*) strain of rabies virus in 0·2 ml. inoculum. 5 ml. of Eagle–Earle's medium were then added and the plates incubated at 37° C. for 24 hr. in an atmosphere of about 5 per cent carbon dioxide. The medium was discarded and the cells were exposed for 45 min. at 37° C. to western equine encephalitis virus. The plates, overlaid with neutral agar, were then incubated for 72 hr., and the cell sheets stained with a 1 : 10,000 solution of neutral red for the plaque count. Complete inhibition was observed of plaque formation by western equine encephalitis virus up to 2 million plaque-forming units, the highest concentration used. Essentially the same results were reproducible on repeated tests. In a preliminary study street virus also appeared to interfere with western equine encephalitis in the same system.

Quantitative studies of the rabies virus with the western equine encephalitis indicator system described gave promising results. Increasing dilutions of rabies virus showed a consistent titration pattern in repeated tests. Table 1 illustrates typical results obtained in one of the tests. In this table it will be noted that the 1 : 5,000 dilution of rabies virus, equivalent to about $10^{3\cdot5}$ *LD*50 in 0·2 ml. inoculum, still interfered with western equine encephalitis.

Although preliminary experiments indicate that the rabies virus particle itself may interfere with subsequent infection of the cell with western equine

Table 1. INTERFERENCE PRODUCED BY FIXED RABIES VIRUS TO WESTERN EQUINE ENCEPHALITIS

Inoculum	No. of plaques per plate exposed to tenfold dilution of western equine encephalitis		
	10^{-1}	10^{-5}	10^{-6}
0·2 ml. of following dilutions of rabies virus* :			
1 : 1,250	0,0 (duplicate plates)	0,0	0,0
1 : 5,000	*D*†, *D*	27,10	4,9
1 : 20,000	*D*, *D*	104,137	31,23
Western equine encephalitis control	*D*	215,154	24,30

* Rabies virus inoculum undiluted contained $10^{7\cdot8}$ mouse *LD*50 per 0·2 ml.

† Degeneration of cells.

encephalitis, the interference can also be mediated in part by 'interferon' (as named by Isaacs and Lindermann[4]). This was demonstrated as follows. The culture medium covering the monolayer sheet exposed for 24 hr. to rabies virus was removed, centrifuged twice at 40,000*g* for 1½ hr., and the supernatant tested for absence of live virus by intracerebral inoculation into mice. This supernate, to which rabies antiserum was added to ensure neutralization of any residual live virus, was placed on fresh monolayers for 24 hr. The medium was then discarded and the cell sheets exposed to western equine encephalitis virus in the usual manner. Partial to complete inhibition of plaque formation by between 10 to 1,000 plaque-forming units of western equine encephalitis was obtained. This inhibition, however, was distinctly less than that observed with cell sheets directly exposed to rabies virus (Table 1).

The specificity of the test described was shown by neutralization of rabies virus with anti-rabies serum (Table 2). Increasing dilutions of anti-rabies serum against a constant amount of rabies virus displayed a titration pattern similar to that which occurred when serial dilutions of rabies virus alone were used as mentioned previously (Table 1).

Table 2. NEUTRALIZATION OF CONSTANT AMOUNT OF FIXED RABIES VIRUS WITH INCREASING DILUTIONS OF ANTI-RABIES SERUM

Inoculum	No. of plaques per plate exposed to dilution of western equine encephalitis		
	10^{-5}	10^{-6}	10^{-7}
0·1 ml. rabies virus* + 0·1 ml. serum to given final serum dilution :			
1 : 2	44,54	3,5	0
1 : 20	81,92	9,18	1
1 : 200	88,84	18,6	0
1 : 2,000	0,0	0,0	0
Western equine encephalitis control	79,40	11,8	1,0

* Rabies virus inoculum contained $10^{7\cdot5}$ mouse *LD*50 per 0·1 ml. inoculum.

The sensitivity of the test compares favourably to that of the hæmagglutination test employed with myxoviruses. The ratio of the number of infective doses (egg *ID*50) per hæmagglutinating unit averages $10^{6\cdot8}$ for myxoviruses of high infectivity[5], as compared with $10^{3\cdot5}$ mouse *LD*50 of rabies virus being equivalent to approximately one interfering unit.

The results indicate the value of the interference system described for both quantitative and qualitative assays of a non-cytocidal virus and its specific antibody.

This work was done with funds provided by Grant *E*-2954 of the United States Public Health Service.

We acknowledge with thanks the technical assistance of Mr. T. Jacobs.

MARTIN M. KAPLAN*
EBERHARD WECKER
ZLATKO FORSEK†
HILARY KOPROWSKI

Wistar Institute,
Philadelphia.

* On leave of absence from the World Health Organization, Geneva.

† On leave of absence from the Veterinary School, University of Sarajevo.

[1] Dawson, jun., J. R., *Science*, **89**, 300 (1939).
[2] Kligler, I. J., and Bernkopf, H., *Nature*, **143**, 899 (1939).
[3] Koprowski, H., *Bull. World Health Org.*, **10**, 709 (1954).
[4] Isaacs, A., and Lindermann, J., *Proc. Roy. Soc.*, B, **143**, 408 (1957).
[5] Isaacs, A., "Adv. in Virus Res.", **4**, 111 (1957).

Distribution-Free Interpretation of Spray-Drop Data

SPRAY-DROP assay results do not always meet the Poisson-distribution test proposed by Williamson and Taylor[1], even though they may be valid and the sole product of expensive measurements. Williamson and Taylor have described an appropriate method for interpreting the spray-drop results obtained by the technique of Williams and Backus[2,3] for estimating the concentration of particles in a suspension. In this technique the unknown suspension is mixed with a suspension of polystyrene latex spheres in known concentration. The mixture is sprayed as a fine mist, and droplets are collected on specimen supports for examination by electron microscopy. For each droplet, the number of particles and the number of latex spheres observed are recorded. Counted for many droplets, these numbers constitute the raw data from which the concentration of particles in the unknown suspension is deduced.

A statistical analysis supplied by Williams and Backus was refined by Williamson and Taylor. This refinement included a test for the likelihood that the raw data represent samples from two Poisson-distributed populations, one for polystyrene latex spheres and one for the particles. If the raw data satisfy the Williamson and Taylor tests, and are free from induced variation arising from large variations in droplet size, then the ratio of the number of particles to the number of polystyrene latex spheres in the mixed suspension can be estimated from the ratio of the total particle-count in all droplets to the total count of polystyrene latex spheres in all droplets. The variance of this estimate can be calculated by the equation of Luria, Williams and Backus[4]. Lack of information on the precise distribution of the ratio precludes the possibility of using this variance to calculate a confidence interval. When data do contain variations induced by variation in droplet size, and do not satisfy the distribution test of Williamson and Taylor, distribution-free statistical methods may still be applied to obtain useful inferences about the concentration of particles in the unknown suspension. The use of order statistics is an appropriate distribution-free method in this instance. The following results, however, apply equally well to data which satisfy the requirements for the Williamson and Taylor analysis. In general, one would not expect the inferences of distribution-free analysis to be as precise as those obtained using the Williamson and Taylor analysis. The measure of central tendency is the median when distribution-free methods are used. The true population mean

Table 1

Drop No.	No. of particles (P)	No. of polystyrene latex spheres (PSL)	Ratio $\left(X = \frac{P}{PSL}\right)$	Order statistic
1	76	35	2·171	10
2	139	66	2·106	8
3	115	54	2·129	9
4	59	40	1·475	2
5	23	28	0·821	1
6	85	41	2·073	5
7	140	79	1·772	3
8	95	15	6·333	12
9	21	10	2·100	7
10	148	71	2·085	6
11	78	35	2·229	11
12	105	57	1·842	4

and median are equal only when the distribution is symmetrical.

Table 1 shows typical raw spray-drop data and the assignment of order statistics. The order statistics are simply integers assigned in increasing sequence to the calculated ratio X. Let n be the number of droplets the contents of which were counted. Let v be the true median of the population of possible ratios. Then the probability that the value of X with order statistic r is less than v, and the value of X with order statistic $n - r + 1$ is greater than v, can be calculated using equation 1:

$$(X_r < v < X_{n-r+1}) = \sum_{i=r}^{n-r} \frac{n!}{(n-i)!\,i!}\left(\frac{1}{2}\right)^n \qquad (1)$$

From this probability statement, confidence intervals for the median may be deduced. These confidence intervals are broader than those which might be obtained if the distribution of the ratio were known precisely. If needed, narrower confidence intervals for the same fiducial probabilities may be obtained by applying Fieller's theorem, which is discussed by Finney[6]. For much work in virus assay, confidence intervals based on equation 1 are sufficiently precise. Fig. 1 represents equation 1 in graphical form and shows, for each sample size, the value of r, which describes the confidence interval on the median.

To use Fig. 1, choose the line labelled with the required level of confidence. For the appropriate sample size, find r and compute $n - r + 1$. Locate the values of r and $n - r + 1$ in the column of order statistics assigned to the data. The data corresponding to these values represent the extremes of the confidence interval. For example, the median ratio for the data in Table 1 would have a 99 per cent confidence interval lying between 1·475 and 2·229 and a 95 per cent confidence interval between 1·772 and 2·171.

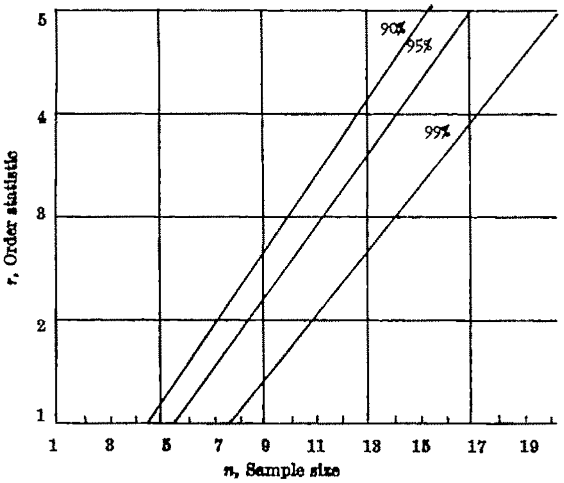


Fig. 1

When the underlying distributions for the data are certain, this information should be used in the analysis in order to discover any defects in the experimental technique, such as a bimodal distribution of drop-sizes. When order statistics alone are used in the analysis of spray-drop data, there is not the internal check for consistency provided by the Williamson and Taylor Poisson-distribution test. The distribution-free statistics are so convenient to use, however, that they can be recommended for broad application in situations where extreme precision in the estimate of the particle concentration is not required. The cost of this convenience may be the requirement for a better exercise of judgment in identifying valid data.

JOHN B. OPFELL

Cutter Laboratories,
Berkeley, California.

---

[1] Williamson, K. L, and Taylor, W. B., *Brit. J. App. Phys.*, 9, 264 (1958).

[2] Williams, R. C., and Backus, R. C., *J. Amer. Chem. Soc.*, 71, 4052 (1959).

[3] Backus, R. C., and Williams, R. C., *J. App. Phys.*, 21, 11 (1950).

[4] Luria, S. E., Williams, R. C., and Backus, R. C., *J. Bact.*, 61, 179 (1951).

[5] Mood, A. M., "Introduction to the Theory of Statistics" (McGraw-Hill, 1950).

[6] Finney, D. J., "Statistical Methods in Biological Assay" (Hafner, 1952).

SOIL SCIENCE

Swelling of Calcium Montmorillonite

WARKENTIN *et al.*[1], following up earlier work of Schofield[2], Bolt and Miller[3], and others, showed that swelling pressures developed by suspensions of sodium montmorillonite on an ultra filter could be predicted satisfactorily from a diffuse ion layer model based on classical Gouy–Chapman theory. Warkentin *et al.* also reported results of preliminary experiments with calcium montmorillonite for which the same model appeared to be inappropriate. A significant result was the decrease in magnitude of reswelling observed as the peak pressure applied to the sample increased. They concluded that forces not taken into account in the calculation must be present. Recently, Aylmore and Quirk[4], Greacen[5] and others have published discussions of these results which may now require reconsideration in view of further studies of calcium montmorillonite swelling.

Blackmore[6], working with calcium-saturated clay, was unable to duplicate the results of Warkentin *et al.*, and as a consequence obtained and re-examined one of the samples used in that study. In Fig. 1 are given some results of compression–decompression measurements on the Warkentin *et al.* sample together with a replot of results from Warkentin *et al.* and corresponding results from a freshly prepared sample. In these curves, the half-spacing is calculated as the quotient of the specific water content by the specific surface, a convention which assumes equal spacing between all clay particles according to the model which was found to be successful for clays saturated with monovalent ions. Apart from a half-spacing displacement for curves obtained with the old and new samples, current measurements on these samples show very similar results and are consistent with more extensive results obtained by Blackmore, but the reswelling observed was less than half that reported by Warkentin *et al.*, except for samples which had experienced high pressures.

It was observed that the Warkentin *et al.* sample contained approximately 25 m.equiv. of sodium per 100 grams, due presumably to preparation by a calcium–resin column with insufficient free electrolyte[7]. This may account for the half-spacing displacement mentioned, but it apparently had little effect upon the magnitude of reswelling. No final solution of this anomaly has been achieved, but increasing evidence suggests that the swelling reported by Warkentin *et al.* is not that associated with a homoionic calcium montmorillonite.

Samples of calcium montmorillonite which had been equilibrated at various points in compression and decompression cycles were examined by X-ray diffraction and the presence of 18·8 Å. [001] spacings was demonstrated at all water contents and pressure equilibria. The average thickness of the 'packets' of particles presumed to be responsible for the diffraction peaks was estimated from the extent of line broadening. It was then possible to correct the swelling results for the presence of this 'condensed' phase and to estimate swelling between packets. It was also demonstrated that the exterior surface of the packets rather than residual single sheets not associated with packets was the active site of swelling.

Fig. 2 shows the original and corrected reswelling curves for a sample of calcium montmorillonite with 10^{-4} M electrolyte, and it is seen that agreement between the corrected curve and the curve obtained from the Gouy–Chapman model is surprisingly good. On the basis of this and related work it may be concluded that any swelling which occurs in a calcium clay–water system is largely of osmotic origin for the water contents studied, is a consequence of disorder within the sample, and can be approximated by calculations based on the Gouy–Chapman model.

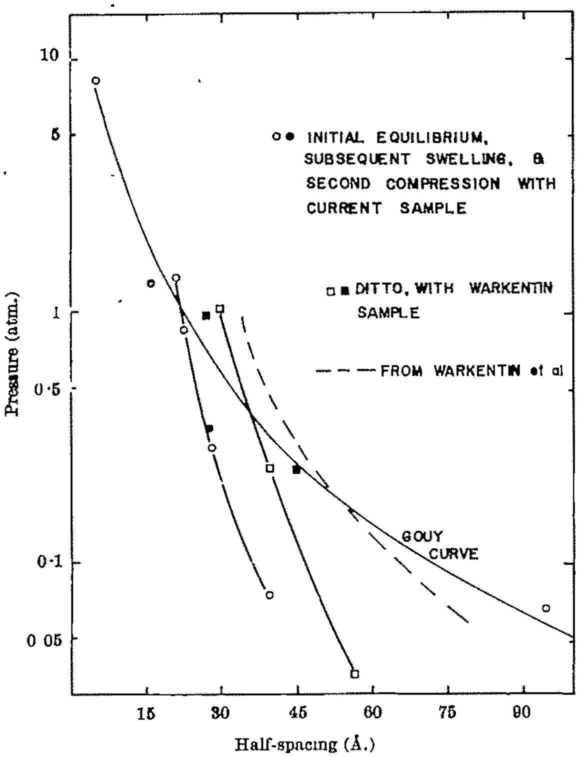


Fig. 1 Swelling pressure as a function of half-spacing for calcium montmorillonite with 10^{-4} M free electrolyte. Results are plotted for the theoretical curve, for a current sample, and for a repeat run with the sample used by Warkentin *et al.* in an earlier study, along with one of the re-swelling curves reported in this latter work

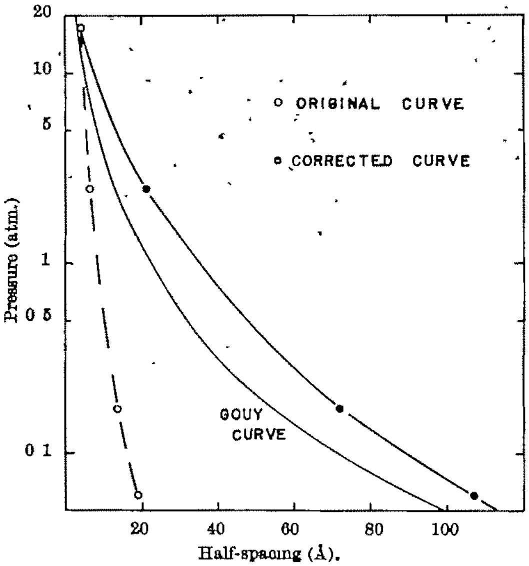


Fig. 2. Swelling pressures as a function of half-spacing for calcium montmorillonite calculated in the original form where half-spacing is obtained from total water and total surface area, and in the form corrected for 'packets' of unit sheets of clay. The average number of sheets per packet in this sample was 7, and the corrected curve has been displaced to the right by 3 Å. so that it will coincide with the uncorrected one at the point of maximum pressure

A. V. BLACKMORE
B. P. WARKENTIN

Department of Agronomy,
Cornell University,
Ithaca, New York,
and
Department of Agricultural Physics,
Macdonald College,
McGill University,
Montreal.
March 4.

---

[1] Warkentin, B. P., Bolt, G. H., and Miller, R. D., *Soil Sci Soc Amer. Proc.*, **21**, 495 (1957).
[2] Schofield, R. K., *Trans. Farad. Soc*, **42**, B, 219 (1946).
[3] Bolt, G. H., and Miller, R. D., *Soil Sci. Soc. Amer Proc.*, **19**, 285 (1955).
[4] Aylmore, L. A. G., and Quirk, J. P., *Nature*, **183**, 1752 (1959).
[5] Greacen, E. L., *Nature*, **184**, 1695 (1959).
[6] Blackmore, A. V., Ph.D. thesis, Cornell University (1960).
[7] Lewis, D. R., *Indust. and Eng. Chem.*, **45**, 1782 (1953).

ANTHROPOLOGY

Apidium and *Oreopithecus*

IN view of attention recently directed to the taxonomic position of *Oreopithecus* among primates, as a result of new discoveries by Hürzeler[1] and Butler and Mills[2], a re-analysis of possible affinities of *Oreopithecus* with *Apidium*, from early Oligocene deposits of the Fayum, Egypt, seems desirable. Two fundamental points regarding this small Egyptian genus have been largely overlooked in recent literature on primate phylogeny. These are: first, that

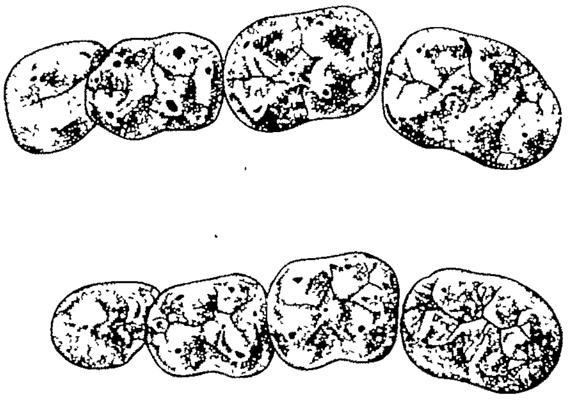


Fig. 1. Above, *Oreopithecus bambolii*, type; size approx. × 2 (after Hürzeler, ref. 1); below, *Apidium phiomense*, type; size approx. ×4. Apices of principal cusps indicated in black

ranking *Apidium* as a primate is still justifiable, and second, that (among primates) its greatest resemblances are to *Oreopithecus* (Fig. 1). As both these assessments depend on partly qualitative taxonomic judgments, either may continue to be debated. In the following account the bases for these two conclusions are briefly outlined.

Osborn's reluctance to designate an ordinal position for *Apidium* in his description[3] of the type and only specimen was understandable in 1908. Much less was then known of *Oreopithecus* dental patterns, and little or nothing had been published regarding a number of early Tertiary primates, with which *Apidium* can now be compared. Such forms, since discovered, include *Parapithecus* and *Propliopithecus*, both from the same Oligocene fluviomarine formation which yielded *Apidium*. Direct observation of the type-specimens of these three genera shows that they are possibly inter-related. Although the teeth of *Apidium* are more cuspidate than are those of the other two Fayum mandibles, substantial agreements obtain among all three in conformation of major molar cusps and in other details. The suggestion by Osborn that *Apidium* might be allied to *Cebochoerus*, a primitive suid of the late Eocene of Europe, was rejected by both Schlosser[4] and Gregory[5]. Even so, Osborn's caution evidently has seeded an unnecessarily persistent doubt that *Apidium* can be given an accurate assignment to an order. Actually, a sound assessment should be possible. The teeth preserved are complex and little worn, so that, together with details of the jaw ramus, the occurrence and morphology of a great many separate features can be noted. Gregory[5] held that *Apidium* represents a plausible structural progenitor for the cercopithecoids, an assessment which still has some merits. He also stressed its close dental similarity to *Oreopithecus*. Since the latter was then regarded as a cercopithecoid monkey correct assessment was further complicated. Recently, Piveteau[6] and Hurzeler[1] have suggested that *Apidium* is a condylarth related to *Phenacodus*, but this is improbable (see Simons, ref. 7).

Among non-primates the closest similarities with *Apidium* are still to be seen in *Cebochoerus*, rather than with any Condylarthra. Nevertheless, these correspondences also appear to be superficial. There are a large number of proposed species of *Cebochoerus*, some of which have very little resemblance to *Apidium*. A specimen of *Cebochoerus* sp. at Princeton University, No. 11472, from the late Eocene phosphorites of south-central France shows more features of agreement with *Apidium* than most members of the genus do. Yet their differences are significant. Although a small individual of *Cebochoerus*, this jaw is almost twice as large as that of the Fayum primate, and, unlike it, has a progressive increase in depth of the horizontal ramus posteriorly, a feature common in artiodactyls, but rare in primates. Moreover, the principal molar cusps of the suid are higher and occupy a more central position on the teeth than they have in *Apidium*. In the latter the antero-internal margin of the mandible starts to turn inward toward the symphysis next to $P_{\bar{4}}$, thus suggesting a reduced number of teeth in the front of the jaw (as in catarrhines) and unlike *Cebochoerus*, other artiodactyls, and Condylarthra generally. While third molar heels in both are large, that of *Apidium* lacks the distinct separation of the hypoconulid lobe of $M_{\bar{3}}$ seen in *Cebochoerus* and typical of Artiodactyla. A raised area or centroconid is present in molars of both forms under consideration, but as this structure also occurs in the same position in *Oreopithecus* it need not indicate a phyletic connexion between *Apidium* and *Cebochoerus*. This suid also differs from *Apidium* and *Oreopithecus* in having a more pronounced constriction between trigonid and talonid of $M_{\bar{1}-\bar{3}}$ and a distinct crest joining hypoconid and hypoconulid.

In spite of this evidence, it cannot be denied that convergence between some primates and some suids can be very deceptive. As late as 1951, the view that *Oreopithecus* might be a suid was advanced in print. A similar confusion of these two groups lay behind the description of "Hesperopithecus". Now that Hürzeler, through recent collecting in Italy, has performed the valuable service of making *Oreopithecus* one of the better-known fossil primates (in terms of skeletal parts represented) its ordinal position is no longer in doubt. This problem resolved, the primate status of *Apidium* is practically confirmed by way of the following observed similarities with *Oreopithecus*.

In *Oreopithecus* the fourth premolar, $P_{\bar{4}}$, is two-cusped, while at best in *Apidium* it is only incipiently so. It must be assumed, however, that at some point in the ancestry of *Oreopithecus* $P_{\bar{4}}$ had only one principal cusp, as is typical of Eocene and earlier primates. Moreover, the multiplication of cusps in the talonid region of $P_{\bar{4}}$ in *Apidium* is reminiscent of the condition here in *Oreopithecus* and in some Eocene primates as well. A small internal cusp also may be the homologue in the Fayum form of the inner cusp of $P_{\bar{4}}$ in *Oreopithecus*. Occasionally in the latter the internal cusp of the trigonid is somewhat smaller and lower than the outer, so that the bicuspedness is not developed to the same degree in all specimens of the Tuscan primate.

Agreement in structure in the first molar tooth, as between the two species, is striking. In both forms the basal cingulum is most distinct around the anterior end of the tooth. The two also agree in the position and shape of the paraconid element, and the protoconid and metaconid of both exhibit three major crests running down from their apices, two of these being directed more or less antero-internally and the third running postero-lingually. They are alike in having the central cusp or centroconid less distinct here than in $M_{\bar{3}}$, but differ from *Cebochoerus* in which this eminence is ridge-like instead of being low and rounded. Possible homologies of this cusp are of some interest. In *Apidium* and *Oreopithecus* the centroconid occupies a position at about the centre of a cross drawn through protoconid, metaconid, hypoconid and entoconid. Among primates such a shape and location of the centroconid is limited to these two forms. In some fossil mammals, including the condylarth *Phenacodus*, there is a subsidiary cusp on the antero-internal slope of the hypoconid which has been called a mesoconid. A slight prominence here is sometimes present in *Pliopithecus* and *Gigantopithecus*, but in them the cuspule never has a completely central position. It seems improbable that the structures here termed mesoconid and centroconid are homologous. If they are, then the centroconid must have arisen by 'slipping' toward a central position along the antero-internal crest of the hypoconid after an initial subdivision of the latter had occurred. That this could happen is doubtful. A preferable assumption may be that the centroconid arose in the *Apidium–Oreopithecus* branch of the hominoids as a neomorph, and is not to be equated with the mesoconid seen in phenacodonts, hyopsodonts and several other archaic mammalian families. In *Apidium* the $M\overline{1}$ talonid is somewhat broader compared to the trigonid than in *Oreopithecus*, but this is true only for the $M\overline{1}$; both differ from *Cebochoerus*, which has broader trigonids than talonids. A rather broad and flat hypoconulid in *Apidium* is suggestive of an earlier condition of development of the large area seen here in *Oreopithecus*; there is already some thickening of the posterior basal cingulum of the hypoconid which, by joining the hypoconulid area, could produce the broad posterior molar shelf of *Oreopithecus*.

In addition to similarities noted for the first molar which are largely repeated here, second molars of both show considerable reduction of the paraconid element, so that it consists only of an anteriorly bowed ridge or crescent between the apices of proto- and metaconids. Each exhibits a more distinct centroconid and elsewhere a slight mesostylid cuspule. As might be expected for an earlier form, in *Apidium* $M\overline{2}$ is slightly less specialized than in *Oreopithecus*, and also shows similarities with $M\overline{2}$ of *Pliopithecus*, and *Gigantopithecus*.

The third molar is the largest and longest of the molar series in both primates (although in *Apidium* its full size is obscured by the fact that it has not fully erupted). In Fig. 1 the orientation of this tooth has been altered, so that its crown can be seen in the same plane as those of the remainder of the series. This illustration shows that in both species there is a large hypoconulid flanked laterally by accessory cuspules. A long postero-internal buttress of the hypoconid runs between ento- and hypo-conulid in the specimen of *Oreopithecus* figured here (after Hürzeler). This might be an important difference from *Apidium*, were it not for the fact that this ridge is missing in some specimens of the former.

The lack of connecting links, interposed temporally and morphologically between these two primates, *Apidium* and *Oreopithecus*, renders claims of an ancestor–descendant relationship between them uncertain. However, the resemblance between the two is striking considering that they are separated in time by more than twenty-five million years. *Apidium* appears to be a primate having particular significance in determining the time of origin of the Oreopithecidae. Fragmentary as they are, when taken together, the Fayum primates indicate the possibility that cercopithecoids, pongids and oreopithecids were already distinct in the early Oligocene. Accurate conclusions about the bearing of both *Apidium* and *Oreopithecus* on the question of hominid origins will have to await the discovery of additional specimens and completion of studies now in progress.

ELWYN L. SIMONS

Zoological Laboratory, The College,
University of Pennsylvania, Philadelphia, 4.

[1] Hürzeler, J., *Abhandl. Schweizerischen Paläont. Gesell.*, 66, 3 (1949); *Verhandl. Naturfor. Gesell. Basel*, 69, No. 1, 1 (1958).

[2] Butler, P. M., and Mills, J. R. E., *Bull. Brit. Mus. (Nat. Hist.)*, 4, No. 1, 1 (1959).

[3] Osborn, H. F., *Bull. Amer. Mus. Nat. Hist.*, 56, 253 (1908).

[4] Schlosser, M., *Beitr. Paläont. und Geol. Österreich-Ungarns*, 24, 51 (1911).

[5] Gregory, W. K., "The Origin and Evolution of the Human Dentition" (Williams and Wilkins Co., Baltimore, 1922).

[6] Piveteau, J., "Primates, Paléontologie Humain", in "Traité de paléontologie", 7, 1 (Paris, 1957).

[7] Simons, E. L., *Amer. Mus. Novitates*, No. 1976, 1 (1959).

MISCELLANY

"The Lunar Surface"

IN proposing new, or partly new, ideas in a field where many conflicting opinions are held, one is always open to misinterpretation and, unfortunately, the review of my book "Strange World of the Moon", appearing in *Nature* of March 12, p. 718, although fair in intention, misrepresents some of the points I make.

Thus, Dr. Pagel states that 'lunavoes' "are essentially broken bubbles of gas bursting out from a contracting surface". This is true only with a considerable degree of poetic licence. Neither Spurr nor I have proposed such an idea. We interpret lunar craters as calderas of collapse, produced by the caving-in of laccolithic domes due to the withdrawal of magmatic support. Escape of gases plays an important part in the process, but the uplift is not a 'bubble'. Collapse calderas are well known to geologists and a classical study of these structures was published by Howel Williams in 1941.

Dr. Pagel states that "Mr. Firsoff attributes ray systems to erosion by running water". This is a very unlikely explanation and he appears to have confused my interpretation of the rays as ejected matter accumulated in hollows with Spurr's suggestion that the radial gullies on the lower slopes of such formations as *Autolycus* and *Aristillus* may be drainage channels produced by torrential downpours during copious eruptions of steam.

Omitting minor inaccuracies, I pass to Dr. Pagel's unexceptionable conclusion that the presence of water "on the lunar surface is highly implausible", which is precisely what I said. Liquid water could exist on the surface of the Moon only exceptionally, temporarily and in small quantities. My contention is that, surface rocks being specifically lighter than water, it may exist beneath the surface. Such investigation as I have made also appears to show that there is no physical reason for denying the possibility of local surface deposits of ice and snow surviving for long periods in certain circumstances. Photodissociation is discussed.

V. A. FIRSOFF

MR. FIRSOFF's clarification of 'lunavoes' is very helpful, and I must apologize for having confused his explanation of rays with Spurr's explanation of radial gullies. My argument against the presence of water applies equally to ice and snow, which would be dissociated by solar ultra-violet radiation in the vapour phase.

B. E. J. PAGEL

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Tuesday, June 7

University of London (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 5.45 p.m.—Mr. G. J. Hurst: "Deserted Medieval Villages".* (Eighth of nine lectures on "Recent Archæological Discovery in Britain". Further lecture on June 14.)

Tuesday, June 7—Thursday, June 9

Institute of Personnel Management (at the Connaught Rooms, Great Queen Street, London, W.C.2), at 9.30 a.m. daily—Conference on "The Implications of Recent Research for Personnel Management".

Wednesday, June 8

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. A. J. Dalton (National Cancer Institute, Bethesda, U.S.A.): "Electron Microscopic Studies on a Series of Plasma Cell Tumours in Mice".*

Women's Engineering Society (at "Hope House", 45 Great Peter Street, London, S.W.1), at 7 p.m.—Annual General Meeting.

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. J. B. Cragg: "Some South Atlantic Islands".

Thursday, June 9

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. G. E. Cook, Mr. D. G. King-Hele and Mr. D. M. C. Walker: "The Contraction of Satellite Orbits Under the Influence of Air Drag"; Mr. F. L. Curzon, Mr. A. Folkierski, Mr. R. Latham and Mr. J. A. Nation: "Experiments on the Growth Rate of Surface Instabilities in a Linear Pinched Discharge".

University of London (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. S. J. Bach: "The Metabolic Fate of Protein-Nitrogen in the Mammal".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Professor, and a Lecturer in the Physics Department—The Secretary, Heriot-Watt College, Edinburgh (June 9).

Lecturer (with research experience in experimental nuclear physics) in Physics—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (June 9).

Research Assistant in the Department of Botany, to assist in cytological studies in algae—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (June 9).

Assistant, Grade B (graduate, preferably possessing a special degree in geology, with ancillary botany and ecology), in the Natural Science Department, to teach geology and biological subjects—The Principal, Derby and District College of Technology, Kedleston Road, Derby (June 11).

Assistant Lecturer, Grade "B", in Biology, for work at G.C.E. ("O") and G.C.E. ("A") standard—The Clerk to the Governors, North Staffordshire Technical College, Stoke-on-Trent, Staffs (June 11).

Assistant Lecturer in the Department of Physiology—The Registrar, The University, Liverpool, quoting Ref. CV/N (June 11).

Assistant Lecturer or a Lecturer in the Department of Botany (with special reference to taxonomy); and a Research Demonstrator in the Department of Botany—The Registrar, University College, Singleton Park, Swansea (June 11).

Lecturer in Physiology—The Registrar, The University, Manchester 13 (June 11).

Lecturers in Physics; a Lecturer in Theoretical Physics; and an Assistant Lecturer in Physics—The Registrar, The University, Manchester 13 (June 11).

Research Assistant (graduate with a higher degree and special interests in instrumental astronomy) in Astronomy in the Department of Physics of the Faculty of Science—The Registrar, The University, Manchester (June 11).

Research Assistant (with a degree in genetics or in botany, biochemistry or microbiology with an interest in genetics) to Prof. D. Lewis, F.R.S., in the Department of Botany—The Secretary, University College, Gower Street, London, W.C.1 (June 11).

Principal Lecturer (with a degree and research experience in pharmacy, extensive experience in the teaching of all branches of pharmaceutics, and preferably industrial pharmaceutical experience) in Pharmacy—The Registrar, Bradford Institute of Technology, Bradford 7 (June 15).

Lecturer in Chemical Engineering—Prof. D. M. Newitt, F.R.S., Department of Chemical Engineering and Chemical Technology, Imperial College of Science and Technology, South Kensington, London, S.W.7 (June 18).

Lecturer (with a special interest in cartography) in Geography—The Secretary of University Court, The University, Glasgow (June 18).

Lecturers (2) in Physics—The Registrar, The University, Hull (June 18).

Temporary Lecturer in Pure Mathematics—The Registrar, University College, Singleton Park, Swansea (June 18).

Lecturer in Hydraulics and Hydrology in the Department of Civil Engineering—The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (June 20).

Assistant in Research (with an appropriate honours degree) in Animal Physiology—The Secretary, School of Agriculture, The University, Downing Street, Cambridge (June 22).

Lecturer or Assistant Lecturer in Biology, Botany or Zoology, to take the subject to pass degree standard; a Lecturer in Chemistry; and a Lecturer in Mathematics—The Principal, Bede College, Durham (June 25).

Research Students in Physics, for work in the following topics: magnetic resonance of the solid state, gas discharge studies, investigations of defects in glass and other fibres, and studies on the properties of oxide cathodes—The Registrar, University College of North Staffordshire, Keele, Staffs (June 25).

Senior Research Assistant (with an honours degree, preferably in metallurgy or alternatively in chemistry, and some postgraduate or industrial research experience) in the Department of Metallurgy, to investigate a problem in the field of electrodeposition—The Registrar, The University, Nottingham (June 25).

Chair of Education in the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 27).

Thermal Syndicate Research Fellow in the Ceramics Division of the Houldsworth School of Applied Science, for research on the physics of silica glass—The Registrar, The University, Leeds 2 (June 28).

Lecturer in Plant Pathology (Virology) at Waite Agricultural Research Institute, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 30).

Research Fellow in Chemistry, for work on the structures of physiologically active polypeptides—The Secretary, The University, Exeter (June 30).

Assistant Lecturer or Lecturer (preferably with research experience in genetics) in the Department of Biology as Applied to Medicine—The Secretary, Department of Biology as Applied to Medicine, Middlesex Hospital Medical School, London, W.1 (July 10).

Immunologist (medical graduate interested in tumour immunology) to develop a Section of Immunology in the Division of Pathology; an Electron-Microscopist (graduate in medicine with experience in pathology or an honours science graduate with histological experience) to be trained as electron-microscopist in the Division of Pathology; a Biochemist (honours graduate) for the Cyto-Chemistry Section of the Division of Pathology; and a Biochemist (honours graduate with research experience in lipid biochemistry) in the Division of Chemistry and Biochemistry—The Director of Research, Imperial Cancer Research Fund, Lincoln's Inn Fields, London, W.C.2 (July 15).

Lecturer (with a higher degree, preferably a doctorate of philosophy, with some research and teaching experience) in Chemistry at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 15).

Senior Lecturer or Lecturer in Botany (Plant Physiology) at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 15).

Lecturer (with an honours degree in philosophy, and a special interest or qualification in either logic or the philosophy of science or the history of ideas) in Philosophy at the University of Canterbury, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 18).

Senior Lecturer in Physical Chemistry, and a Lecturer (with special interests in inorganic chemistry) in Chemistry at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong and London, August 31).

Field Assistant (female, with an honours degree in geography, preferably with subsidiary geology and/or botany or zoology) at Malham Tarn Field Centre, near Settle, Yorks—The Secretary, Field Studies Council, 9 Devereux Court, Strand, London, W.C.2.

Grade B Assistant (graduate, preferably with industrial and/or research experience) in Physics—The Principal, Medway College of Technology, Horsted, Maidstone Road, Chatham, Kent.

Lecturers (graduate metallurgists or physical chemists interested in extraction metallurgy, chemical metallurgy or metallurgical analysis) in Metallurgy—The Secretary, Sir John Cass College, Jewry Street, London, E.C.1.

Physical Chemist, Scientific Officer grade, to study the persistence and toxicity of residual films of insecticides—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Plastics Chemist or Plastics Technologist (preferably with appropriate research or industrial experience) in the Department of Materials, to assist in the organization and supervision of the teaching laboratories and to participate in the research activities of the plastics group—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

Postdoctorate Fellow (with a Ph.D. degree (or equivalent) of a recognized university) in Biochemistry in the Psychiatric Research Unit situated in the University Hospital, Saskatoon, to carry out fundamental research into some of the biochemical aspects of mental illness—The Personnel Officer, Saskatchewan Department of Public Health, Health and Welfare Building, Regina, Saskatchewan, Canada.

Research Assistant (with a first degree of the University of London and an interest in ultrasonics and electronics) in Ultrasonic Physics—The Principal, Kingston Technical College, Fassett Road, Kingston-upon-Thames, Surrey.

Research Fellow (Senior or Junior) (with the degree of Ph.D., and preferably experience in research involving proteins) in the Department of Biological Chemistry, for work with Dr. J. L. Simkin on biosynthesis of proteins—Dr. J. L. Simkin, Marischal College, The University, Aberdeen.

Science Graduate (male or female) in the Laboratories of the Aberdeen and North-East Scotland Blood Transfusion Service

—The Regional Director, Aberdeen and North-East Scotland Blood Transfusion Service, Royal Infirmary, Aberdeen.

SCIENTIFIC OFFICER (honours graduate in chemistry or biochemistry) IN THE RADIOBIOCHEMISTRY DEPARTMENT, for biochemical research involving the use of radioactive isotopes, and in particular C^{14} and tritium—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, Berks, quoting Ref. 60/3.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

International Tin Research Council. Annual Report 1959. Pp. 36. (Greenford, Middx.: Tin Research Institute, 1960.) [163

Polymer: The Chemistry, Physics and Technology of High Polymers, Vol. 1, No. 1 (March 1960). Pp. 124. Published quarterly. Annual Subscription including postage—U.K. 100*s*.; U.S.A. 15 dollars. (London: Butterworths Scientific Publications, 1960.) [163

University of Cambridge. Report of the Observatories Syndicate for the year ending 1959 September 30. Pp. 5. (Cambridge: The University, 1960.) [163

Planning, Vol. 26, No. 440 (14 February 1960): Challenge and Change—Papers from the CED Conference. Pp. 65–104. (London: Political and Economic Planning, 1960.) 4*s*. [163

Royal Society of Arts. Industrial Art Bursaries Competition—Report for 1959. Pp. 56. (London: Royal Society of Arts, 1960.) [163

The Registrar General's Statistical Review of England and Wales for the Three Years 1954–1956. Supplement on Mental Health. Pp. viii+198. (London. H.M. Stationery Office, 1960.) 11*s*. 6*d*. net. [163

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 15: Suitable Varieties of Fruit. Pp. 15. Leaflet No. 48: Tuberculosis in Poultry. Pp. 3. Leaflet No. 86: Manuring Farm Crops. Pp. 15. Leaflet No. 140: Fowl Typhoid. Pp. 3. (Belfast: Ministry of Agriculture, 1960.). [163

Association of Public Analysts. Separation and Identification of Food Colours Permitted by the Colouring Matters in Food Regulations, 1957. Pp. vi+31. (London: The Association of Public Analysts, 1960.) 21*s* net. [163

Northampton College of Advanced Technology. Post-Graduate Diploma Courses. Pp. 23. (London: Northampton College of Advanced Technology, 1960.) [163

University of Birmingham. University Research Committee Thirtieth Annual Report (Session 1958–1959). Pp. 123. (Birmingham: The University, 1960.) [163

English Electric Valve Co., Ltd. Abridged Valve Data. Pp. 36. (Chelmsford: English Electric Valve Co., Ltd., 1960.) [163

Forestry Commission Leaflet No. 1: The Large Pine Weevil (*Hylobius abietis*). Revised edition. Pp. 11. (London: H.M. Stationery Office, 1960.) 1*s*. [163

The Royal Institute of Chemistry. Report of the Council for the year ended 30 September, 1959. Pp. 35. (London: Royal Institute of Chemistry, 1960.) [163

National Union of Students of England, Wales and Northern Ireland. Memorandum to the University Grants Committee on the Expansion of University Education 1960–1970. Pp. 12. (London: National Union of Students of England, Wales and Northern Ireland, 1960). [163

Building Research Station Digest, No. 132: Condensation in Dwellings. Pp. 4. (London: H.M. Stationery Office, 1960.) 4*d*. [163

Transactions of the Suffolk Naturalists' Society, including the Proceedings of the year 1959 (Vol. XI, Part III). Pp. 217–288. (Ipswich: Miss Janet C. N. Willis, Hon. Secretary, 1 Holly Road, 1960.) 7*s*. 6*d*. [163

The Year Book of the Royal Society of London, 1960. (No 64.) Pp. 302. (London: The Royal Society, 1960.) 21*s*. [163

Air Ministry: Meteorological Office, Professional Notes No. 124: The Preparation of Statistical Wind Forecasts and an Assessment of Their Accuracy in Comparison with Forecasts made by Synoptic Techniques. By C. S. Durst and D. H. Johnson. Pp. 27. (M.O. 623*d*.) (London: H.M. Stationery Office, 1959.) 1*s*. 9*d*. net. [183

Commonwealth Mycological Institute. Mycological Papers, No. 75: A Revised List of Plant Diseases in Tanganyika Territory. By Dr. E. A. Riley. Pp. ii+42. (Kew: Commonwealth Mycological Institute, 1960.) 10*s*. [183

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 11: Fruit Tree Pests—Aphids and Apple Sucker. Pp. 7+2 plates. (Belfast: Ministry of Agriculture, 1960.) [183

Other Countries

United States Department of Commerce: Coast and Geodetic Survey. Publication 20–1: Wire Drag Manual. By Commander Kenneth, S. Ulm. Pp. v+103. (Washington, D.C.: Government Printing Office, 1959.) 35 cents. [83

United States Department of Commerce: Weather Bureau. Technical Paper No. 15: Maximum Station Precipitation for 1, 2, 3, 6, 12, and 24 Hours. Part 24: Texas. Pp. 210. (Washington, D.C.: Government Printing Office, 1959.) 1 dollar. [83

United States Department of Agriculture. Leaflet No. 456: Cattle Lice: How to Control Them. Pp. 8. (Washington, D.C.: Government Printing Office, 1959.) 5 cents [83

Fisheries Research Board of Canada. Bulletin No. 121: The Herring Fishery of the Northwest Atlantic. By Leslie W. Scattergood and S. N. Tibbo. Pp. vii+42. (Ottawa: Queens Printer 1960.) 75 cents. [163

Organization for European Economic Co-operation: European Nuclear Energy Agency. Second Report on the Activities of the Agency, presented to the Consultative Assembly of the Council of Europe. Pp. 154. (Paris: Organization for European Economic Co-operation, European Nuclear Energy Agency, 1960.) [163

Cawthron Institute, Newson, New Zealand. Annual Report 1958–1959. Pp. 46. Thomas Cawthron Memorial Lecture No. 33 (1958): The New Zealand Antarctic Expedition. By Sir Edmund Hillary. Pp. 12+4 plates. (Nelson: Cawthron Institute, 1959.) [163

The Regional Research Centre of the British Caribbean at the Imperial College of Tropical Agriculture, Trinidad, W.I. Soil and Land-Use Surveys, No. 8: Jamaica—Parish of St. James. By R. W. Price. Pp. 26. (Trinidad: Imperial College of Tropical Agriculture, 1959.) 12*s*. [163

Australian Atomic Energy Commission. Seventh Annual Report, 1958–59. Pp. 48. (Sydney: Australian Atomic Energy Commission, 1960.) [163

Ceylon. Administration Report of the Director of National Museums for 1958. Pp. 51+3 plates. (Colombo: Director of National Museums, 1959.) Rs. 1.30. [163

International Nickel Company of Canada, Ltd. Annual Report, 1959. Pp. 28. (Copper Cliff, Ontario. International Nickel Company of Canada, Ltd., 1960.) [163

CERN, European Organization for Nuclear Research. Data Sheets and Status Reports on Accelerating Machines in the Energy Range 1 GeV and Above and Models of New Machines, Presented at the International Conference on High-Energy Accelerators and Instrumentation at CERN. (CERN 60–4. Proton Synchroton Division.) Pp. 105+8 plates. (Geneva: CERN, European Organization for Nuclear Research, 1960.) [163

World Health Organization. Public Health Papers. No. 1. Psychiatric Services and Architecture. By A. Baker, R. Llewelyn Davies and P. Sivadon. Pp. 59. 2 Swiss francs; 3*s*. 6*d*. No. 2: Epidemiological Methods in the Study of Mental Disorders. By Prof. D. D. Reid. Pp. 79. 3 Swiss francs; 5*s*. No. 3: Health Services in the U.S.S.R.—Report prepared by the World Health Organization. Pp. 58. 2 Swiss francs; 3*s*. 6*d*. Technical Report Series. No. 184: European Technical Conference on Food-Borne Infections and Intoxication, Geneva, 16–21, February, 1959—Report. Pp. 18. 1 Swiss franc; 1*s*. 9*d*. (Geneva: World Health Organization; London: H.M. Stationery Office, 1959 and 1960.) [183

Federation of Malaya. Annual Report of the Institute for Medical Research for 1958. Pp. v+135. (Kuala Lumpur: Government Printer, 1959.) 2.50 Malayan dollars. [183

East Africa High Commission. East African Institute for Medical Research Report, 1958–1959. Pp. 32. (Nairobi Government Printer, 1959.) Sh. 2. [183

Indian Forest Bulletin (New Series). Entomology. No. 216: Results of Laboratory and Field Experiments on Protection of Bamboos in Storage Against *ghoon* Beetles, *Dinoderus* spp. (Coleoptera: Bostrychidae). By Dr. M. L. Roonwal, Dr. P. N. Chatterjee, and R. S. Thapa. Pp. i+32. (Delhi: Manager of Publications, 1960.) Rs. 3.62 nP.; 5*s*. 9*d*. [183

Bulletin of the American Museum of Natural History. Vol. 119, Article 2: Results of the Puritan American Museum of Natural History Expedition to Western Mexico. 9: Herpetology of the Tres Marias Islands. By Richard G. Zweifel. Pp. 77–128+plates 41–44. (New York: American Museum of Natural History, 1960.) 1 dollar. [213

Rensselaer Polytechnic Institute, Troy, New York. Annual Development Report, 1958–1959. Pp. 16. (Troy, New York: Rensselaer Polytechnic Institute, 1960.) [213

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 39, No. 33 (January 21, 1960): A New Species of Babbling Thrush from the Philippines. By Austin L. Rand. Pp. 377–378. (Chicago: Chicago Natural History Museum, 1960.) 10 cents. [213

United States Department of Agriculture. Leaflet No. 455: The Pickleworm—How to Control It on Cucumber, Squash, Cantaloup and other Cucurbits. Pp. 8. 5 cents. Leaflet No. 462: The Bollworm—How to Control It. Pp. 6. 5 cents. (Washington, D.C.. Government Printing Office, 1960.) [233

Notulae Naturae of the Academy of Natural Sciences of Philadelphia. No. 313 (May 29, 1959). A Bionomic Shell Study of *Monetaria annulus* (Gastropoda: Cypraeidae) from Zanzibar. By Virginia Orr. Pp. 11+2 plates. No. 314 (May 29, 1959); A New Genus of Grasshoppers (Orthoptera, Acrididae; Cyrtacanthacridinae) from the Comoro Islands. By James A. G. Rehn. Pp. 5. No. 315 (May 29, 1959): Some Tendipedidae from Montana. By Selwyn S. Roback. Pp. 4. No. 316 (May 29, 1959): Variability in Three Species of *Gomphonema* (Bacillariophyceae) Undergoing Auxospore Formation. By Matthew H. Hohn. Pp. 7. No. 317 (May 29, 1959): On Certain Old World Genera of Teratodini Recently Placed in the Subfamily Romaleinae (Orthoptera; Acridoidea; Acrididae). By James A. G. Rehn and Harold J. Grant, Jr. Pp 9. No. 318 (May 29, 1959): Results of the Catherwood Foundation Peruvian Amazon Expedition. *Petacara*, a New Genus of the Bunocephalis Catfish, *Bunocephalus dolichurus* Delsman. By James E. Bohlke. Pp. 6. (Philadelphia: Academy of Natural Sciences, 1959). [213

East Africa High Commission. The East African Council for Medical Research Annual Report, 1958–1959. Pp. ii+29. (Nairobi: Government Printer, 1959.) Shs 3. [213

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

Pure Chemistry Library, SCIENCE COLLEGE. 92, Upper Circular Road, CALCUTTA.
26.7.60

BRITISH DYESTUFFS AND WIDER CO-OPERATION IN EUROPE

THE European Free Trade Association Bill, which received Royal Assent on March 22, ended the system of protection which the British dyestuffs industry had enjoyed since the Dyestuffs (Import Regulation) Act was passed in December 1920 in accordance with an official pledge given by the Government in May 1918. That Act prohibited the import of dyestuffs except under licence granted by the Board of Trade on the recommendation of the Dyestuffs Advisory Licensing Committee, usually on the ground that there was no British equivalent or on grounds of price. Originally licences were granted when the price of the British product was more than three times that of the foreign equivalent, and during the years this factor was progressively reduced to 1·75; but by 1932 imports of dyestuffs were almost entirely of those not made in Britain.

The Dyestuffs (Import Regulation) Act was originally to run for ten years, but when in November 1930 the then President of the Board of Trade, Mr. W. Graham, announced the Government's decision to allow the Act to lapse, there were stormy debates in Parliament. In the Commons on December 4 the Government carried by a majority of 30 its motion to allow the Act to lapse, but a motion to continue the Act to December 31, 1931, was carried against the Government in the Lords. Afterwards, on December 17, the Government's majority fell to 6 on a motion to disagree with the Lords, and it was in this debate that the late Major A. G. Church, then general secretary of the Association of Scientific Workers, spoke and voted against his party, urging the importance of the industry to research and voicing the arguments raised by many leading scientists and industrialists in a discussion on the industry at the British Association meeting at Bristol in the previous September. The Lords insisted on their amendment, and on December 18 the President of the Board of Trade moved that the Commons should not insist on disagreement.

As a result, the Act was renewed annually under the Expiring Laws Continuance Act for the next three years, until in December 1933 a new Dyestuffs (Import Regulation) Bill was introduced by Dr. E. L. Burgin, then President of the Board of Trade. In the meantime the Import Duties Act, 1932, had been passed, under which, since March 1932, all imported dyestuffs had been subject to the general *ad valorem* duty of 10 per cent, and an Import Duties Advisory Committee established. When the Dyestuffs Industry Development Committee therefore reported in 1932 on the position and development of the industry in Great Britain, the questions whether further assistance to the industry was necessary and, if so, the form such assistance should take, were referred to the Import Duties Advisory Committee. This Committee in July 1933 recommended that the 1920 Act should be continued indefinitely, but that colouring matters not used in dyeing should be dealt with under the Import Duties Act of 1932. Intermediates, but not dyestuffs, should be subject to the general *ad valorem* duty of 10 per cent. Accordingly, the Bill introduced by Dr. Burgin proposed that dyestuffs not used in dyeing should be dealt with by the Import Duties Advisory Committee, and provided for the consideration of complaints by that Committee and for the imposition of duties up to 20 per cent on pigments. Most other materials from which the prohibition was removed by the Bill were already subject to duty under the Safeguarding of Industries Act or other Acts.

This Bill had a smooth and uneventful passage through both Houses of Parliament, although the Colour Users' Association maintained that the Act had already served its purpose and firmly established the industry; and the debates were marked by none of the heat or tension of those in December 1931. The Act, which received Royal Assent on March 28, 1934, continued in force until it was recently repealed under Clause 5 of the European Free Trade Association Act; but, as the Minister of State, Board of Trade, Mr. F. J. Erroll, explained in moving the second reading of the Bill on February 15 last, the Dyestuffs (Import Regulation) Acts had not been used since 1939. The obligation to eliminate qualitative restrictions on imports involved in participation in the European Free Trade Association necessitated the abandonment of the present system of prohibition of dyestuffs and their intermediates except by licence, and, in turn, this has entailed a decision to substitute protection by tariff.

The protective import prohibition is contrary to the general rules of the General Agreement on Tariffs and Trade, and dyestuffs obviously could not be excluded from the scope of the European Free Trade Association arrangements, although, as was explained by the Earl of Dundee in the House of Lords on March 8, Britain arranged in 1947 that we should be allowed, if licensing was terminated, to put on instead an import duty of 33⅓ per cent. Progressive liberalization of the import prohibition would involve the admission duty-free from member countries of the Association of increasing quantities of dyestuffs of types already produced in the United Kingdom. While it is difficult to predict the effect of this step, clearly, as Mr. Erroll observed, some difficulties for the British industry must be expected, and once imports have been allowed in duty-free from members of the Association, it would become extremely difficult to establish a tariff in the context of any wider free-trade area.

It was therefore important, said Mr. Erroll, to introduce as soon as possible a protective duty on dyestuffs and their intermediates imported from all foreign sources, and such a duty would be subject to progressive reductions on imports from member countries of the Association until, at the end of ten years, dyestuffs from such countries would be admitted free of duty. Mr. Erroll reiterated that repeal of the Dyestuffs Acts was one part of the Bill and a necessary step in the change-over from a system of protection by prohibition and licence to a system of protection by the tariff. In broad terms, the import of dyestuffs and their intermediates would receive the same treatment as other chemicals, and this section of industry would thus receive the same level and form of protection as was enjoyed by the rest of the chemical industry. Mr. Erroll assured the House that the dyestuffs industry had been duly consulted on the change-over, which would be effected by tariff orders, and said that amendment of the open general licence, operating from March 2, would be introduced to the House in due course.

It is perhaps the most emphatic testimony to the way in which over the past forty years the dyestuffs industry has been built up that this unique British system should have been terminated so quietly and almost without notice. The arguments as to the key importance of the industry advanced during the First World War and afterwards have not lost their importance, however, and it would ill become the British scientist or technologist to allow the system to end without saluting alike the vision and determination of those who first established it, who saw thirty years ago that it was maintained even at personal sacrifice, or the forebearance and co-operation between makers and users which made the system work. Both dyestuffs manufacturers and users of dyestuffs in the textile industry appear to expect very little change in the pattern of trade under the new conditions, and the dyestuffs industry seems to be reasonably confident of continuing to supply 90 per cent of the requirements of the textile industry in Britain. Moreover, the co-operation of the users in building up the British industry, especially thirty years or more ago, has established a strong community of interest as well as a tradition of co-operation. Dyers have come to depend largely on, the technical services of the dyestuffs manufacturers as well as on his supplies of colour, and those servicet are unlikely to be so readily available from overseas sources. While it is too early to be sure of the effect of the new arrangements on the industry, there appears to be every reason for confidence that the British industry will continue to flourish and to make important contributions in products and technique.

The dyestuffs industry is not the only reason why the European Free Trade Association Act has at least passing interest for the scientist. Like other measures towards freeing European trade, it should serve to develop that community of interest and freedom of communication which science and technology alike require for unimpeded advance, and which are the greatest safeguard against waste of effort or resources. Two recent broadsheets issued by Political and Economic Planning bring this out a little further. The earlier one, "European Unity—A Review" (No. 436; September 28, 1959), assesses generally such institutions as the Economic Commission for Europe, the Organization for European Economic Co-operation, the Council of Europe and the North Atlantic Treaty Organization, and the obstacles to the rationalization of such organizations. A much more elaborate analysis has also been published by Political and Economic Planning under the title "European Organizations"*, as the outcome of the work of a research group.

Apart, however, from the summary and conclusions of this report, and the long chapter on the Organization for European Economic Co-operation, the broadsheet is likely to meet most of the needs of the scientist or technologist, particularly if supplemented with the second broadsheet, "Challenge and Change" (No. 440; March 14, 1960). This broadsheet contains four papers delivered last autumn at a conference, "Is the Economy of the Western World splitting apart ?", arranged by the Committee for Economic Development, an American research organization conducted on somewhat similar lines to Political and Economic Planning. In the first of these papers, Sir Oliver Franks, dealing with "The New International Balance: Challenge to the Western World", refers to the importance of a right answer to our relation to the developing countries and a proper allocation of our resources to this cause. The same point is made by Mr. P. van Zeeland in his paper, "The Economic Community: Move towards Atlantic Union", in discussing the relations between the Common Market and Africa. Mr. van Zeeland suggested in particular the creation of an Atlantic economic community, open to all free peoples, averse to discrimination and ready to serve the under-privileged, while Mr. P. C. Hoffman, in his paper, "Development and Growth: Goals for a Crucial Decade", dealt at some length with assistance, including technical assistance, to the under-developed countries. The significant emphasis placed on these problems of the relations between the relatively advanced and the under-developed countries should not be lost on the scientist and technologist, who have much to contribute in that field. There is undoubtedly much still to be done to work out the most effective means by which such assistance can be given, before we can regard the channels of communication, even of information, reasonably clear, and the waste of scientific and technical resources or man-power unlikely.

---

* European Organizations. Pp. xvi+372. (London: Political and Economic Planning, and George Allen and Unwin, Ltd., 1959.) 30s. net.

HEISENBERG, PHYSICS AND PHILOSOPHY

Physics and Philosophy

The Revolution in Modern Science. By Prof. Werner Heisenberg. (World Perspectives.) Pp. 176. (London: George Allen and Unwin, Ltd., 1959.) 15s. net.

FROM the group of physicists who, thirty-five years ago, built the rational foundation of the quantum theory of atomic systems, the figure of Heisenberg emerges as the leading one, both by his creative imagination and by his powerful grasp of the novel logical relationships which confront us in this domain. To those who, like myself, look to him for continued guidance and inspiration, a book containing his views on the philosophical aspects of modern physics would raise high expectations. It is therefore with great dismay that I am forced to confess my disappointment, and to set down, for the edification of potential readers, my reasons for it. Just because I regard Heisenberg as one of the highest authorities in the domain of fundamental physics, I shall do this with unsparing frankness.

The book reproduces the text of a course of Gifford Lectures; I was unable, however, to discover any plan or leitmotive in this course; the single chapters might just as well have been detached lectures on their respective subjects, and they are not even presented in any obvious logical order. The lack of any pre-occupation with systematic or scholarly discussion is also apparent from the complete absence of references to any books or articles which would allow the reader to pursue the subject of his choice. Indeed, the author, who is undoubtedly well read in some parts at least of philosophy and history, has taken so little care in checking his facts that his sketches of the historical development of philosophical and scientific problems are everywhere marred by serious inaccuracies, which are the more disturbing as the inexpert reader does not get any hint about the sources of the author's information. Lest one suspect me of being pedantic, let me just mention that even such widely known historical developments as that of electromagnetism or the notion of the atom in chemistry are presented in a false light. It is unfortunately no exaggeration to say that as an exposition of the basic data which the author takes as a starting point for his comments and considerations, the book is worse than valueless: it is positively misleading.

One may perhaps console oneself by observing that, after all, one is not looking here for any systematic study, but rather for some conversation, as it were, with the author about the thoughts and reflexions which are familiar to him and which inspire him in his creative work. From this point of view the book has undeniably documentary value: but how much more interesting would have been the conversation if the author had been more attentive to his interlocutors! In the chapters more specially devoted to the physical problems in which he is no longer a negligent dilettante, but a supreme master, the author has apparently made no effort to express his thought with the precision and neatness one has a right to demand from him: he alternates uneasily between a popular exposition of results (which is not his *forte*) and a hazy, superficial discussion of the logical and philosophical issues, which certainly does not convey to the layman an adequate idea of their importance.

Turning now, with these reservations in mind, to the contents of the book, one again meets with disappointing features. One of the lectures is devoted to Greek philosophy, another to the modern philosophical systems from Descartes to Kant; these surveys, however, are presented as mere catalogues of ideas which appear to follow each other in arbitrary succession; and this unhistorical approach is still more underlined by the fact that the whole discussion of these philosophical conceptions is directed towards their assessment in comparison with our present views, derived from the development of atomic physics! It would be hard indeed to find a less-inspiring subject than the consideration of the epistemological situation of quantum theory from the point of view of the Kantian *a priori*.

With regard to the epistemological problems just mentioned, Heisenberg's exposition naturally follows the line of argument which he has himself so decisively contributed to establish, and which he calls, in homage to Niels Bohr's great leadership, the "Copenhagen interpretation". He even devotes a whole chapter to the thankless task of tearing to pieces the various objections raised against this conception, and this is the best chapter of the book. But the account he gives of the "Copenhagen" ideas is unfortunately not so good as it ought to be; and certainly not one of the physicists now working in Copenhagen would subscribe to the general philosophical attitude underlying this account. Altogether, it would be better to discard such an ambiguous expression as "Copenhagen interpretation", were it only because it falsely suggests that there could be other possible interpretations of quantum theory.

I am particularly unhappy about the chapter entitled "Language and Reality in Modern Physics", in which it is suggested that in the description of atomic events the classical concepts are used "in a somewhat vague manner", reminding us "of a similar use of language in daily life or in poetry". Taken literally, such a statement runs counter to the very spirit and purpose of the unceasing efforts of the Copenhagen physicists to develop an epistemology guaranteeing a fully precise use of the classical concepts, exempt from contradiction in every conceivable situation. Of course, the wave-concept, when applied to an electron, has not the same relation to possibilities of observation as when it is applied to a beam of light; it is tempting to say, for example, that the wave-pattern of electrons in a crystalline lattice, constructed by the crystallographers from X-ray diffraction measurements, represents a 'blurred' or 'smeared-out' picture of reality: but this temptation should be resisted, not encouraged. For the term 'blurred' or 'smeared-out' implies a reference to the particle picture, which, according to the rules of interpretation, cannot legitimately be used in this case. I fail to understand why the author, instead of insisting upon this kind of language problems—well known to physicists, but puzzling to outsiders—has preferred to dwell at length on questions of multi-valued logics, which can only confuse everybody.

If this book had been better, I should have deplored its inclusion in a collection which, under the grandiloquent title "World Perspectives", assembles all the shades of woolly thinking with which our time is afflicted. In this series, Heisenberg's text appears preceded by an introduction which a professional philosopher has thought fit to write for it. But I am loath to load further reproach for a missed opportunity on a colleague whom I deeply revere; to see his book saddled with that introduction must be the punishment meted out to him by the gods.

L. ROSENFELD

ZOOLOGICAL LITERATURE

The Zoological Record

Vol. 93. Being the Records of Zoological Literature relating chiefly to the year 1956. Edited by G. Burder Stratton. Pp. v+2,014. (London: The Zoological Society of London, 1959.) 160*s*.

THE "Zoological Record" is yet another of the many publications held up by the printing dispute last year, and great credit reflects upon the editor and recorders for its appearance after such a comparatively short delay. The present volume is 162 pages longer than the previous one (then the largest on record), and although part of this increase (69 pages) is the result of including the Trilobita for 1955 as well as 1956, there is once again evidence of the rapid expansion of the subject in recent years. The relative size of the various sections shows comparatively little change, Insecta still remaining by far the largest with 536 pages, rather more than a quarter of the volume. This section is prepared by, and obtainable from, the Commonwealth Institute of Entomology; and is arranged with a list of all the titles coming first, with full references following the author's name, and each reference is given a serial number; this year rising to 3,444. Then follows the subject index prepared for those working on general problems, without affecting its importance for taxonomists. This is divided under eight headings: general, morphology, development, physiology, bionomics, ecology, evolution, and geographical or faunistic, and information is arranged by orders under each heading. Finally, there is the systematic index where orders and families are arranged in alphabetical sequence. An appeal is made to writers of systematic papers to mark new synonyms with the words (*n. syn*) as otherwise it is impossible to ensure that they will be correctly recorded. A similar plan is followed in the other seventeen sections with the exception that the use of serial numbers has now been abandoned. These sections, compiled by twenty-four recorders, experts in the various branches of the subject, remain the same as in previous volumes, with the exception that the classes Amphibia and Reptilia are now separated instead of being united in one section.

Protozoa; Vermes—a very heterogeneous assembly; Mollusca; Arachnida; and the various classes of vertebrates comprise most references. Apart from the first two, these sections include animals which attract the attention of amateurs and this may explain their size. It is difficult to understand, however, why such very large groups as Coelenterata and Echinoderma do not receive more attention, but economic importance is doubtless significant. A total of 2,042 generic and subgeneric names is listed in the final section, made up as follows:

Protozoa 78; Porifera 9; Coelenterata 51; Echinoderma 8; Vermes 82; Brachiopoda 96; Bryozoa 10; Mollusca 153; Crustacea 84; Trilobita (1955) 85, (1956) 62; Arachnida 200; Insecta 974; Protochordata 4; Pisces 69; Amphibia 6; Reptilia 16; Aves 5; Mammalia 50.

The "Zoological Record" is compiled for the Zoological Society of London and published by it. The very heavy expenses involved are met, in part, by donations from institutions and individuals amounting, during 1956, to a total of just over two thousand pounds. All these donations come either from the British Commonwealth or the United States, with the exception of the International Council of Scientific Unions (£500) and the Naples Zoological Station (£10). It is regrettable that a publication of this nature, the only one which attempts to give each year a complete list of zoological publications through the world, and indispensable to any zoologist trying to trace the literature of his subject, should not receive support from zoological institutions in other countries.

EDWARD HINDLE

GENETIC RECOMBINATION

Exchange of Genetic Material

Mechanisms and Consequences (Cold Spring Harbor Symposia on Quantitative Biology, Volume 23.) Pp. xvi+433+2 plates. (Cold Spring Harbor, L.I., New York: Long Island Biological Association, 1958.) 8 dollars.

THE recombination of genetic materials, its mechanism, control and significance, constitutes one of the great central problems of genetics. Recombination was first observed by Mendel, but the free recombination of genes carried on different chromosomes, such as he was presumably seeing, present little problem of mechanism. However, with the discovery of linkage groups and the analysis of the restricted recombination between the genes of a group came the much more difficult, and theoretically much more significant, question of how homologous chromosomes exchange material during the process of meiosis. This commanded wide study by genetical, and later cytological, means for some thirty years and much was discovered about the process: interference, the non-random distribution of recombination along the physical chromosome and the reciprocity of exchange were all established, but perhaps not surprisingly the mechanism eluded us. There were theories but no finality; and here the study of how recombination comes about rested for more than a decade. Interest revived with the advent of micro-organisms as subjects of genetical investigation, for these not only offered the technical advantages of analysing recombination too rare to be followed even in *Drosophila* but also revealed new mechanisms by which it could come about—parasexuality, transformation, transduction and the like—and also brought to light the phenomenon of gene conversion with its curious and as yet unclear relation to recombination. An additional fillip was given by the growing understanding of how deoxyribonucleic acid is organized.

This new interest in the mechanism of recombination is well exemplified by the Cold Spring Harbor Symposium of 1958. Sixteen of the papers deal with recombination as seen in various bacteria and fungi, and these include the address with which Sir Macfarlane Burnet opened the symposium. Two further papers specifically consider it in relation to the replication and arrangement of deoxyribonucleic acid in the chromosomes. Non-reciprocal recombination and conversion, transduction and the possible restriction of effective pairing to specific sites are all considered. The unity and the duality of mechanisms underlying recombination in its various manifestations are both argued. Five papers, all but one of them dealing with *Drosophila*, present cross-over studies of the more classical type. There is as much information and as much stimulation in these twenty or so papers as there is absence of agreement on conclusions and points of view. This is no doubt as it should be in a field of active study, but it warns us that understanding of how recombination comes about is as elusive as ever.

The symposium was not confined to mechanisms but considered consequences as well. It has long been realized that the significance of sexual reproduction lies in the recombination it makes possible. Not until the development of polygenic theory, however, did the full importance emerge of recombination as the prime agent of genetic flexibility in populations. This relation of variation and selective response to recombination is explored further in three papers, and several others discuss the control of recombination by both its direct restriction and its reduction to ineffectivity through inbreeding and apomixis in the wild. Again, as with mechanisms, we see a diversity of approach, but this time with more unity of conclusion; polygenic recombination is the key to understanding variation, adaptation and change in the wild.

The breadth of the symposium is finally emphasized by the inclusion of a number of papers dealing with such varied topics as recombination in relation to the stability of genes, nuclear-cytoplasmic relations and the remarkable phenomenon of paramutation in maize. If evidence were needed that recombination is of central significance in genetics this symposium most certainly supplies it. It is scarcely to be recommended as reading for the novice, but few geneticists will fail to gain stimulation and profit from it no matter where their interests lie between the chemical basis of heredity and the behaviour of populations in the wild. KENNETH MATHER

THE PLEISTOCENE ERA

The Pleistocene Period

Its Climate, Chronology and Faunal Successions. By Prof. Frederick E. Zeuner. Pp. 477. (London: Hutchinson and Co. (Publishers), Ltd., 1959.) 42*s*. net.

BEFORE the Second World War, most of the books about the Pleistocene Period were becoming out of date, and the publication of Prof. Zeuner's book "The Pleistocene Period" by the Ray Society in 1945 was therefore most welcome. The subject of the present review is an enlarged edition of that work, brought up to date by the addition of a chapter which presents "New Evidence", the main body of the work remaining almost unaltered. This arrangement is unfortunate, as it fails to include references to many new publications which have appeared since 1945.

The book starts by describing the evidence of past climatic changes as deduced from glacial and periglacial beds and from physiographical features, and to a lesser extent from the study of fossil plants and animals. On this rather one-sided basis the sequence of climatic fluctuations for most parts of the Earth are examined in detail. This is followed by Prof. Zeuner's well-known comparison between the climatic results thus assembled and the calculations by Milankovitch of the variation of the amount of heat received by the Earth from the Sun during the past 600,000 years or so. He has always believed that these two lines of evidence agree remarkably well, although some geologists have never accepted this point of view. Whatever one's personal opinion may be, an important statement by Prof. Zeuner (on p. 372) points out that a radioactive test by the potassium-argon method has recently confirmed the dating of the end of the Elster glacial phase in Germany as the same as that calculated from the astronomical theory. He also believes that these climatic fluctuations caused changes in sea-level, and this leads him to a correlation of the Pleistocene beaches, mainly according to their heights. It is unfortunate that the author seems to ignore much work by Lecointre and others on the correlation of the marine beds by faunal methods, as some of that work agrees well with Zeuner's conclusions based on the heights of the shore-lines. Finally, the chapter on the rate of evolution of some land-mammals is reprinted in its original form in this new work.

The main subjects included in the new additional chapter are based mainly on Prof. Zeuner's own observations, and include some features of the terraces of the Thames and of part of the Rhine basin; of the Nile Delta and of some Pleistocene beaches of the Canary Islands, Norfolk and Devonshire. In Appendix 3 (pp. 378–379) an interesting table sums up the shore-line heights from a large number of places, but one wonders whether there is any advantage in the sequence being represented upside-down, with the youngest events at the bottoms of the pages?

It is unfortunate to have to record omissions from this stimulating book, but they are mentioned here in the hope that they can be put right in future editions. As an example, no mention is made of the investigation, mainly by pollen analysis, of interglacial plant beds in Holland and Germany and places like Hoxne in England, although this work would have given so much information about climatic fluctuations. Again, some methods of investigating glacial tills, especially that of stone orientation, seem to be ignored, although they are so useful for correlation.

But with all its defects, this book, with its unique bibliography, is a valuable work of reference for anyone who is trying to solve the puzzles of the Pleistocene Period. D. F. W. BADEN-POWELL

METHODOLOGY AND SUPERCONDUCTIVITY

A New Method in the Theory of Superconductivity

By N. N. Bogoliubov, V. V. Tolmachev and D. V. Shirkov. Translated from the Russian. Pp. iii+121. (New York: Consultants Bureau, Inc.; London: Chapman and Hall, Ltd., 1959.) 5.75 dollars; 50*s*.

THIS monograph is addressed primarily to theoretical physicists: from the start the formalism of quantized fields is employed. The presentation is fairly clear, and the calculations are easy to follow.

The 'new method' of the title consists in the application of a certain transformation of the field variables. The Hamiltonian of the system of interacting electrons is re-expressed in terms of a set of 'quasi-particles'. The transformation is applied to the Bloch-Fröhlich model of a metal and to more complicated models, with Coulomb interactions and with renormalization of the phonon energy and the electron-phonon coupling constant.

The calculation of energy-levels seems convincing, and certainly suffices to explain some of the properties of superconductors. The energy spectrum has a gap, and it has been known for some time that many of the properties of superconductors can be derived from a phenomenological energy-gap model—for example the specific heat or the microwave absorption edge. The electrodynamical properties are another matter, and their treatment is less than adequate. The authors make it fairly plausible that the electrical resistance should vanish, but they do not discuss the Meissner-Ochsenfeld effect. It is just here that certain difficulties arise, which have been the source of much controversy.

The transformation has some strange features. The procedure introduces singularities, and then selects the parameters of the transformation to remove them again, to the same order of perturbation theory. Moreover, although the starting point of the theory is a model with a fixed number of electrons, after transformation the total number of electrons is no longer a good quantum number. The use of a chemical potential for the electrons enables calculations to proceed, but the physical meaning of the slight blurring of the electron number is obscure. The states of the system are identical with those found by Bardeen, Cooper and Schrieffer, and indeed the lack of sharpness of the electron number is also a feature of their theory. The new method is, however, both more elegant and more widely applicable ; the form of the theory due to Bardeen, Cooper and Schrieffer could not be applied directly to the Bloch-Fröhlich model.

The claim is made that this volume constitutes a complete solution to the problem of superconductivity. For reasons set out above, I do not accept this claim, but nevertheless warmly welcome the appearance of the volume. Bogoliubov's quasi-particle transformation is a very valuable addition to the methodology of theoretical physics, even if it is not quite an all-purpose tool. It is extremely useful to have a connected and systematic account of the method and its application to superconductivity.

C. G. Kuper

HOROLOGY IN MEDIEVAL CHINA

Heavenly Clockwork

The Great Astronomical Clocks of Medieval China. By Dr. Joseph Needham, Dr. Wang Ling and Dr. Derek J. de Solla Price. Pp. xv+254+21 plates. (Cambridge : At the University Press, 1960. Published in association with the Antiquarian Horological Society.) 65*s.* net.

Dr. NEEDHAM'S researches into the history of science and technology in China are well known for the breadth of their scope and the vast array of new material which he has brought to light, and the book under review throws a spotlight of great brightness on one aspect of this history. With the help of his distinguished collaborators Dr. Needham has revealed the existence of a school of Chinese makers of astronomical clocks and armillary spheres at work over the period A.D. 100–1600, and in this book, besides describing these in great detail, has shown their relationship with the early water-clocks which preceded them and the wholly mechanical clocks of Europe which appear to have developed independently of the Chinese technology from the late thirteenth or early fourteenth century onwards.

The first five chapters of the book consist of an elucidation and explanation of a Chinese text "New Design for a Mechanized Armillary Sphere and Celestial Globe" written by Su Sung in A.D. 1090, the appropriate sections of which are fully translated.

Su Sung's 'Clock' was a great astronomical clock-tower more than 30 feet high, surmounted by a huge bronze power-driven armillary sphere and containing an automatically rotated celestial globe ; while on the outside of the tower various automata appeared through doors to ring bells and gongs indicating the time.

Perhaps the most remarkable feature of the whole structure was, however, the water-wheel escapement inside the tower, which controlled the time-keeping and forms a 'missing link' between water-clocks of uniform flow as employed in the Egyptian, Greek and Roman civilizations and the all-mechanical intermittent escapements of medieval Europe.

The water-wheel carried a succession of troughs into which water flowed uniformly, and when a trough became full a weighbridge tipped and allowed the wheel to turn until it was brought to rest by a form of detent with the next trough beginning to fill. This operation was repeated every quarter of an hour. The book reproduces original illustrations of the tower and of many of its details and includes carefully drawn modern diagrams clearly illustrating the detailed operation of the water escapement and the other important mechanical features of the clock.

In interpreting these, the authors were set the task of recognizing unfamiliar Chinese technical terms for the various parts : this they eventually succeeded in doing without ambiguity, and the vocabulary they thus learned was invaluable to them in interpreting earlier Chinese texts on similar subjects.

These earlier texts, in fact, reveal that Su Sung's clock was not the pioneer, but the culmination of a series of astronomical clocks, and the sixth chapter of the book traces these backwards to their origin in the second century A.D. at the hands of Chang Heng (A.D. 78–*c.* 142), well known as the inventor of the seismograph of A.D. 132.

Chang Heng's clock consisted of an armillary sphere rotated by the force of flowing water, and after a careful examination of all the evidence the authors conclude that this implies drive by a water-wheel with scoops. The first water-clock with an escapement of the Su Sung type they attribute to the third decade of the eighth century.

The authors now turn their attention to Chinese clockwork after Su Sung and find a steady progression without spectacular developments, the function of the mechanism being still to rotate an armillary sphere and operate automata rather than to indicate the hour. The next turning point is the arrival of the Jesuits in 1583, bringing contact with the European clock-making tradition.

It appears, somewhat surprisingly, that the mechanical striking clocks which the Jesuits took with them to China created a great impression there and added much to the prestige of their bearers ; later, during the seventeenth and eighteenth centuries, a considerable export trade in clocks from Europe to China developed

The main part of "Heavenly Clockwork" concludes with a review of the early development of European mechanical clocks, the conclusion being that recently put forward by Dr. Price that the mechanical clock was a by-product of an elaborate mechanical mechanism for driving globes and orreries rather than an independent invention as a pure time-keeper.

The above rapid survey does scant justice to the immense scholarship and detailed labour which went into the creation of "Heavenly Clockwork" and is set down therein in a most orderly fashion. The book is both immensely learned and very readable.

It has been published in association with the Antiquarian Horological Society, before which Dr. Needham first set forth his discovery of the Su Sung text in a lecture on January 11, 1956.

F. A. B. Ward

Steric Course of Microbiological Reactions

Edited by G. E. W. Wolstenholme and Cecilia M. O'Connor. (Ciba Foundation Study Group, No. 2.) Pp. viii+115. (London: J. and A. Churchill, Ltd., 1959.) 12s. 6d. net.

THE volumes describing the proceedings of the three-day and four-day conferences arranged by the Ciba Foundation are well known, and they have firmly established themselves as an important guide to current research in the sciences allied to medicine. This little book represents a new venture, namely, publication of the proceedings of a one-day study group. It contains five communications, preceded by an introduction by the chairman (A. Neuberger). The first (by F. H. Westheimer) is a historical review of the steric course of microbiological reactions. This is followed by articles on the mechanism of hydrogen transfer with pyridine nucleotides (K. Wallenfels), steric mechanisms in reactions of lactic acid (N. O. Kaplan), and the steric and molecular specificity of steroid dehydrogenases (P. Talalay and H. R. Levy). The final communication, on the steric course of some microbiological and enzymic reductions of ketones, is by Prof. V Prelog of Zurich, in whose honour this particular study group was organized.

These papers describe different aspects of an exciting and rapidly advancing branch of enzyme research, one which is of importance to biochemists and organic chemists alike. They are presented with great clarity, in spite of the complexity of the subject. They could be read and enjoyed by final-year honours students as well as by postgraduate workers, and for this reason the low price of the book is especially welcome. The papers are well illustrated with chemical structures, curves of reaction rates, diagrams of suggested means of attachment of enzymes to their coenzymes and substrates, and so on, and they are accompanied by a detailed account of the discussions which followed. According to the preface, the publishing of the first four of these one-day study group conferences is regarded as an experiment. Judging by this sample, the experiment must be considered highly successful. It is greatly to be hoped that these stimulating accounts of the work of the study groups will continue to appear from time to time, together with the volumes of the longer conferences.

D. C. HARRISON

Milk Testing

The Laboratory Control of Milk. By Dr. J. G. Davis. Second edition. Pp. xiv+309. (London: Dairy Industries, Ltd., 1959.) 30s.

THIS book is intended to provide all the necessary information for the routine control of milk by those concerned with laboratory work in collecting depots and processing dairies. It is therefore in the nature of a selection of standard methods for the sampling and chemical and bacteriological examination of milk for use in the dairy industry. The author has collected a great deal of information into a small publication. The sections dealing with the sampling of dairy products and the organization of the dairy laboratory are very good, but the author is at his best when dealing with the bacteriological tests. The section dealing with chemical tests might be criticized because it consists to a very large extent of reprints of British Standards specifications, which are readily available from other sources. The section dealing with the calibration of glassware—a basic need in any dairy laboratory—is dealt with very scantily and is not given sufficient attention.

The publication would be a valuable addition to the library of any dairy laboratory, and provides an easy means of reference to some of the more rarely used techniques which may be required for special investigations. However, the author does not deal fully with these methods, but all too often only provides references which will be difficult to obtain in the type of laboratory where the book will be of greatest use. The book is well printed, on the whole well written, and very free of mistakes. The most serious error is on p. 86, where it is stated that the total nitrogen is automatically determined when the casein is estimated.

A. L. PROVAN

A Supplement to "Helium"

By E. M. Lifshits and E L. Andronikashvili. Translated from the Russian. Pp. v+167. (New York: Consultants Bureau, Inc.; London: Chapman and Hall, Ltd., 1959.) 7.50 dollars; 60s.

ONE gets the curious impression, on reading this book, that one has been here before, and then one realizes that although the book has only now appeared in English translation, it was actually written in 1949. In other words, it was written, from its notions about liquid helium, in pre-Feynman days, and from its style and ethos, in the days of Stalin.

The great virtue of Keesom's "Helium" is that it contains every measurement made and every idea expressed on helium, good, bad, and indifferent, from the year one up to near the year 1942, when the book was published. All the ideas were allowed to find their own level with only the gentlest help from the author. Thus the book has an abiding value in spite of its appearance before the Landau theoretical break-through in the mid-'forties and the Feynman theoretical break-through in the mid-'fifties.

The "Supplement to Helium" is entirely different in character. It is a Russian view of the work done on liquid helium during the late 1930's and the 1940's when the Russian contribution was undeniably outstanding, but it was written at a time when it was apparently politically necessary to make it appear that non-Russian efforts were at best confused and at worst wrong-headed. The present reviewer gets off rather lightly in having his work described as "carried out under very complicated conditions . . . ", but Tisza, whose contributions to the theory of helium-II have been of very great importance, is treated very unfairly indeed. A decade ago one could sympathize with Russian colleagues who were in a difficult position, but it would have been an act of grace on the part of the authors if they had modified the text prior to its present translation. As it is, the repeated slanging somewhat mars an otherwise quite useful addition to the literature on liquid helium.

From the point of view of readability, appearance and accuracy the book is no great advertisement for either the Consultants Bureau or for the "multilith process from the International Business Machines, Ltd., 'cold' type". The printing is uneven and there are many blemishes, the mathematical type-setting is poor, the references in the text to figures and equations are sometimes wrong, and there are other proof errors such as Michels's name appearing as Milelson on p. 100.

J. F. ALLEN

THE VISUAL SYSTEM OF *OCTOPUS*

(I) Regularities in the Retina and Optic Lobes of *Octopus* in Relation to Form Discrimination

By Prof. J. Z. YOUNG, F.R.S.
Department of Anatomy, University College, London

THE capacity of an octopus to learn to make distinct reactions to differing visible shapes depends largely upon analysis of the vertical and horizontal extents of the figures[1]. Certain regularities now found in the retina and optic lobes provide clues to the mechanism for computing in these two directions.

The cells of the optic lobes show a bewildering variety of shapes. Often it is not possible to distinguish clearly between dendrites and axons, or to establish histologically the probable sites of origin of action potentials or the direction of conduction of the cells. Some of the cells have orientated dendritic trees within which there may be complex interactions such as are known in neurons of somewhat similar form in Crustacea[2,3]. There are sufficient data to suggest that the shapes and anatomical arrangements of the cells are of fundamental importance in the coding system. Deutsch[4] has proposed a hypothesis based on the general arrangement of the system as revealed by previous workers[5,6]. Further study now provides additional evidence of regularities It must be emphasized, however, that the forms of the cells are so complicated and difficult to investigate that much further work will be needed before it is certain which features are significant.

The outer segments of the retinal elements, directed towards the centre of the eye, form squares ('rhabdomes') as seen in tangential section, separated from each other by pigment granules[7] (Fig. 1). Further examination shows that the rhabdomes are orientated in the dorso-ventral and horizontal planes of the eye, as it is usually held with the pupil horizontal.

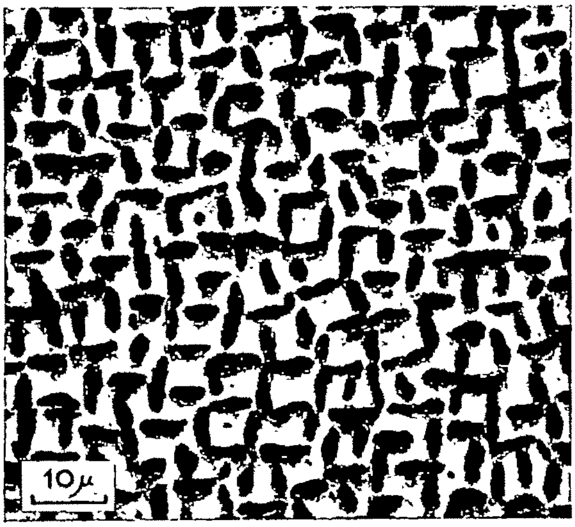


Fig. 1. Photograph of tangential section of retina of *Octopus*. Only the pigment shows, the rhabdomes being unstained. The long axis of the figure is dorso-ventral

Each rhabdome contains four 'rhabdomeres', composed of piles of tubules[8,9], and these lie with their long axes approximately in the vertical plane in one pair and the horizontal plane in the other pair in each rhabdome. The rhabdomes are connected to inner segments, each with a nucleus and nerve fibre, and counts show that there are twice as many nuclei as there are squares in the retina. Each rhabdome thus contains two receptor units (retinal cells), probably arranged as in Fig. 2. There are altogether 1–2 × 10^7 nuclei—a density of about 50,000 per mm.[3]. There are no striking differences in density in the central and peripheral parts of the retina.

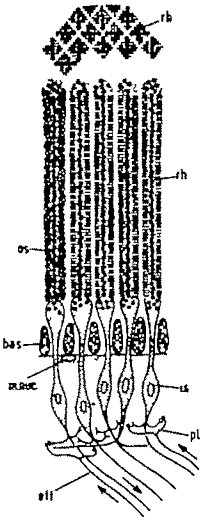


Fig. 2. Diagram of probable arrangement of the elements of the retina; above as seen in a tangential section, below in radial section. *bas.*, basal cell (which probably sends branches between the rhabdomes), *eff.*, efferent axon to the retina; *i.s*, inner segment; *o.s.*, outer segment; *pl.*, plexus beneath retina; *rh.*, rhabdomes. It is calculated that each retinal unit (pair of rhabdomeres) subtends a visual angle of 1 3′

The processes of the retinal receptors pass through a plexus and then through a chiasma that inverts the display in the dorso-ventral plane. They end within the optic lobes mainly in a complicated plexiform layer, the deep retina. This layer shows the following features in Cajal and Golgi preparations:

(1) A marked layering; four layers of tangential fibres are recognized, separated by four in which they are mainly radial (Fig. 3).

(2) Each optic nerve fibre has endings at more than one depth in the plexiform zone. The endings are mainly either superficial or deep, but there are also intermediates.

(3) Numerous amacrine cells send processes that spread to increasing distances with increasing depth (Figs. 3 and 5). These cells often do not show one distinct process that could be called an axon, though

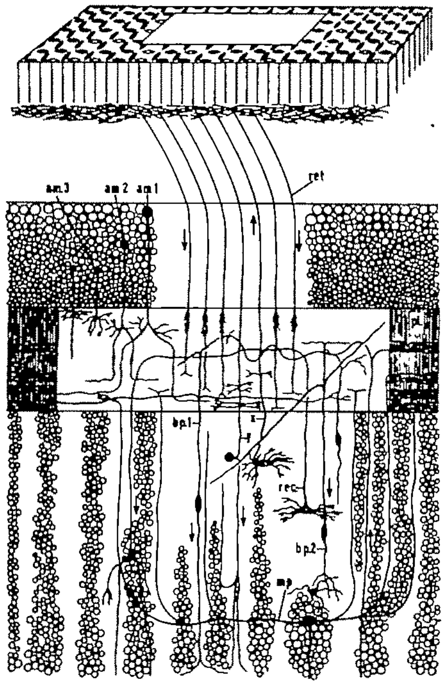


Fig 3. Diagram of the structure of the outer part of the optic lobe of *Octopus*. The retina is shown above with the image of a small rectangle. *am*. 1, 2 and 3, amacrine cells; *bp*. 1 and 2, bipolar cells the dendrites of which at different levels in the plexiform zone are orientated in opposite directions; *mp*., multipolar cell with many dendrites reaching to plexiform layer; *pl*., plexiform layer; *rec*., cell with dendrites in plexiform layer and a recurrent axon, *ret*., retinal nerve fibre. *x* and *y* cells with efferent processes to the retina, *x* has short basal processes, *y* long ones. All the cells are shown very schematically. A rectangle of 20 cm.^{2} seen at 1 m. would produce an image covering 14,000 retinal cells. A length of 100μ on the surface of the lobe corresponds to a visual angle of 40′, receiving some 30 optic nerve fibres

it is possible that these are unseen with the light microscope. If these cells ensure that excitation occurs where their processes overlap they may produce activity in the more superficial layers for points near together on the retina and in deeper layers for those more distant, thus serving to produce a neural representation of length. However, without information as to the physiological characteristics of such cells, it is not possible to say exactly how they function. An alternative possibility is that they serve to produce inhibition when neighbouring retinal elements are active, sharpening the effect of contours.

(4) Deep to the plexiform layer are further layers of small cells. Some of these are amacrines. Others have numerous processes in the plexiform layers and an axon that passes outwards into an optic nerve Fig. 3) and presumably provides an efferent pathway to the retina. Collaterals have been described at the base of the inner retinal segments[5,6], and there are thus probably synaptic connexions in the plexus behind the retina, as in *Limulus*[10]. The efferent cells to the retina also have basal processes, sometimes long (Fig. 3).

Table 1. NUMBER AND LENGTHS OF FIBRES IN AN AREA OF 22,500μ^2 IN THE PLEXIFORM LAYERS OF THE OPTIC LOBE OF AN OCTOPUS (CAJAL'S METHOD)

Layer of plexus	Degrees from horizontal 75–105	105–135	45–75	135–165	15–45	165–180 0–15
Second tangential						
Number	39	8	13	6	5	13
Length (μ)	1,455	393	462	204	179	531
Mean length (μ)	37	49	36	34	35	50
Third tangential						
Number	24	18	11	16	11	19
Length (μ)	625	447	373	490	445	664
Mean length (μ)	26	25	34	31	41	35
Fourth tangential						
Number	26	14	14	11	13	16
Length (μ)	760	450	321	357	359	415
Mean length (μ)	29	32	23	32	29	26
Total						
Number	89	40	38	33	29	48
Mean length	32	32	30	32	34	34

(5) Conduction inwards from the plexiform zone is by cells that can be called bipolars. They have numerous dendrites in the plexiform zone while the axon either proceeds from the base of the cell or as a recurrent fibre from one of the dendritic processes (Figs. 3 and 5). The dendrites may be in several of the layers or only in one layer. They extend over an appreciable portion of the lobe (1 mm.) and each is thus influenced by a wide angle of the visual field (see legend to Fig. 3). They do not run equally in all directions. Measurements on Cajal preparations show the greatest number and total length of dendrite to be in the vertical direction (Table 1). There are also many horizontal ones, but fewer obliques. The individual fibres are longest in the horizontal direction, and Golgi preparations show that many of the dendritic fields are oval, with the long axis horizontal (Fig. 4). However, others have the main axis vertical or oblique. It may be that where a cell has dendritic fields in several of the plexiform zone layers, these lie predominantly in different directions, as shown diagrammatically in Fig. 3. Since the fields can only be seen fully in tangential sections, it is difficult to obtain evidence on their orientation. That they have some relation to the main axes suggests a possible connexion with the fact that an octopus can discriminate between vertical and horizontal rectangles but not between obliques[11]. Sutherland[12] has provided evidence that octopuses discriminate between visual figures largely by taking account of some function of their vertical and horizontal extents. Cells with dendrites at different depths might be individually

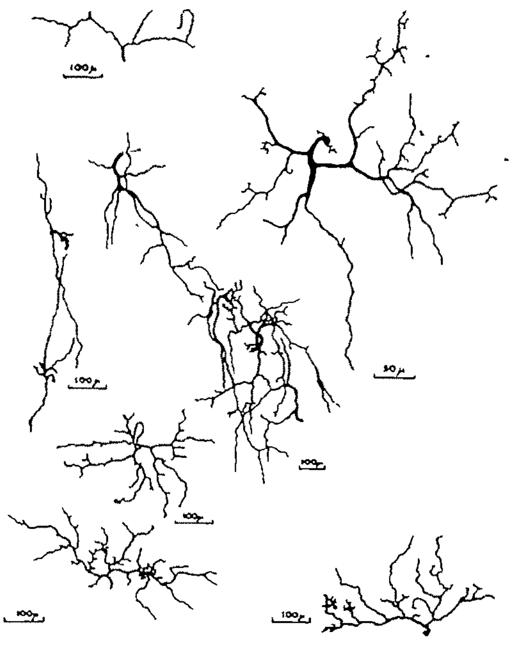


Fig. 4. Drawings of dendritic fields of some bipolar cells in the plexiform layer as seen in tangential sections of Golgi preparations. The fields are oval, with long axes directed mainly horizontally, but sometimes vertically

responsive to different ratios in these directions, if the amacrines ensure that excitation by contours of greater length occurs at greater depths.

(6) However, there is the further possibility that cells deeper in the optic lobes are sensitive to such ratios. Bipolar cells with oriented fields in one plexiform layer only project to depths proportional to the sizes of their receptive fields (Figs. 5 and 6). Here they meet the dendrites of the cells of the medulla of the lobe, the fields of which have most elaborate forms. These are even harder to study than the flatter fields in the plexiform layer, especially as they extend through considerable depths. Some of them have many superficial branches and fewer at deeper levels, others the reverse. If the parts of the field at different depths lie in differing directions these cells might be specifically sensitive to excitation by shapes with particular vertical and horizontal extents

Thus there are undoubtedly regularities in the distribution of the dendrites in the plexiform layer, and this may also be true throughout the lobe. The whole set of some 60 million cells would then provide a system able to learn to make appropriate responses to the vertical/horizontal extent of a moving figure.

The effect of visual stimulation of an octopus by an 'unknown' figure is to elicit attack only occasionally and after long delay[13]. As a hypothesis it is suggested that if food reward occurs following showing of a given shape, the cells that were active become conditioned to produce attack. During the period immediately after presentation, pathways to other parts of the same and the opposite optic lobes and through the vertical lobes would ensure that further cells with appropriate structure become conditioned, in addition to those originally stimulated. This would allow for spread of the representation throughout the tissue and thus for generalization of the response to retinal regions other than that stimulated. Generalization for figures of different sizes might also be achieved in this way, but this requires further investigation. Conversely, a figure that was followed by a shock would come to produce an avoidance response. Learning would thus consist of the accumulation of a sufficient number of suitably conditioned cells to produce a reliable response.

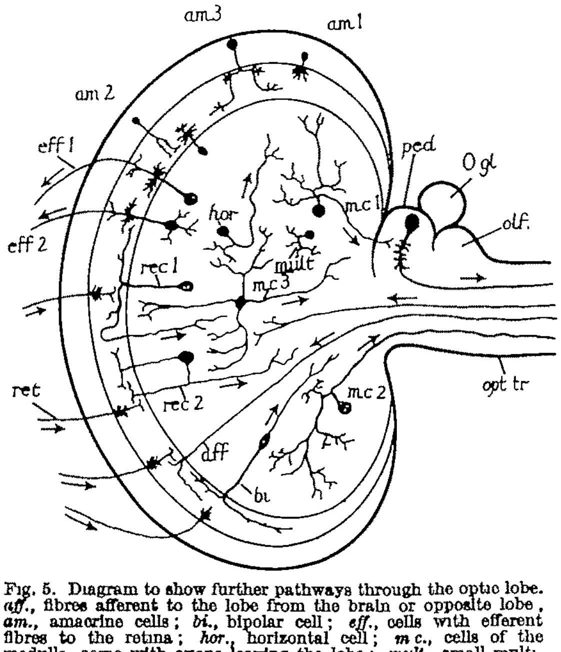


Fig. 5. Diagram to show further pathways through the optic lobe. *aff.*, fibres afferent to the lobe from the brain or opposite lobe, *am.*, amacrine cells; *bi.*, bipolar cell; *eff.*, cells with efferent fibres to the retina; *hor.*, horizontal cell; *m c.*, cells of the medulla, some with axons leaving the lobe; *mult*, small multipolar cell; *o.gl.*, optic gland; *olf.*, olfactory lobe, *opt tr.*, optic tract; *ped.*, peduncle lobe; *rec.*, cells with recurrent axons. All the cells are shown schematically

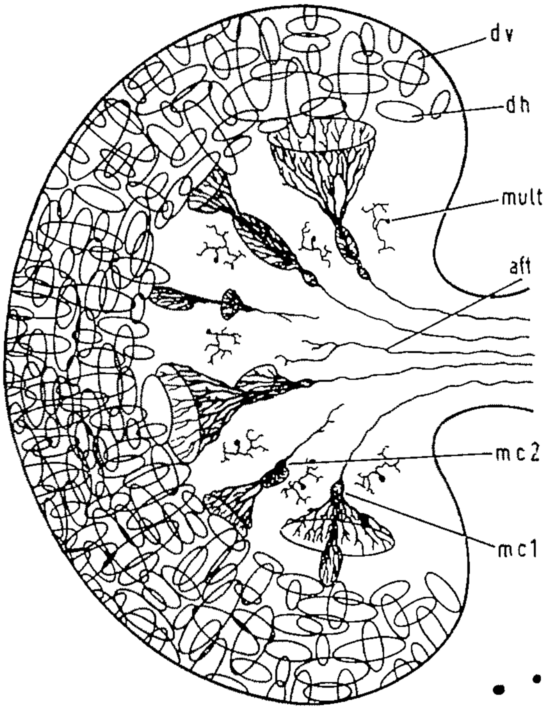


Fig. 6. Diagram of a thick horizontal section of the optic lobe to show probable arrangement of dendritic fields of some bipolar cells in single layers of the plexiform zone. Some run mainly vertically (*d.v.*), others horizontally (*d h.*). The axons of the smaller cells end nearer the surface The cells of the medulla have dendrites at many levels and these may run in different directions at different levels. Very diagrammatic. *aff.*, afferent fibres; *m.c.* 1 and 2, cells of the medulla with deep and superficial dendrites orientated in different directions and spreading to different extents

If the learning of appropriate responses to shapes depends upon the presence of cells with pre-set orientations, then it may be expected that training with several pairs of figures would produce confusions. This proves to be the case. After training in the relatively difficult discrimination between a square and a diamond octopuses discriminated between vertical and horizontal rectangles at a significantly lower level than normal[14]. Other interpretations of this result are possible, and it cannot be claimed that it is proved that the mechanism operates as here suggested. It is interesting, however, that an animal that recognizes shapes largely by their vertical and horizontal extents shows elements in the retina and brain arranged in these directions.

There is a general similarity of the plan of organization of the visual system of *Octopus* with that of insects and vertebrates, which prompts the search for orientation of neuronal fields also in these animals. Indeed, some projections from the mammalian retina to the visual cortex are oval fields each with characteristic orientation[15]. The evidence serves to direct attention to the need for considering the form of the distribution of dendritic fields as a factor allowing coding by selection of particular features of an input.

The research reported in this and the next communication has been sponsored in part by the United States Air Force Office of Scientific Research. We are also greatly indebted to the Nuffield Foundation for continual support and to Dr. P. Dohrn and the staff of the Zoological Station at Naples for their help.

[1] Sutherland, N. S., *J. Comp. Phys. Psychol.*, 51, 452 (1958).
[2] Bullock, T. H., and Terzuolo, C. A., *J. Physiol.*, 138, 341 (1957).
[3] Hughes, G. M., and Wiersma, C. A. G., *J. Exp. Biol.* (in the press).
[4] Deutsch, J. A., *Nature*, 185, 443 (1960).
[5] v Lenhossek, M., *Arch. mikr. Anat.*, 47, 54 (1896).
[6] Cajal, S. R., *Trab. Lab. Invest. Biol., Madrid*, 15, 1 (1917).
[7] Schultze, M., *Arch. mikr. Anat.*, 5, 1 (1869).
[8] Wolken, J. J., *J. Biophys. Biochem. Cytol.*, 4, 835 (1958).
[9] Moody, M. F., and Robertson, J. D., *J. Biophys. Biochem. Cytol.*, 7, 87 (1960).
[10] Ratcliff, F., Miller, W. H., and Hartline, H. K., *Ann. N.Y. Acad. Sci.*, 74, 210 (1958).
[11] Sutherland, N. S., *Brit. J. Psychol.*, 48, 55 (1957).
[12] Sutherland, N. S., *J. Comp. Phys. Psychol.* (in the press).
[13] Young, J. Z., *Proc. Roy. Soc.*, B (in the press).
[14] Parriss, J. R. (to be published).
[15] Hubel, D. H., and Wiesel, T. N., *J. Physiol.*, 148, 574 (1959).

(2) Discrimination of Polarized Light by *Octopus*

By M. F. MOODY and J. R. PARRISS

Department of Anatomy, University College, London

MANY animals, when illuminated by plane polarized light, orient their movements with respect to the plane of polarization. In a recent review Kalmus[1] has discussed the fact that this orientation is not necessarily dependent upon the ability of the animal's eye to analyse polarized light; in many cases the orientation is merely due to brightness patterns in the environment, since the polarized light may be preferentially scattered[2] and reflected in certain directions.

When the experimental results are primarily of ecological interest, the exact mechanism of discrimination is not relevant. However, there is electron microscopical evidence[3,4] to suggest that the discrimination could be performed inside the photo-receptor cells of the eyes, and that it is connected with the orientation of the groups of numerous, parallel, tubular photo-receptor elements inside these cells. To provide evidence on this point it is necessary to show that the discrimination is intra-ocular and to determine whether the retina can give different responses to different directions of the plane of polarization.

In an orientation experiment it is not easy to satisfy either of these criteria. First, it is difficult to illuminate so small a portion of the animal's environment that brightness patterns cannot arise. Second, when the animal orientates itself in a *fixed* direction with respect to the plane of polarization, one is only able to conclude that all other directions give different retinal responses from the preferred direction.

These difficulties can partly be overcome by training an animal to discriminate different planes of polarized light using a modification of the method originated by Boycott and Young[5] in the study of shape discrimination. An octopus, kept in an asbestos tank, was shown a small disk transmitting plane polarized light the electric vector of which could be rotated. When the electric vector was in one direction ('positive') attacks on the disk were rewarded by feeding; when the electric vector was in a different direction ('negative') attacks were punished by giving a mild electric shock.

Table 1

	No. of octopuses	Directions of the electric vector Positive	Negative	Correct responses/ total trials	Correct responses (per cent)
Group *A*	4	↔	↕	571/720	79
Group *B*	4	↕	↔	551/730	75
Group *C*	1	⤢	⤡	143/200	72
Group *D*	2	⤡	⤢	261/400	65

Arrows indicate direction of the electric vectors; the obliques were at 45° or 135° from the horizontal.

Using a two-cell table of χ^2 for equal expected frequencies, the discrimination of each of these four groups is clearly significant beyond 0 01 level.

The light was produced by a small water-tight electric torch, and was passed through a circular sheet of 'Polaroid' (diameter 2·1 cm.) in the rotatable metal front of the torch. The torch lamp voltage was adjusted to give a dim orange light. The octopus viewed the resulting circular disk of light through 3–4 ft. of sea-water. Four groups of animals were trained with different directions of the electric vector. There was evidence of discrimination in each group (see Table 1) but the animals of groups $A + B$ trained on ↕ and ↔ did significantly better than the animals of groups $C + D$ trained on ⤢ and ⤡. (Using a two-by-two contingency table for χ^2, $P = < 0{\cdot}01$.)

It is possible that these discriminations were based on extra-ocular scattering or reflexion patterns (see above), but the nature of the experimental situation leads us to believe that this is unlikely; the variety of discriminations made by the octopus is difficult to explain on these grounds.

It is more likely that the retina is responsible for the discriminations. The receptor cell layer consists of retinula cells and rhabdomes[6], often arranged in rectangular array[7] and lying mainly in the horizontal and vertical planes (see article 1). The rhabdomes contain sub-units, which Wolken[8] called rhabdomeres. He showed that each rhabdomere consists of close-packed fine tubules, almost exactly as in the insect

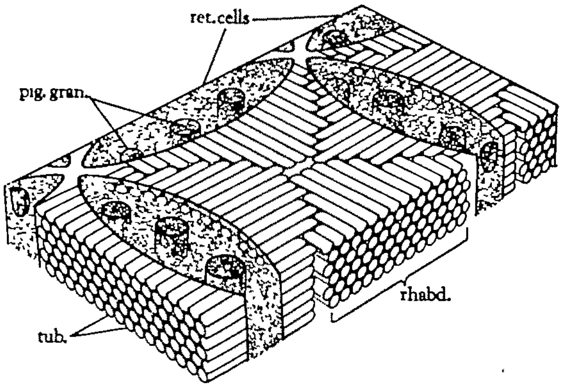


Fig. 1. Tangential section of the receptor layer of the octopus retina; the light would travel vertically from above. The fine tubules (*tub.*) are packed parallel in groups called rhabdomeres (*rhabd.*). The rhabdomeres usually occur in groups of four, each group or rhabdome being bounded by four retinula cells (*ret. cells*). *pig. gran.*, pigment granules. (Semi-diagrammatic; adapted from refs. 5, 7 and 9)

rhabdomeres. Fig. 1 shows the probable arrangement of the tubules in a rectangular rhabdome. The similarity of many structural features in insect ommatidia and in the octopus retina suggests that similar mechanisms might be responsible for the discrimination of polarized light in both cases.

It is proposed to explain the discriminations by postulating the existence in the retina of 'polarizing receptors', each measuring the component of the electric vector in a certain direction (the 'characteristic direction'). Such a receptor might work either by birefringence combined with internal reflexion, or by a dichroic arrangement of the visual pigment molecules[9].

As the simplest hypothesis let us suppose that all the polarizing receptors in the octopus retina have the same characteristic direction. Then unpolarized light would give a response more similar to one of the directions of the electric vector than to the direction perpendicular to it. This possibility was tested, after the discrimination had been established, by showing the octopuses the torch with the 'Polaroid' removed, but with equal brightness. These tests, given without reward or shock, were inserted between normal training trials at regular intervals. Considering the proportion of attacks to non-attacks in each group there was no significant difference between groups *A* and *B* ($\chi^2 = 2\cdot3$) or between groups *C* and *D* ($\chi^2 = 0\cdot10$). This shows that unpolarized light was associated with neither ↕, ↔, ⤢ nor ⤡. The simplest hypothesis is therefore disproved, and it would appear that the retina must contain polarizing receptors with *at least two* characteristic directions.

One possibility is that the receptors have *only two* characteristic directions. This may be connected with the fact that the retinula cells lie approximately in horizontal and vertical planes (see article 1). But if the characteristic directions were to lie exactly in these horizontal and vertical planes, the corresponding receptor cells would be unable to distinguish ⤢ from ⤡, as the component of the electric vector in the characteristic direction would be the same in both cases. One way of explaining how the discrimination of the obliques is possible would be to assume that the axes of the rectangular array are either tilted or at less than 90° ; then the relatively poor discrimination of ⤢ and ⤡ might imply that these distortions would be only slight.

The other possibility is that there are receptors with more than two characteristic directions. The receptors responsible for discriminating ⤢ from ⤡ might be identified with those retinula cells that deviate from the strict horizontal–vertical array. However, it is always possible that there might be no fixed relation between the characteristic direction of the receptors and the orientation of the retinula cells.

[1] Kalmus, H., *Nature*, 184, 228 (1959).

[2] Bainbridge, R., and Waterman, T. H., *J. Exp. Biol.*, 35, 487 (1958).

[3] Fernández-Morán, H., *Exp. Cell Res.*, Supp. 5, 586 (1958).

[4] Goldsmith, T. H., and Philpott, D. E., *J. Biophys. Biochem. Cytol.*, 3, 429 (1957).

[5] Boycott, B. B., and Young, J. Z., Symp. Soc. Exp. Biol., IV, Animal Behaviour, 432 (1950).

[6] Grenacher, H., *Abh. d. Naturforsch. Gesell. z. Halle*, 16, 209 (1886).

[7] Schultze, M., *Arch. f. mikrosk. Anatomie*, herausgegeben von M. Schultze, 5, 1 (1869).

[8] Wolken, J. J., *J. Biophys. Biochem. Cytol.*, 4, 835 (1958).

[9] Stockhammer, K., *Ergebnisse der Biol.*, 21, 23 (1959).

---

(3) Theories of Shape Discrimination in *Octopus*

By DR. N. S. SUTHERLAND

Institute of Experimental Psychology, University of Oxford

THIS article attempts to summarize the results and theoretical implications of a continuing series of experimental studies of shape discrimination in *Octopus vulgaris* Lamarck. The purpose of these experiments is : (1) To discover what are the properties in terms of which shapes are classified by the octopus's brain, and (2) thus to provide evidence to assist in unravelling the neural arrangement in the octopus brain which analyses the relevant properties. Since a property is usually thought of as being either present or absent, whereas shapes resemble one another for a given species to a greater or lesser *degree*, it is more accurate to talk of the *dimension* along which shapes are analysed. This word will be used in what follows, and its meaning will be made clear by examples. Discovering what are the relevant dimensions may be regarded as a first step towards uncovering the neural mechanisms at work : final verification of the existence of a given neural mechanism would, of course, depend upon corroboration from neuroanatomical and neurophysiological studies of brain structure and functioning in *Octopus*.

Two main behavioural methods have been used to provide the data : (*a*) Animals are trained to discriminate between different pairs of shapes, that is, they are trained to attack one member of a pair and not to attack the other. If they discriminate more readily between one pair of shapes than between another, it can be assumed that the former pair exhibits a larger difference on a dimension discriminated than the latter. (*b*) After such training, animals are shown new shapes (transfer shapes), and according to whether they treat these in the same way as the shape they were originally trained to attack, or in the same way as the shape they were originally trained not to attack, it is possible to scale the transfer shapes in degree of similarity to one or other of the original training shapes. Transfer shapes can then be examined, and a dimension sought such that the position of each shape on that dimension predicts the extent to which each shape is treated as like the original positive or the original negative. Examples of such dimensions are absolute vertical extent of a shape, vertical extent relative to area, ratio of vertical to horizontal extent, contour relative to area, number of re-entrants : all these dimensions except the last are continuous.

Two complications need to be mentioned : (*a*) It has been discovered[1] that octopuses have preferences for shapes moving along their long axes and for shapes moving in the direction of their points. Where such shapes are used, care is necessary in interpreting the data since both performance on the initial discrimination and performance on transfer tests are affected by pre-existing preferences. (*b*) It is probable that the octopus can analyse shapes along more than one dimension : this makes the interpretation of results much more difficult since in general any change in a shape introduces changes along several different dimensions.

I put forward[2] a simple mechanism intended to interpret early findings, and to serve as a guide for further research by providing hypotheses for testing. The major purpose of the present article is to examine the original theory in the light of subsequent findings and to indicate current cruxes in the interpretation of the data. The initial findings could, of course, be explained by hypotheses other than that put forward by me: in subsequent experiments some alternative hypotheses have been deliberately tested. Two such alternative hypotheses have now been published by other authors[3,4], and it will be shown that in the light of further data these hypotheses are not tenable. The three theories will first be stated, and then examined in the light of the evidence. It is impossible to summarize all the evidence here: detailed accounts will be found in papers already published and in further papers forthcoming.

Statement of Theories

(*A*) *Vertical and Horizontal Extents.* I suggested[1] that two of the dimensions along which octopuses analyse shape are those of horizontal and vertical extents. A simple neurological mechanism was proposed which counts horizontal extents of a shape at each point on the vertical axis, and vertical extents at each point on the horizontal axis. This converts each shape into its horizontal projection and its vertical projection: such projections are shown in Fig. 1. It is suggested that further analysis proceeds in two ways: (*a*) The ratios maximum horizontal extent to square root of area, and maximum vertical extent to square root of area are computed. (*b*) The two projections obtained may be differentiated so that they are analysed in terms of the direction and size of changes[5]. This means that octopuses will be able to discriminate between shapes which yield a different distribution of vertical extent along the horizontal axis, or a different distribution of horizontal extent along the vertical axis. It must be emphasized that the theory is incomplete at this point in that no attempt has been made to specify exactly how such differences in distribution are analysed. This point will be referred to again below. It is further hypothesized that behaviour is more readily controlled by differences in the horizontal projections than by differences in the vertical projections, possibly because horizontal projections of shapes are more accurately represented in the nervous system. Therefore the discriminability of shapes will be more determined by the similarity of their horizontal projections than the similarity of their vertical projections. In general the theory makes three types of prediction: (1) Shapes having large differences in relative horizontal or vertical extents will be more readily discriminable than shapes having small differences. (2) Shapes which have the same horizontal projections as one another and the same vertical projections will be indiscriminable. (3) Shapes differing only in their horizontal projections will be more readily discriminable than shapes differing only in their vertical projections.

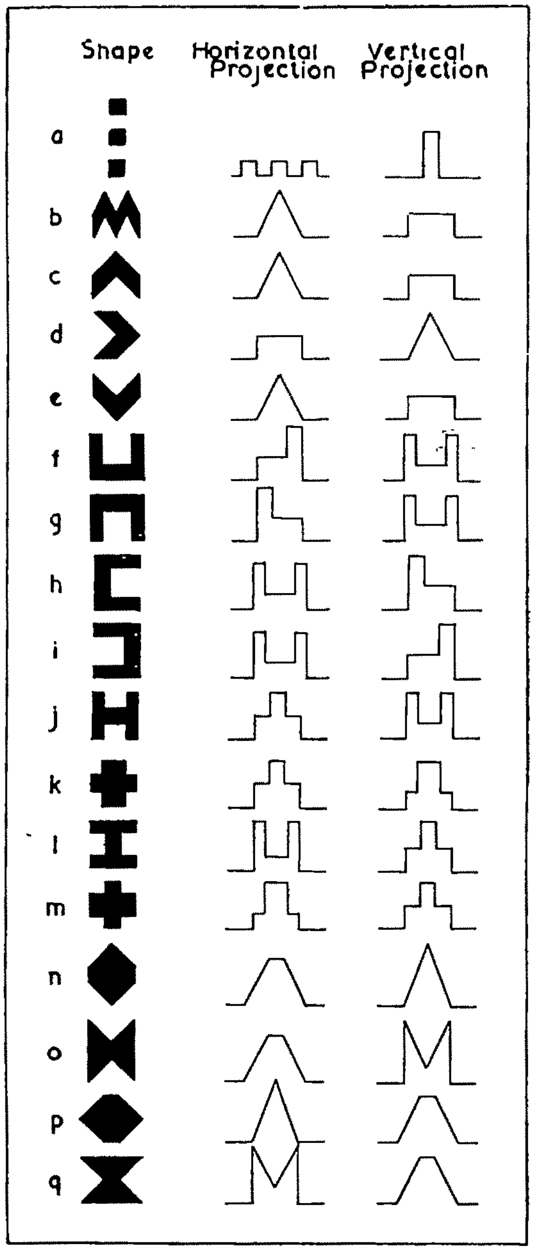


Fig. 1

(*B*) *Vertical Extents between Contours.* Deutsch[3] has proposed a modification of the above theory. He suggests that octopuses count distances between contours in the vertical direction at all points along the horizontal axis. The count is made in such a way that the reciprocal of the distance between contours is taken. All shapes are then scaleable on a single dimension: shapes with small distances in the vertical direction between contours (for example, horizontal rectangles) will be high on this dimension; shapes with large distances between contours in the vertical direction (for example, vertical rectangles) will be low on this dimension. Where a shape contains contours not running in horizontal or vertical directions, it will tend to be high on this dimension since as the contours approach one another the reciprocal of the distance between them will become very large, approaching infinity where they intersect (for example, this will occur at the two basal angles of an isosceles triangle with base horizontal). To prevent obtaining the number infinity from such shapes, it would be necessary to specify some small vertical distance between contours within which no count is made: otherwise the position on this dimension of shapes with contours running in directions other than vertical and horizontal cannot be computed. On general grounds this theory is rather implausible, since it is possible to find a horizontal or vertical rectangle which is at the same point on this dimension as any other shape however complex: it would be difficult to test this prediction, but it seems most unlikely to be correct. (I am indebted to Mr. Sime of this laboratory for this point.)

(*C*) *Direction of Contours.* Dodwell[4] proposed that animals might discriminate between shapes by analysing the direction of their contours with reference to horizontal or vertical. For example, a large response might be given in the nervous system to a horizontal contour and zero response to a vertical with intermediate responses to contours running in intermediate directions. Such an analysis would confuse contours running at, for example, 45° and 135° to the horizontal since both are midway between horizontal and vertical. The theory could be supplemented by assuming that such a count of contour direction was made separately at each point on the vertical or horizontal axis.

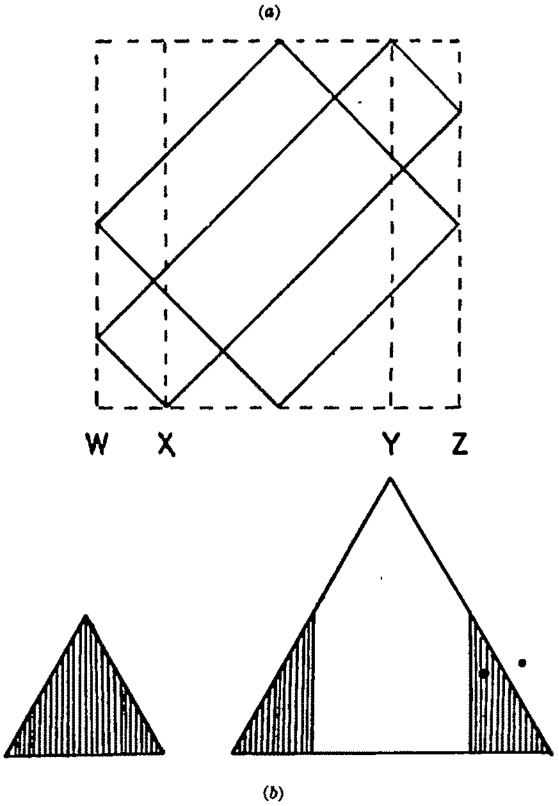
Evaluation in Relation to Experiment

(1) Early findings showed that vertical and horizontal rectangles are very readily discriminable by octopuses, whereas two oblique rectangles in opposite 45° rotations from the horizontal are either indiscriminable or discriminable only with extreme difficulty[6]. Theories *A* and *B* explain this because vertical and horizontal rectangles have large differences in horizontal and vertical extents whereas opposite obliques have none; *C* explains it on the grounds that a horizontal rectangle has much horizontal contour whereas a vertical has little, while two oblique rectangles have the same amount of oblique contour as one another.

(2) The pairs, horizontal and oblique rectangle, and vertical and oblique are both discriminable but not as readily as a vertical and horizontal rectangle[7]. This is predicted by the same sort of reasoning by all three theories. It should be noted that Deutsch's theory (*B*) predicts very poor discrimination between horizontal and oblique since at its extreme left and right sides an oblique has contours approaching one another at a angle of 45° to the horizontal, thus giving very small distances between contours, and therefore when reciprocals are taken placing it high on the dimension analysed: a horizontal rectangle is also high on this dimension. Such poor discrimination was not found, and the difference in performance between animals discriminating vertical and oblique and horizontal and oblique is due to a pre-existing preference for the vertical when moved vertically.

(3) Animals trained to discriminate between a horizontal and oblique treat a vertical rectangle as an oblique, and vice versa[7]. This emphasizes that we are dealing with dimensions rather than properties: on the dimension of 'horizontality' a vertical rectangle differs from a horizontal in the same direction as an oblique (that is, it is less 'horizontal') but it differs to a larger extent.

(4) Animals trained to discriminate between vertical and horizontal rectangles treat the broken vertical rectangle shown in Fig. 1*a* as a vertical rectangle[8]. This is predicted by *A*, since the heights of the horizontal and vertical projections are little changed. *B*, however, predicts that the broken vertical rectangle will be treated as a horizontal since if the reciprocals of distances between contours are counted in the vertical direction, it will yield a large count like the original horizontal rectangle. *C* also predicts that this shape should be treated as a horizontal rectangle, not a vertical. Thus this result supports *A*, but is evidence against both *B* and *C*.


(*a*)

(*b*)

Fig. 2

(5) All theories predict that animals should discriminate better between a square with base horizontal and a triangle than between a triangle and a diamond: this prediction was confirmed[9].

(6) Animals discriminate equally well between the following six pairs of shapes: a square (with base horizontal) versus a vertical, horizontal or oblique rectangle; and a diamond versus a vertical, horizontal and oblique rectangle[10]. This is predicted by *A*, since for all 6 pairs of shapes the difference between amount of vertical extent and between amount of horizontal extent for opposite members of a pair is about the same. It is not clear what theory *B* predicts since some shapes have contours running at right angles to horizontal and vertical axes and some at 45°: as pointed out above it is not possible to say where shapes of the latter kind (that is, diamonds and oblique rectangles) will lie on the dimension under analysis, since at their left and right corners the vertical distance between contours approaches continuously to zero thus making these shapes infinite on this dimension.

The experiment was performed mainly to test a differential prediction between *A* and *C*, since *C* must predict that an oblique rectangle and a diamond will be impossible to discriminate: Fig. 2*a* illustrates how this prediction is made. It will be seen that the diamond and oblique rectangle have two oblique contours at all points on the horizontal axis. The contours are identical between points *W* and *X*, and *Y* and *Z*; between *X* and *Y* they differ only in that one of the contours of the diamond is rotated through 180°. However, since all contours are midway between the vertical and horizontal they should still be indiscriminable. Since this constitutes a crucial test of C, this theory will not be discussed in detail in what follows.

(7) When an animal has been trained to discriminate between a square and a vertical rectangle, it tends to treat a horizontal rectangle as a square (and a vertical as a square if initial training was between a horizontal rectangle and a square)[10]. In terms of the way in which human beings classify shapes this was a surprising finding, but it was predicted by A, since on the dimension under analysis a vertical rectangle differs from a horizontal in the same direction as a square but to a greater degree.

(8) A and B both predict that shapes b and c in Fig. 1 should be indiscriminable: a glance at the projections of these shapes will show that they are the same and therefore should be indiscriminable on A. Since they have the same vertical distance between contours at all points on the horizontal axis they will also be indiscriminable on B. It was found[10] that shapes b and c were in fact barely discriminable whereas c and d were more readily discriminable. Also after training with c and d, b was treated as like c. In addition c and e were found to be indiscriminable, which again is predicted by A and B (cf. the projections in Fig. 1). This experiment thus yields some support for A and B; the reason why some discrimination between b and c occurred will be considered below.

(9) Deutsch rightly points out that B predicts perfect transfer to smaller and larger figures where shapes have contours running in the vertical and horizontal planes: for example, if we halve the linear dimensions of a vertical rectangle we halve the length of contour running in the horizontal plane, but we double the reciprocal of the vertical distance between the two horizontal contours, and thus the smaller shape occupies the same position on the dimension analysed as the larger. However, by changing the size of figures with oblique interior angles, we alter their position on this dimension. This is illustrated in Fig. 2b. The cross-hatched portions of the large triangle are equivalent to the whole of the small triangle: but the reciprocals of distances between contours in the vertical direction in the unshaded central portion of the large triangle must be added, so that the large triangle will be higher on this dimension than the smaller. Thus the theory predicts good transfer to different-sized rectangles, but poor transfer to different-sized triangles. These predictions are not confirmed: there is diminished transfer to all figures including vertical and horizontal rectangles and squares when the area of the figures is reduced by a quarter[6,10]. There is usually better transfer to larger figures, than to smaller, though even this transfer is sometimes less than complete. The results of transfer tests to different-sized figures thus constitute a direct refutation of one of the most interesting predictions made by B.

The reduced transfer found to small shapes cannot be directly explained on any current theory: the most likely explanation is that as the size of the figure is reduced the relative importance of noise in the neural analysing mechanisms may increase, thus giving less-precise representations for such figures.

(10) Up–down mirror image shapes are more readily discriminable than right–left mirror image shapes (for example, shapes f and g in Fig. 1 are more readily discriminable from one another than are shapes h and i)[11]. B cannot account for any discrimination between mirror image shapes of this sort since they fall on the same point as one another on the dimension under analysis. In terms of A the greater ease of discrimination of up–down mirror image shapes than of right–left must mean that behaviour is more accurately controlled by differences in the horizontal projection (on which up–down mirrow images differ; see Fig. 1) than by differences in the vertical projection: this does not confirm the theory since this experiment was run in order to discover whether the horizontal or vertical projection was more important. However, once the theory is modified in this way it yields some interesting further predictions.

(11) One such prediction is that horizontal rectangles of different lengths will be more readily discriminable than vertical rectangles of different lengths (this follows because horizontal extent is more accurately analysed than vertical extent). This prediction was strikingly confirmed[12]. (B predicts equal discriminability.)

(12) A further prediction of the same sort can be made about the two pairs of shapes shown in Fig. 1, j, k and l, m. Since the former pair differs only in vertical projections while the latter pair differs only in horizontal projections, the former pair should be less readily discriminable than the latter. This prediction was not confirmed: both pairs were equally discriminable[13]. A further experiment was conducted with two other pairs of shapes (n, o and p, q), one of which differed only in vertical projections, the other only in horizontal projections: again neither pair was made up of mirror-image shapes. These two pairs were also found to be of equal discriminability[14]. Thus in both cases A yields a false prediction. It should be noted that in these tests, theory B fares even worse than A: not only does it predict better discriminability for the pairs l, m and p, q than for j, k and n, o, it also makes the further prediction that the latter two pairs should be completely indiscriminable, whereas in fact all four pairs are readily discriminated. Pairs j, k and n, o should be indiscriminable on theory B because the two members of each pair have exactly the same total vertical distances between contours, as will be clear from inspection of these shapes in Fig. 1. The reason why these pairs of shapes were in fact readily discriminable although theory A predicts poor discriminability and theory B none will be considered below.

In summary, theory A has yielded consistently correct predictions with the exception of (8) (it predicts no discrimination between shapes b and c whereas slight discrimination was found) and (12) above. Theory B in no instance yields a correct prediction where A fails; in several instances it yields incorrect predictions where A succeeds (4, 9, 10, 11), and in one instance it makes no prediction (6). Theory C yields incorrect predictions throughout with the exception of some of the initial findings. Some slight additional confirmation for A has been forthcoming from Young's work on the neuroanatomy of the optic lobe of octopuses (article 1): there is some evidence that the dendritic fields of pick-up fibres from the input to the optic lobe are orientated primarily in planes corresponding to the visual horizontal and vertical axes. Moreover, there appear to be more fields orientated in the horizontal than in the vertical axis: this would be expected on the theory if the function of these cells was to compute horizontal and vertical extents.

Further Discussion

Because of the large number of correct predictions which it has yielded, it seems likely that *A* is at least along the right lines: it may therefore be worth while appending a brief discussion of some of the current cruxes in the theory.

(1) The major crux arises from the incorrect predictions set out under (8) and (12) in the previous section. The pairs of shapes involved differ from other pairs used in one important respect: the members of each pair differ from one another in the total amount of contour present in each shape. The findings could be interpreted if a second analysing mechanism were present in the octopus which computed the total contour of a shape relative to its area or to the square root of its area. Very extensive transfer tests have been run with some of the shapes involved, and the results give some confirmation to this hypothesis[13,14].

(2) It will be noticed that no attempt has been made to specify how the mechanism which differentiates changes in the projection operates: some such operation as this is necessary to account for findings on mirror image shapes and on squares and circles, squares and triangles, and circles and triangles[9,15]. More experimental work is necessary before a fuller specification can be made.

(3) A further crux is that although most of the results are best fitted by assuming that animals analyse shapes in terms of the ratio, vertical extent to square root of area, there is evidence that in some cases absolute extent is important as well. Thus in transfer tests run after animals had learned to discriminate between horizontal rectangles of different lengths and vertical rectangles of different lengths it was found that animals had been discriminating both in terms of absolute length and in terms of length relative to area[12]. This was established by showing that after the initial discrimination had been learned, animals showed no transfer where these two properties were pitted against one another; for example, if a rectangle was shown which was the same absolute length as the original long one but the same ratio of length to square root of area as the original short one, there was transfer from neither of the original rectangles. This can be reconciled with previous findings if it is supposed that octopuses are capable of analysing both features of shapes (that is, absolute and relative horizontal and vertical extents) but that behaviour is finally controlled by whichever feature gives the biggest difference between the shapes they are asked to discriminate. In previous experiments relative horizontal extent had given a bigger difference between the shapes to be discriminated than absolute horizontal extent (for example, the difference for a horizontal and vertical rectangle with sides in the proportion of 5 : 1 is in the ratio 25 : 1 for relative extent, 5 : 1 for absolute extent, whereas with the rectangles of different lengths used in the experiment under discussion the difference was in the ratio 2 : 1 for both features).

Further experimental work is being directed to the resolution of these three issues. It will be seen that as a theory *A* has proved its usefulness as a guide for the collection of systematic data. Although probably on the right lines, the theory may have to be modified in the light of subsequent neuroanatomical findings. A further method of approach to the problem of shape discrimination is also being explored: systematic data on other species are being collected, and an attempt is being made to correlate species differences in shape discrimination with differences in neural arrangements. In dealing with the central nervous system, this is a promising and previously little-used method for pinpointing the behavioural function mediated by a given neuroanatomical arrangement.

This article was written as part of a project on "Stimulus Analysing Mechanisms": the project is financed jointly by the Nuffield Foundation and by the American Office of Naval Research (Contract *N*62558-2453). I am greatly indebted to Prof. J. Z. Young for extensive discussion of the problems considered in this article.

[1] Sutherland, N. S., and Muntz, W. R. A., *Pubbl. Staz. Zool Napoli*, 31, 109 (1959).
[2] Sutherland, N. S., *Nature*, 179, 11 (1957).
[3] Deutsch, J. A., *Nature*, 185, 443 (1960).
[4] Dodwell, P. C., *Brit. J. Psychol.*, 48, 221 (1957).
[5] Sutherland, N. S., *Nature*, 179, 1310 (1957).
[6] Sutherland, N. S., *Brit. J. Psychol.*, 48, 55 (1957).
[7] Sutherland, N. S., *J. Comp. Physiol. Psychol.*, 51, 452 (1958).
[8] Muntz, W. R. A., *J. Comp. Physiol Psychol.*, 53 (in the press).
[9] Sutherland, N. S., *Quart. J. Exp. Psychol.*, 10, 40 (1958).
[10] Sutherland, N. S., *J. Comp. Physiol. Psychol.*, 53, 95 (1960).
[11] Sutherland, N. S., *Brit. J. Psychol.*, 51, 9 (1960).
[12] Sutherland, N. S., *J. Comp. Physiol. Psychol.*, 53 (in the press).
[13] Sutherland, N. S., *J. Comp. Physiol. Psychol.*, 54 (in the press).
[14] Sutherland, N. S., *J. Comp. Physiol. Psychol.*, 53, 104 (1960).
[15] Sutherland, N. S., *Quart. J. Exp. Psychol.*, 11, 24 (1959).
[16] Sutherland, N. S., *J. Comp. Physiol. Psychol*, 52, 135 (1959).

NEW LABORATORIES AT THE UNIVERSITY OF LIVERPOOL

Chadwick Laboratory

THE Chadwick Laboratory, named after Sir James Chadwick, Lyon Jones professor of physics in the University of Liverpool during 1935–48, was opened to visitors for the first time on April 29 and 30. This Laboratory replaces the George Holt Physics Laboratory, which was opened in 1904 (ref. 1). It has an area of 87,923 sq. ft. and capacity of 1,318,000 cu. ft., and was designed for the teaching of experimental and theoretical physics to undergraduate students, for research in nuclear physics and acoustics, and for postgraduate teaching and research in theoretical physics. The site conditions were such that the most economical plan was to provide piling through to the rock, beneath a bed of pre-glacial peat, for the erection of a framed tower structure at the south end, shown in Fig. 1, with light foundation over the rest of the area for a single-storey structure comprising teaching and research laboratories, and three lecture theatres, one of which can be seen on the extreme right of Fig. 1. The lecture theatres are cantilevered outward from a central service area, a large one on one side, balanced by a medium and a small one on the other, accommodating about 300, 150 and 100 students,

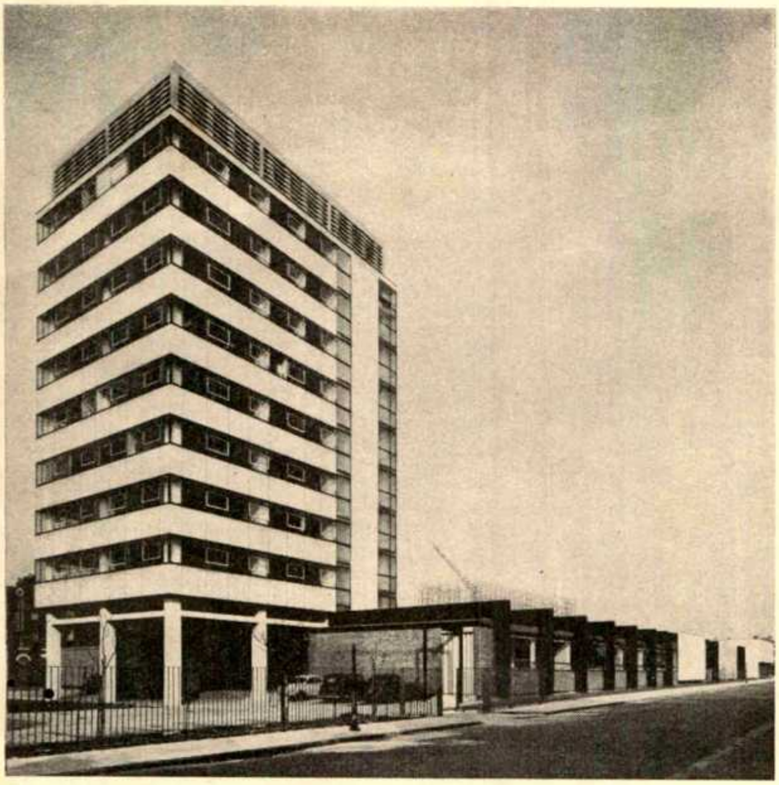


Fig. 1. The Chadwick Laboratory seen from Chatham Street, Liverpool. On the far right the cantilevered lecture theatres

respectively. Artificial illumination and ventilation are used in all three theatres, which have acoustic ceilings and timber-lined walls.

The students' entrance hall, between the theatres and the teaching laboratories, is glass-walled and is approached on each side from the street-level by ramps. The most striking feature of the hall is the mural decoration designed by Geoffrey Clarke.

The six large teaching laboratories, separated by four smaller ones, are constructed in load-bearing brickwork. The ceilings are supported on 40-ft. steel lattice beams placed at 10-ft. intervals. The large laboratories will each accommodate on average about sixty students, and each of the smaller ones about twenty-five.

Similar in style to the group of large teaching laboratories opening off the main corridor is the departmental library. It will accommodate seventy readers and about 5,000 books.

A duct beneath the main corridor connecting the lecture theatre block to the tower carries all the services for the building.

Between the south end of the main corridor and the tower lies the research area, the east side of which is shown in Fig. 1. The research laboratories are mainly of reinforced concrete with columns and deep upstand beams at 20-ft. centres. The outer walls are in grey-brown brickwork with purple brick plinths. Eight rooms, each of approximately 400 sq. ft., are used as preparation rooms for nuclear research, which is carried out in the Nuclear Physics Research Laboratory in Mount Pleasant, some 400 yards away. In the preparation rooms, research groups construct, test and develop apparatus to be used with the 156-in. synchrocyclotron, which has already been described[2], the 37-in. cyclotron, the Cockcroft–Walton high-tension set and the 10-in. diameter liquid-hydrogen bubble chamber, as well as the design and development of a 60-in. bubble chamber for use in the Rutherford Laboratory at Harwell and in the CERN Laboratory at Geneva.

Beta-ray spectroscopy is carried out in a specially designed room of approximately 800 sq. ft. in area, with a small adjoining room for motor generators. One half of the floor, which is of black quarry tile, is reinforced to take a 7-ton magnet. The other half is free from iron so that accurate magnetic field-strength measurements may be made.

The Sub-Department of Acoustics occupies the rest of the research block, which includes, besides a general laboratory of area 1,600 sq. ft., a large anechoic room, a reverberation room, a suite of three transmission rooms and two common control rooms. Facilities are available for work on the propagation of acoustic waves in materials, on aerodynamic sources of sound, on electro-acoustic devices and on communication acoustics, including room and building acoustics.

A modern workshop and a well-equipped glass-blowing room serve the requirements of most of the teaching and research carried out in the Laboratory. The glass-blowing room has floor heating and a means of obtaining diffuse daylight when required. The transfer of heavy equipment in and out of the building is facilitated by the use of three sliding doors opening from the spectrometer room, the workshop and the acoustic block at street-level. That serving the latter may be seen with its loading gantry in Fig. 1.

The 110-ft. tower is a reinforced concrete structure with beamless slabs for each floor supported on twelve columns at 20-ft. centres. The wall cladding is in the form of 5-ft. square pre-cast panels faced in glass mosaic. The eight storeys of this block are accessible by means of two lifts and stairs. The first five stories are devoted to experimental physics and house two large laboratories for the teaching of practical physics to honours students, a reading and writing room, a staff common room, research rooms, administrative and staff offices.

The Department of Theoretical Physics occupies the sixth, seventh and eighth floors of this block. The Department concerns itself principally with post-graduate teaching and research; the only research facilities required are books and journals, and these are provided by an up-to-date library on the sixth floor. Discussions and seminars are held in the discussion room on the seventh floor.

Projecting above the roof-level of the tower are a small observatory and a penthouse containing services. On the observatory is housed a 4½-in. refractor astronomical telescope with an equatorial mounting. The dome is moulded in fibre glass and weighs only 3 cwt.

The part of the site outside the tower has not been completed, owing to the construction of a separate building to house a 12-million volt tandem Van de Graaff machine. When completed there will be a paved courtyard with an ornamental pool in which there will be erected a sculpture of abstract composition by Hubert Dalwood. This sculpture has already been executed and is now placed on a temporary pedestal at the south end of the Laboratory.

The planning of the Chadwick Laboratory was directed by the late Prof. H. W. B. Skinner and Mr. A. M. Hudson Davies, the chairman of the Building Committee.

---

[1] *Nature*, **71**, 63 (1904–5).

[2] Moore, M. J., *Nature*, **175**, 1012 (1955).

Civil Engineering and Building Science Laboratories

A PROJECT for the provision of adequate laboratories for the Department of Civil Engineering in the University of Liverpool was frustrated by the outbreak of the Second World War, and during the post-war period the Department had to be accommodated in an old building, originally built for quite a different purpose, until such time as new laboratories could be provided. It is therefore pleasing to note that this has now been achieved and that the inauguration of a new building housing the Departments of Civil Engineering and Building Science was marked during April 29–30 by a series of functions in the University, which was also associated with the opening of the Chadwick Laboratory for the Department of Physics.

The building for civil engineering was designed by Mr. E. Maxwell Fry, and erected by Holland and Hannen and Cubitts (North West), Ltd. It has a total area of 50,275 sq. ft., of which only about 15 per cent is given over to circulation space. Construction commenced on June 1, 1958, and the building was occupied on October 1, 1959; the total cost was £253,144.

The main part of the building is an eight-storey block, roughly *T*-shaped (Fig. 1). This is flanked by a single-storey building containing the Structures Laboratory. From the outside, the most striking feature of the building is a panel some 60 ft. in height which carries in huge concrete letters a selection of names well known to engineering historians, ranging in time from Archimedes to Parsons, and in achievement from Leonardo to Bessemer. The entrance hall gives a pleasing impression of space, resulting partly from a large observation window looking into the Structures Laboratory. The entrance hall has now been further enlivened by a mural in ceramic tiles by Mr. Peter Lanyon.

The largest laboratory in the building, measuring about 100 ft. × 40 ft., is devoted to structural testing. The laboratory is being equipped with a variety of frames for tests on struts, beams, slabs and other elements. A system of steel beams is to be laid on the floor to provide a foundation for test rigs. Facilities for pulsating load tests will eventually be a special feature of the laboratory; a wide variety of equipment for static and dynamic strain measurement is already available. The Concrete Laboratory is adjacent to the Structures Laboratory and is equipped with plant for mixing, placing, vibrating and curing concrete and for tests on this material. Aggregate is stored in a series of bunkers filled from outside the building, and there is provision for screening and drying material used for test purposes.

The Hydraulics Laboratory, also on the ground-floor, has a long section which accommodates a tilting channel 48 ft. in length and a more square area for other hydraulic model work. At present a model of Milford Haven is being constructed for the study of a tidal barrage project, intended to provide freshwater storage for the future needs of that port. A workshop is situated between the Hydraulics and Structures Laboratories and provides facilities for the construction and maintenance of apparatus and the preparation of test specimens of all kinds.

Other laboratories are located on various floors in the main part of the building and include laboratories for photoelasticity, soil mechanics, road engineering, model analysis and municipal engineering. In addition to these rooms there are lecture rooms, drawing offices and other accommodation in the building sufficient for an eventual expansion to final-year classes of sixty students in civil engineering and for a complement of about twelve research students.

The Department of Building Science, which shares the new building, was established in 1957 to promote the scientific study of problems arising in the design, construction and use of buildings. Laboratories for the study of building materials and physics of environment are located on the fifth floor. These

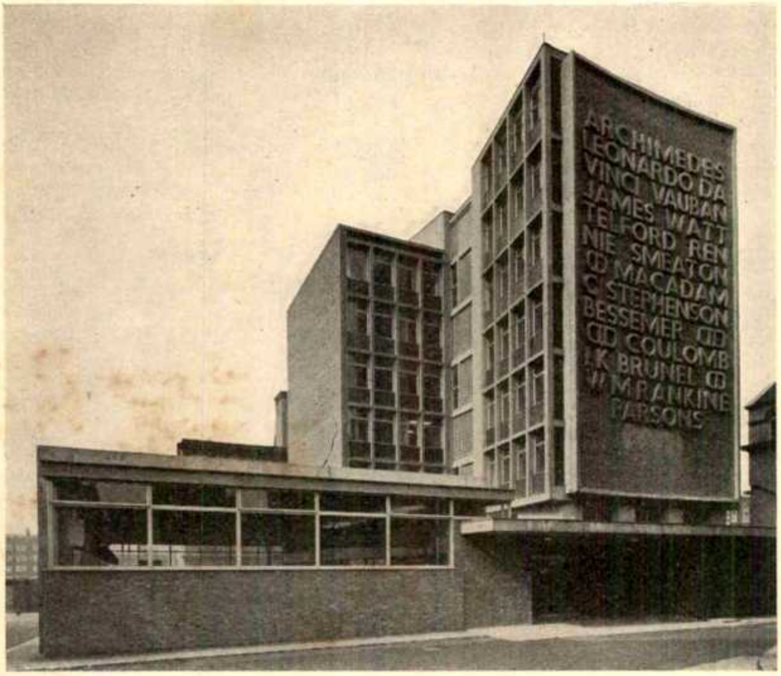


Fig. 1. Civil Engineering and Building Science Laboratories at Liverpool

laboratories are well equipped for teaching and research work in their respective spheres. There is also on this floor a general research laboratory, a study room for research students, a small workshop and a number of staff offices. Although the Lighting Laboratory belonging to the Department is located in another building, there is a photometric room on the ground floor of this new building which is used for the calibration of photo-cells and other equipment used in lighting studies.

An exposure site for studying the weathering of building materials in a polluted industrial atmosphere is being established on the roof, together with instruments for the measurement of meteorological parameters—such as wind, rainfall and radiation—and of atmospheric pollutants. These measurements are, of course, essential for the proper evaluation of the results of weathering tests, and it is intended to obtain continuous records by using suitable recording apparatus.

The Concrete Laboratory, previously referred to, is operated jointly by the Departments of Building Science and Civil Engineering, and facilities are available for the study of building structures in the main Structures Laboratory. Funds have been provided for the construction of a low-speed wind tunnel for studying the wind-flow around buildings in relation to structural, heating and ventilation problems. A controlled-environment room is also to be installed for the study of temperature, radiation and air movement patterns in rooms heated or cooled in various ways.

This new Civil Engineering Building represents the first phase in the building programme for the Faculty of Engineering of the University of Liverpool. New buildings are also projected for other departments in the Faculty during the next few years; their construction will permit the University to make its contribution towards meeting the national need for a greatly increased number of graduates in engineering.

OBITUARIES

Dr. Agnes Arber, F.R.S.

Dr. Agnes Arber, one of the world's most erudite and distinguished plant morphologists, died in Cambridge on March 22. Her contributions to botany were not only original observations of the structure and development of the higher plants, with generalizations based on these observations and contributions to the philosophy of biology, but also studies of outstanding interest in the history of the science.

She was born in 1879, the eldest child of H. R. Robertson, an artist, from whom she inherited the ability shown in the many illustrations drawn for her books and papers. She was educated at the North London Collegiate School, at University College, London, and at Newnham College, Cambridge. In London her work was much influenced by F. W. Oliver and A. G. Tansley; at Cambridge she came under the spell of William Bateson. Leaving Newnham, she worked as research assistant to Miss Ethel Sargant in her private laboratory at Reigate, and later became Quain Student in Biology at University College (1903–8) and lecturer in botany during 1908–9.

In 1909 she married Dr. E. A. Newell Arber, demonstrator in palæobotany in the University of Cambridge, author of many papers and books on fossil plants. From him she obtained both encouragement and training in botanical research. They had one daughter; her husband died in 1918. During 1910–27 she carried on her studies in the old Balfour Laboratory, which then belonged to Newnham College, and afterwards continued in a small room, fitted up as a laboratory, in her private house.

Working very assiduously, her observations covered a wide field; but the monocotyledonous plants were her special interest. The results of her studies were published in more than fifty papers and some books of outstanding merit. "Water Plants, a Study of Aquatic Angiosperms" (1920), "Monocotyledons" (1925), "The Gramineae" (1934), all published by the Cambridge University Press, are models of their kind both for the many beautiful line drawings with which they are illustrated, and for their admirable bibliographies. Plant morphology, from its inception by Goethe, has been intimately bound up with philosophy and metaphysics; but in the present century it has become mainly a study of plant phylogeny. From 1929, Mrs. Arber became increasingly interested in philosophy, and in the more general ideas which have arisen from the study of plant form since the time of Aristotle. From her studies of the literature and her wide knowledge of the facts, she produced one of the most important botanical books of the present century, "The Natural Philosophy of Plant Form" (1950). In this work she gave an account of the history of the ideas about plant form which have occupied men's thoughts since classical times, she explained how the modern confusion of thought had arisen between the older typological outlook on plant form and the modern evolutionary mode of thought. So long as the study of form and structure remains as part of the education of a botanist, this book should remain as an indispensable introduction to such a study.

Her last books were devoted mainly to philosophy, "The Mind and the Eye" (1954) examines the relationship between the eye that sees and the mind that weighs and pronounces. It is a book which was badly needed, especially by biologists who had no philosophical training, and it probably reveals the stages in the author's own mental development. "The Manifold and the One" (1957) was a purely philosophical essay, reflecting the depth and maturity of her mind and the outcome of quiet contemplation.

By many, Dr. Arber will be remembered for her first book, "Herbals, their Origin and Evolution" (1912; second edition 1938), a charming and fascinating book, abundantly illustrated, about the early history of study of plants and the men who worked at it.

When still young she became well known for the excellence of her work, and was elected a Fellow of the Linnean Society of London in 1908, two years after the time when women were first admitted to that Society. She held at different times a Research Fellowship at Newnham College, a Fellowship and a Studentship at University College, London, and a

Leverhulme Research Fellowship. In 1946 she was elected to the Royal Society, and in 1948 received the Linnean Gold Medal from the Linnean Society. Abroad the recognition of her work was shown by her appointment as Corresponding Member of the Botanical Society of America.

H. HAMSHAW THOMAS

Dr. Donald J. Hughes

IT was with sadness and consternation that his many friends learned that Don Hughes had died on April 12 through heart failure at the age of forty-five years.

Hughes's research activity began with cosmic-ray studies in the University of Chicago under Prof. A. H. Compton, followed by an expedition to the Andes, where the change of the slow-meson component with altitude was studied. When war broke out, Hughes joined first the National Ordnance Laboratory and later the Metallurgical Project, assisting in the provision of data relevant to the atomic bomb.

After the War, Hughes joined the Argonne National Laboratory as director of the Nuclear Physics Division, and in 1949 accepted a position as senior physicist at the Brookhaven National Laboratory, which he held until his death. At these Government Laboratories he carried out the research in low-energy neutron physics which made him internationally famous. Hughes's activities in this field fell into three sections: neutron optics, neutron interaction with crystal lattices and liquids, and nuclear physics.

The work with neutron beams from the local reactors yielded three important results. A study of the total reflexion of a neutron beam by a magnetized cobalt mirror gave two critical angles demonstrating the spin $\frac{1}{2}$ of the neutron. Measurements of the angular dependence of intensity agreed with the idea that 'Ampère currents' are responsible for the effective magnetic field of ferromagnets and not dipole–dipole interactions. Next, a compensation method applied to reflexion measurements by various liquid hydrocarbons allowed Hughes to obtain the coherent cross-section of the proton with great precision. This quantity in conjunction with other data is needed to support our belief that the nuclear interaction of the proton–proton and neutron–proton are the same. A slight modification of the same method yielded the basic neutron–electron interaction with better accuracy than obtained previously.

In the solid state field, Hughes was able, by a time-of-flight method, to obtain from scattering experiments with 'cold' neutrons the energy transfer from the lattice to the neutrons. This information permitted a determination in the case of vanadium with the help of formulæ due to Van Hove, of the frequency spectrum of the lattice. His last paper concerned the energy interchange of neutrons with water, showing the existence of discrete levels due to hindered rotation of the water molecule in the field of its neighbours, an interpretation which was supported by Raman spectrum observations. Both examples mentioned open up wide new fields of studies of the condensed state.

Hughes's activities in nuclear physics were manifold. Cross-sections were measured with a chopper or crystal spectrometer, methods invented for the rapid evaluation of resonance parameters, neutron-strength functions and nuclear radii determined and the results compared with the predictions made by theoreticians. Some of the work, such as with fissile nuclei, was required for reactor calculations, some was due to scientific questions which had to be settled.

In all his experiments, Hughes showed a gift for obtaining, with comparatively simple means, novel and reliable results. He had the insight to know what was important and to absorb and exploit theories in spite of their present complexities and the abstract nature of the quantum mechanical formalism.

Besides experimental work, Hughes initiated the collection, evaluation and presentation of a large body of low-energy neutron data, known as the weighty report *BNL*-325, which has contributed a great deal of stimulation to nuclear programmes and is indispensable to all. His clear thinking, ease of expression, and his very great didactic skill in lucidly presenting a complex problem made his papers, and particularly his books, of the greatest value to the expert and the young physicist. I am certain their influence in university teaching, though indirect, was considerable. These same personal properties made him one of the best lecturers among the nuclear physicists, and many 'keynote' addresses were demanded of him at scientific conferences. In view of his popularity as a speaker he acted as lecturer to the U.S. Information Service in many countries in Europe. During 1953–54 he was Fulbright professor at the Clarendon Laboratory, Oxford.

It is unfortunate that death has taken from us this boyish-looking scientist at the very peak of his activity. We shall all miss his optimism and excellence in reporting physics at our meetings and his stimulating intensity on our visits to Brookhaven.

E. BRETSCHER

Dr. C. J. Still

CHARLES JAMES STILL, who died on April 6, was a well-known and well-liked figure in teaching, scientific and industrial circles in Northern Ireland. After being one of the first members of the staff of the Chemistry Department of the Municipal Technical Institute, Belfast (now the College of Technology), he played a considerable part in the development of the Department, and when he retired from his lectureship in 1944 he left behind a large and flourishing group, closely associated with the relevant industries.

Educated in Belfast, Still was first apprenticed to a pharmacist in Bath; he returned to Belfast, however, in 1902, to be first laboratory assistant, demonstrator and then lecturer in chemistry (1913). During this time he had taken a London B.Sc. with honours. Between 1917 and 1920 he worked as a research chemist with the British Dyestuffs Corporation, Manchester, and was then appointed lecturer in bleaching and dyeing in the Applied Chemistry Department of Belfast College of Technology. In research work, in conjunction with the late Prof. H. Wren, he gained a Ph.D. for studies in stereochemistry and, while his interests were mainly in the field of textile chemistry, he also became a member of the Pharmaceutical Society of Northern

Ireland (1927). He was a consultant to many textile firms and external examiner for various bodies in textile and pharmaceutical chemistry.

As the work at the College became more specialized and as the Queen's University of Belfast developed, it became a natural consequence for certain College departments to constitute a Faculty of Applied Science and Technology of the University. Indeed, to the present day, the Applied Chemistry section of the Faculty is also the Chemistry Department of the College. As one of the founder members of the Faculty, Dr. Still played a part in guiding its early development. In this, as in all other fields of his activities, Dr. Still was well liked for his quiet wisdom, and his associates and former students still remark on his gentlemanly bearing and consideration for others. He is survived by his second wife, a son and a daughter.

D. Hamer

NEWS and VIEWS

Chemical Engineering at Birmingham : Prof. F. H. Garner, O.B.E.

Prof. F. H. Garner, who is retiring from the chair of chemical engineering in the University of Birmingham at the end of the present session, has had a distinguished industrial and academic career. After graduating at Birmingham he was awarded an 1851 Exhibition Research Scholarship at the Mellon Institute of Research, Pittsburgh, where he became a research Fellow. On returning to Great Britain in 1921 he became chief chemist at the Agwi Petroleum Refinery at Fawley and later director of research of the Esso European Laboratories. He was appointed to the chair of chemical engineering at Birmingham in 1942 (*Nature*, 150, 545; 1942). Under his leadership the Department of Chemical Engineering has earned a high reputation as a centre of training for chemical engineers. During the past seventeen years the number of undergraduates has increased from 22 to 350, the teaching laboratories have been extended and the facilities for research greatly improved. There are now about sixty postgraduate students engaged in original investigations, mainly on problems of a fundamental character. Prof. Garner's contributions to chemical engineering theory and practice are varied and important. Initially his interests were mainly directed towards problems connected with the petroleum industry, and included some of the earliest systematic studies on 'knock' rating, and on the unit operations of distillation and solvent extraction in petroleum refining. Lately his work has been concerned with mass transfer processes operative in two-phase systems ; in particular he has carried out a detailed analysis of the effects of hydrodynamic conditions on internal circulation and vortex formation in moving drops. Prof. Garner has taken a great interest in the methods of training of applied scientists for industry and has consistently advocated the value of advanced courses of a specialized character in enabling students to make use of the latest scientific and technological innovations. He was awarded the Redwood Medal of the Institute of Petroleum in 1951 and the Melchett Medal of the Institute of Fuel in the same year.

Prof. J. T. Davies

Dr. J. T. Davies, who will succeed Prof. Garner at Birmingham, is best known as a distinguished surface chemist. Although born in Swansea, he took his B.Sc. and M.Sc. in chemistry at Canterbury College, New Zealand. In 1946 he left for England and worked with Sir Eric Rideal at the Royal Institution, taking his Ph.D. in 1949. During 1948–49 he was Bristol-Meyers Fellow and a research associate at Stanford University, California, where he worked with Prof. J. W. McBain. During 1949–52 he was Beit Memorial Fellow for medical research (for physico-chemical investigations of surface effects of biological interest) at the Royal Institution and at King's College, London, with five months at the Institut Pasteur in Paris. He was a lecturer in chemistry at King's College during 1952–55, and since then has been a lecturer in the Department of Chemical Engineering, Cambridge. Dr. Davies's scientific interests have been mainly in the field of surface monolayers, in which he is acknowledged as an authority. Since going to Cambridge he has begun to consider the applications of surface chemistry to chemical engineering problems, where its importance is becoming increasingly evident. His appointment to the Department at Birmingham will ensure the continuation of a vigorous research tradition, and will bring to the teaching of chemical engineering there a first-class mind with a rigorous scientific outlook.

The Kanematsu Memorial Institute of Pathology, Sydney Hospital

The Kanematsu Memorial Institute was founded in 1933 by the shareholders of the firm of F. Kanematsu (Australia), Ltd., and was built as a memorial to Fusajiro Kanematsu and his wife. It replaced the old Pathology Department of Sydney Hospital, and a Research Department was established ; Dr. W. K. Inglis was the first director. In 1936, Dr. Inglis resigned to accept the chair of pathology in the University of Sydney and was succeeded as director by Dr. J. C. (now Sir John) Eccles. Between 1937 and 1944 Dr. Eccles developed a Neurophysiology Research Department in which much fundamental work was undertaken. Dr. F. C. Courtice (now professor of experimental pathology in the Australian National University) succeeded Dr. Eccles, who had resigned to become professor of physiology in the University of Otago, New Zealand. Dr. Courtice formed a unit for the investigation of lymph-flow, lipid metabolism, and the passage of lipids through membranes.

Dr. H. M. Whyte

The Kanematsu Institute has now been divided into the Department of Medical Research and the Department of Clinical Pathology. Dr. H. M. Whyte has been appointed director of the Department of Medical Research and will investigate both fundamental and clinical problems of vascular and renal diseases. Dr. Whyte is a graduate in science and medicine of the University of Queensland. He was awarded a Rhodes Scholarship in 1947 and later a grant from the Nuffield Foundation. He obtained a D.Phil. at Oxford in 1951 while an assistant to the Nuffield Professor of Clinical Medicine at the Radcliffe Infirmary. He is a member of the Royal College of Physicians and of the Royal Australasian College of Physicians, and was formerly director of the Clinical Research Department of the Kanematsu Institute.

Dr. A. A. Palmer

THE Department of Clinical Pathology provides the laboratory services in morbid anatomy, biochemistry, hæmatology and bacteriology for Sydney Hospital. It will be directed by Dr. A. A. Palmer, who has been acting director of the Institute since the resignation of Dr. Courtice in 1958. Dr. Palmer graduated in medicine from the University of Sydney in 1941, and after war service trained as a pathologist at the Royal Prince Alfred Hospital, Sydney Hospital, and University College Hospital Medical School, London. He was appointed senior pathologist to the Institute in 1949. The staff of the Department of Clinical Pathology will be encouraged to undertake surveys and investigations in addition to routine duties.

Science and Mathematics Teaching

WHEN Colonel Alexander Strange suggested in *The Times* of February 6, 1874 (see *Nature*, February 12, vol. 9, p. 277), that a Ministry for Science be established, he was expressing concern, echoed by many of his contemporaries, that the teaching of science in Britain was neither as adequate nor extensive as it should be in the schools of his day. Now, eighty-six years later, the first Minister for Science, Lord Hailsham, has given a public address at a seminar on "Policy for School Science", organized by the Office for European Economic Co-operation; nor, in view of the delay in establishing this post is it surprising that he should be saying the same thing. A lot of heavy water has flowed through a lot of reactors even since the Office for European Economic Co-operation was set up, yet the attempts made to satisfy the voracious hunger of the community for scientists seem similarly inadequate. Now Lord Hailsham is anxious to strike "an ideal balance between specialization and general education". To English ears at least, some hope of the balance being struck depends on the provision of science teachers of calibre. Lord Hailsham agrees that this is the "heart of the matter". "It is almost certain", he continues, "that any serious attempt to clothe with reality the picture of an ideal range of scientific education, suitably balanced and fortified by an adequate background of mathematics, would reveal in every country a serious shortage of science teachers without whom the project, in its ideal form, can be never better than a pipe dream". All sections of industry, the universities and schools will wish him well in the future as he grapples with this shortage.

Atomic Physics in Norway

THE first report (in Danish and English) covering the nine months period, October 1, 1957–June 30, 1958, of the activities of the Nordisk Institut for Teoretisk Atomfysik in Copenhagen has recently been issued (Årsberetning 1957/58 (Annual Report). Pp. 29. København: Nordisk Institut for Teoretisk Atomfysik, 1959). The Institute forms part of the Nordisk Organisation for Teoretisk Atomfysik and is intended in particular to be a gathering place for Nordic physicists, where they may carry out research during long or short visits, and where they may meet and collaborate with colleagues from other countries interested in theoretical atomic physics. Provision is also made for the advanced training of young physicists from the Nordic countries who are admitted on fellowships to work at the Institute. Of the five participating countries (Denmark, Finland, Iceland, Norway and Sweden), Denmark has promised to make available premises for the Institute and to defray the expenses connected with their maintenance. During the period under review, the temporary board of the Institute met three times and elected Prof. Niels Bohr as chairman and Prof. T. Gustafson as vice-chairman. The board dealt with the appointment of staff and the selection of research Fellows, and discussed and approved a draft convention. Prof. C. Møller acted as director of the Institute during the interim period, and on June 30, 1958, the staff consisted of four scientific and two administrative staff. There were ten research Fellows. A detailed list of the lectures and colloquia given by members of the Institute and by invited scientists, together with the titles of papers published, complete the report.

The Ciba Foundation

THE report for 1959 of the Ciba Foundation for the Promotion of International Co-operation in Medical and Chemical Research, to which are appended details of the colloquia and symposia held during the year, records as the principal event the tenth Anniversary Symposium on "Significant Trends in Medical Research" (Pp. 52. London: The Ciba Foundation, 1960). It also contains particulars of the four study groups, on the nervous mechanisms of pain and itch, the steric course of microbiological reactions, diagnosis of early cancer of the cervix and virus virulence and pathogenicity, and of the research forum on the shortening of life-span of mammals following irradiation, as well as lists of publications and of periodicals taken by the Foundation's library. Three of the Foundation's conferences were held abroad—in Naples, in Paris and in Buenos Aires—and three new overseas members joined the Foundation's Scientific Advisory Panel: Prof. T. P. Feng, Prof. L. F. Leloir and Dr. M. Roche. The five-year period of special encouragement of research into the fundamental aspects of ageing ended during the year. Two demonstrations were arranged of a new Swiss large-screen colour television system called 'Eidophor' (see *Nature*, June 4, page 773). Four Anglo-French bursaries were awarded by the British Selection Committee and five by the French Selection Committee. The eleventh annual lecture was given on June 26 by Prof. Pasteur Vallèry-Radot on "The Role of Intuition in Medical Research".

The American Philosophical Society

THE Yearbook for 1959 of the American Philosophical Society, of which more than half is occupied by reports from recipients of grants, includes the reports of standing committees (with a list of publications) as well as the list of members and reports on finance (Pp. 779. Philadelphia: American Philosophical Society, 1960). From the Penrose Fund, 175,000 dollars was assigned for research and the 188 grants made are listed together with the 60 grants made with 52,000 dollars from the Johnson Fund, and the 6 fellowships for research in clinical medicine for which 27,000 dollars was appropriated from the Daland Fund. A brief history of the Society adds to the reference value of the Yearbook.

Solid State Electronics

The discovery of transistor action was followed by an explosive growth in the world output of publications devoted to the physics, the fabrication technology, and the applications of the transistor and of related semiconductor devices. There have been parallel though less-spectacular developments in the applications of other solid-state phenomena such as ferrimagnetism, ferroelectricity and electroluminescence, but theoretical and practical progress in the latter fields has undoubtedly been hampered by the difficulties of adequately controlling the materials involved. A new channel for the publication of papers on the applied physics and technologies in all these and related fields has been created by the appearance in March 1960 of the first number of the new bi-monthly international journal, *Solid State Electronics* (Pergamon Press, London, New York, Oxford, Paris). The chief editor is Dr. W. C. Dunlap (United States), who is assisted by Dr. L. Pincherle (United Kingdom), Prof. H. Welker (Germany) and Dr. G. M. Hatoyama (Japan). All the ten papers in the first issue deal with semiconductors, the treatment in most of them being such as will appeal to the device designer and device fabrication specialist, as well as, in some cases, to the user. As stated in the foreword, the new journal is intended to be complementary in treatment and scope to "Physics and Chemistry of Solids", which deals with the more fundamental and theoretical aspects of the fields covered.

Statistics of Petroleum Consumption and Refinery Production in Britain: 1958–59

One hears repeatedly of the plight of British collieries with the limitation of coal consumption, a remarkable situation in the light of the picture that was presented of the coal situation ten years ago. The explanation is forthcoming in a recent informative publication by the Petroleum Information Bureau, which reveals the consumption statistics covering all petroleum products, whether imported or from indigenous sources, as well as substitutes such as benzole and hydrogenated spirit (Petroleum Information Bureau. U.K. Petroleum Industry Statistics relating to Consumption and Refinery Production 1958 and 1959. Pp. 10. London: Petroleum Information Bureau, 1960). The data for the years 1958 and 1959 enable the nature of the increasing use of these products to be recognized. In 1959 the oil consumption in Great Britain rose by 17·5 per cent as compared with the previous year, to reach a total of 36½ million tons. Among the major products, fuel-oil consumption (including that for public electricity generation) again showed the greatest increase, being almost a third greater than that for the previous year and reaching 13,811,874 tons. There was also an increase in the use of motor spirit, which exceeded the figures for 1958 by 7·5 per cent. Deliveries of propane and butane increased by 40·5 per cent, and bitumen used for road-building reached a record annual consumption of nearly a million tons. The remarkable growth in demand for oil in Great Britain during the past twenty years is evident from the following milestones: 1938, 8,990,686 tons; 1948, 12,766,025 tons; 1953, 19,000,000 tons; 1959, 36,500,000 tons (all products). The development must undoubtedly continue and provide a really serious challenge to the more active technological development of the use of coal.

Electronic Computers in Population Genetics

Two recent papers add to our understanding of the frequency and distribution of self-compatible homostyled primroses. When homostyly appears in a population it might be expected to increase to a high frequency at the expense of pins and thrums because of the advantage conferred by self-compatibility. Counts made between 1941 and 1954 by Sir Ronald Fisher of the actual frequencies of the three types in populations near Sparkford, Somerset, have been analysed by W. F. Bodmer (*Phil. Trans. Roy. Soc.*, B, 242, 517; 1960). Populations with only moderate homostyle frequencies showed no significant increase during this time, and others with an initially high frequency showed a decrease. Bodmer demonstrates by mathematical models that these situations can be explained by the high degree of cross-fertilization now known to occur between homostyles, coupled with a possible reduction in viability of the homostyles. Populations thus appear to be protected against the retrograde change from an outbreeding to an inbreeding regime. J. L. Crosby (*Phil. Trans. Roy. Soc.*, B, 242, 551; 1960) has studied the irregular distribution of homostyle frequencies among neighbouring populations. The expected pattern with a centre of high frequency corresponding to the point of origin of homostyly, and decreasing frequencies with increasing distance, does not agree with field observations. The irregularities are attributed to random fluctuation (the Sewall Wright effect), and artificial models which take this into account produce distributions similar to those observed. Both authors have used electronic computers to predict the evolutionary changes likely to occur in a population under given conditions. The ability to simulate a large number of generations in a short time is of great value, and there is little doubt that computers will become of increasing importance in population genetics.

Structural Loading in Factories

Four years ago the Building Research Station of the Department of Scientific and Industrial Research started a series of investigations into the special needs of factory building. This work was undertaken in conjunction with the Midland Regional Board for Industry. Already three reports dealing with separate aspects of this problem have been published, and the latest report, "Structural Loading in Factories", is published for the Department of Scientific and Industrial Research by H.M. Stationery Office, price 1*s*. 9*d*. The floors and roofs of modern factories are expected to accommodate an ever-greater variety of equipment. Much of the production plant, service equipment, transport and goods may be carried by the floor, but a great deal of it is now suspended from above. The resulting loading conditions are not fully covered by existing codes of practice, but failure to make reasonable allowance for them will restrict the adaptability of a building to permit improvement of method or change of product. The information in the report supplements the codes by giving more details of various kinds of load for which provision may have to be made, with some indication of typical ranges of sizes, weight and performance of the equipment concerned. The equipment considered includes that for heating and ventilation, lighting units and power distribution, piping, handling plant, machinery and tools. The information will assist factory managements in assessing their needs as well as designers. The loads to be carried can affect the selection of a site and influence the design of a factory. Where very heavy loadings are necessary, they may be a deciding factor in the choice between single- and multi-storey construction.

New Instruments for Electronic Engineers

The latest edition of the Pye Scientific Instrument Catalogue "N" describes several important new developments and supersedes previous editions. The new developments include a stabilized d.c. power-supply unit with output voltages within the range 0–500 V. (250 m.amp. max. load); a d.c. amplifier (contact modulator); 'Scalamp' double-reflexion galvanometers; new ranges of measuring microscopes and cathetometers; an argon chromatograph with new accessories; and industrial flow-type assemblies and density measuring equipment. The illustrated catalogue is divided into nine sections and covers thirty-two pages. Individual descriptive leaflets of most of the instruments are available on request. The catalogue is obtainable from W. G. Pye, Ltd., Cambridge; prices are not quoted.

Ageing and Research

An account of its investigations into the problems of ageing has been published by the U.S. Department of Health, Education and Welfare ("Research Programmes in Ageing". Superintendent of Documents. U.S. Government Printing Office, Washington, D.C. 15 cents). The growing interest in gerontology is reflected in the announcement that, in addition to the continuing research programme carried out by Government scientists, grants by the Government to medical schools and other private institutions for research in ageing have increased 62 per cent in expenditure over 1959. The investigations conducted or supported by Government departments covered many aspects of ageing in three broad areas: (1) the biological process of ageing; (2) the chronic diseases commonly associated with the aged; and (3) additional health problems of the aged, such as the mental health difficulties growing out of changing cultural demands.

Food-borne Infections

Centralization of food production and distribution and consumption on a mass scale involve an increased risk of spreading food-borne disease. It is essential that measures for the control and prevention of such diseases should be strengthened, not merely in each individual country but also at the international level, since foods are being exported and imported on an ever-mounting scale, and tourist travel is continually increasing. If such measures are to be effective, they must be based in the first place on proper notification of cases of food-borne disease in each country, and on the collation at international level of the reports published by the public health administrations. In addition, thorough epidemiological surveys are required. In a report issued by the World Health Organization of a European Technical Conference on Food-Borne Infections and Intoxications, the various control measures designed to promote the production of pure and safe food are reviewed (Technical Report Series, No. 184. Geneva, 16–21 February, 1959—Report. Pp. 18. Geneva: World Health Organization; London: H.M. Stationery Office, 1959. 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars). The conference also drew up a series of recommendations on what the physician should do when faced with a case of food-borne disease, on what action should be taken by public health services and laboratories, and on national and international measures for the control and prevention of such diseases.

Strontium-90 Content of British Diet

One of the main objects of the investigations being carried out by the Agricultural Research Council on the radioactive contamination of human food and agricultural land is to provide information on the trend of the level of strontium-90 in the British diet. Some of the foods involved in the survey are produced only at a single time in the year, and consequently the assessment of changes in the average dietary intake is most satisfactorily made on an annual basis. However, the contribution from dairy produce represents some 65 per cent of the total dietary intake of strontium-90, and it is useful to have interim reports on activity-levels in milk, particularly during periods when the rate of fall-out has shown some increase. Report No. 2 from the Council's Radiobiological Laboratory ("Strontium-90 in Milk and Agricultural Materials in the United Kingdom 1958–1959". Pp. 91, 17 tables, 15 figures. H.M.S.O., London, 1960. 5*s*.) gives an account of the changes which occurred in the strontium-90 levels in milk samples, representative of a substantial fraction of United Kingdom milk production, during the period January–June 1959. The report indicates a general rise in levels by about 50 per cent during this period, but notes that "such information as is available for samples collected after June 1959 shows that the values have since decreased". The report also includes the results of surveys on strontium-90 in permanent pastures and animal bones, together with summaries of the results of experimental studies which assist in the interpretation of the dietary trend.

Russian Machine Translation Dictionary

The difference between the Russian machine translation dictionary and an ordinary dictionary is discussed in an article by H. S. H. Massey in *Research* (13, No. 4; April 1960). The principles on which a dictionary for machine translation are based appear to be a combination of the syntactical and semantic analysis approach of the Massachusetts Institute of Technology and the polysemia approach of the Rand Development Corporation. The Russian machine translation dictionary differs from an ordinary one in several ways. First, it is divided into separate units corresponding to the languages to be treated. Each word in the source-language dictionary is given the number of its equivalent in the target-language dictionary; for translation in the other direction the words in the target-language-dictionary are allotted indices showing the numbers of their equivalents in the source-language dictionary. Secondly, the dictionary of each language is divided into a section of monosemantic words and a section of polysemantic words, the monosemantic word section being further subdivided into groups of terms belonging to particular spheres of science and a group of widely used monosemantic words. The third peculiarity of the dictionary is that it contains not only a list of lexical units (words) but also a definite set of grammatical characteristics for each word, which is not fully formalized in ordinary dictionaries. This kind of dictionary also provides a system of relative word values, relating the lexical system of the target-language to that of the source-language. This is closely related to the fact that the dictionary provides 'zero values' for words, that is to say, those cases when a word should not be translated as a separate lexical unit.

Mineralogy in the U.S.S.R.

In an article published in the *Bull. All-Union Miner. Soc.* (88, 609; 1959), V. F. Alyavdin, after giving a review of the present-day reference books on crystallography and mineralogy, such as those of Dana, Hintze, Doelter, Goldschmidt and Groth, as well as all the important periodical publications, suggests the necessity of publishing a special series of reference books, but in this case, dealing only with minerals and crystals found in the U.S.S.R. This, proposed, series is as follows: (1) Mineralogy of the U.S.S.R. (in 12–15 volumes); (2) Atlas of crystals of minerals in the U.S.S.R. (in 3–4 volumes); (3) Chemical composition of minerals of the U.S.S.R. (in 2–3 volumes); (4) Optical mineralogy with determinative tables according to the immersion method and according to Fedorov's method; (5) Crystal-goniometric determinative tables, representing the continuation of the Boldyrev's tables for minerals of lower syngonies. At the end of his article V. F. Alyavdin provides a list of Russian publications dealing with regional mineralogy, since the publication of N. Y. Koksharov's "Materials for the mineralogy of Russia (1853–1891)". This list includes numerous publications on the minerals of the Kola Peninsula, Crimea, Urals, Altai and other regions.

Bio-electric Potentials of Plants

In earlier papers, D. S. Fensom (*Canad. J. Bot.*, 35, 573; 1957; 36, 367; 1958) discussed the possible relationships between the bio-electric potentials in plants and translocation systems, and demonstrated that correlations exist between transport patterns and biopotential patterns. While the evidence did not prove conclusively that transport is due to internally generated electricity, it suggested that the two are closely linked, and that both are related to metabolism. Other investigators have advanced somewhat similar views. In a further paper, Fensom (*Canad. J. Bot.*, 37, 1003; 1959) has considered the phenomenon of the production of continuous potentials across membranes in plant tissues by the circulation of the hydrogen ion. Of the three types of membranes which occur generally in plant cells, lipoid, protein and cellulose, it would seem that a protein-coated grid of cellulose can be envisaged as surrounding the cells. Such a membrane would appear to have the right pore size and properties to allow almost unfettered hydrogen ion diffusion but yet permit intercell biopotentials to be built up. It is pointed out that the most important ion involved in diffusion and in subsequent ion exchange would seem to be the hydrogen (as hydronium) ion, and that tissue can conveniently be divided into general areas of hydrogen ion production or hydrogen ion absorption. The resulting circulation of this ion is explored and discussed in relation to photosynthesis, respiration, protoplasmic streaming, and transport. These ideas are shown to give reasonable explanations for the results obtained in experiments and to resolve certain difficulties related to biopotential studies. They are considered to be useful since they predict some important results which can be experimentally tested, some of which are here given.

Griseofulvin

In his presidential address to the British Mycological Society (*Trans. Brit. Mycol. Soc.*, 43, 1; 1960), Dr. P. W. Brian presented a history of the research into griseofulvin. One is led behind the scenes and given an example of how initial interest and careful choice of materials can play an important part in subsequent developments. The reference list shows that workers in a variety of fields have found it a profitable subject for research. Academic aspects that have attracted attention are its chemistry, leading to synthesis of homologues, its mode of action, reflecting upon the normal constitution and development of fungal cell walls, and its translocation in angiosperms, bearing upon the relationship between molecular structure and ease of transport. The applied aspects recorded centre on its use as a systemic fungicide in the treatment of fungus diseases of plants and animals. Its importance in the growth of the concept of systemic fungicides is well known, and its use in animals, particularly against diseases like ringworm of cattle which are resistant to topically applied fungicides, promises to revolutionize treatment of animal mycoses.

Priapulus caudatus Lamarck

The discovery of *P. caudatus*, which was found for the first time in the Flatford area on March 1, 1958, is announced (*Trans. Suffolk Nat. Soc.*, 11, Part 2; 1959). A single specimen was taken from soft mud just below mean sea-level on the shore of the Stour estuary at Stutton Ness. Afterwards, it was proved to be widespread on both Suffolk and Essex shores of the estuary and occurs intertidally in small numbers wherever there is a suitable substrate of soft mud. No individuals have been taken from the region of lowered salinities above Brantham. In addition to the animals from the Stour, *P. caudatus* has been found in the mud of the large lagoon at Shingle Street in Suffolk and from a similar habitat by the Wade at Hamford Water, Essex. The "Victoria History of Suffolk" (1911) notes that this animal is common in the mud of the Deben at Waldringfield. *Priapulus* is an unusual unsegmented worm. The genus appears to have only slight affinities with other groups of invertebrates and is usually placed in a phylum of its own—*phylum* Priapulida.

CIBA Foundation

The seventy-fifth anniversary issue of the *Journal of the CIBA Foundation*, the publication of the chemical firm in Basle, gives an account of the development of the concern, and also brief historical sketches of the branches of science which are concerned in its processes. The *Journal* is richly illustrated, largely in colour, and although some of the text is in the style of popular journalism, it is on the whole instructive and attractive. The part taken by Basle in the development of science, learning and industry is explained, but the field covered is generally wider, the development of science and industry from early times in many lands being dealt with. The style is in general non-technical. The main interest of the publication is the wealth of illustrative material.

National Research Council of Canada Scholarships

THE National Research Council of Canada has granted 486 scholarships for 1960–61, with a total value of 1,040,000 dollars; of these 423 are for graduate work at Canadian universities. These include 140 bursaries worth 1,800 dollars each, and 283 studentships worth 2,200 dollars each. Awards for study in other countries include 34 special scholarships worth 2,200 dollars each. 27 of these are to be held in the United Kingdom, and 7 in the United States. 29 postdoctorate overseas fellowships, valued at 3,500 dollars for married and 2,700 dollars for single Fellows, have been granted for work in the following countries: 21 in the United Kingdon; 2 in Australia; 2 in France and 2 in Germany; 1 in Belgium and 1 in the Netherlands.

Manchester Literary and Philosophical Society

THE Manchester Literary and Philosophical Society announces the election of officers and committee as follows: *president*, Prof. H. Lipson; *vice-presidents*, Miss A. C. Alexander, Sir Geoffrey Jefferson, Mr. F. G. Glossop, Prof. R. D. Waller; *honorary secretaries*, Dr. G. T. Ashley, Dr. L. Cohen; *honorary treasurer*, Mr. H. Hayhurst; *honorary librarians*, Mr. L. L. Ardern, Dr. W. H. Brindley; *honorary curator*, Dr. J. A. Petch; *council*, Mr. L. Cohen, Mr. A. H. Coulty, Mr. S. M. Milner, Mr. N. G. C. Pearson, Miss M. Pilkington, Mr. M. P. Pariser, Mr. B. Rodgers, Mr. F. C. Toy, Mr. C. E. Young.

The Institution of Metallurgists

MR. W. E. BARDGETT, research manager of the United Steel Companies, Ltd., was elected president of the Institution of Metallurgists in succession to Prof. A. J. Murphy. The following appointments to officers and council are also announced: *president-elect*, Dr. N. P. Allen (National Physical Laboratory); *vice-presidents*, E. A. Bolton (I.C.I., Metals Division), and E. G. West (Aluminium Development Association); *honorary treasurer*, L. W. Derry (Battersea College of Technology); *members of council*, I. Jenkins (General Electric Co., Ltd., Wembley, Middlesex), Dr. A. H. Sully (British Steel Castings Research Association, Sheffield), Prof. C. R. Tottle (University of Manchester) and E. Mitchell (Lucas Group Research Centre, Birmingham).

The Institute of Mining and Metallurgy: Awards

THE following awards of the Institute of Mining and Metallurgy are announced: *Gold Medals*, to Mr. E. D. McDermott, in recognition of his services to the mining industry and profession, and of his services to the Institution as its representative on the Governing Body of the Imperial College of Science and Technology for fifteen years; and to Mr. J. Kruttschnitt, in recognition of his services to the mining industry in Australia; *Honorary Membership*, to the Right Hon. Lord Robins, in recognition of his services to the mineral industry, particularly in southern Africa; to Sir Patrick Linstead, in recognition of his services to the profession of mining and metallurgical engineering in the field of education; and to George Augustus Whitworth, in recognition of his services to the mining industry and profession on the occasion of his retirement from the principalship of the Camborne School of Metalliferous Mining.

Announcements

DR. GERALD B. COOK has been appointed chief chemist of the International Atomic Energy Agency. Dr. Cook, a graduate of the University of Birmingham, has worked at the Cavendish Laboratory, the Canadian atomic energy project in Montreal and at Chalk River, and at the Atomic Energy Research Establishment at Harwell, first in the Chemistry Division and from 1954 as head of the Chemistry Group of the Isotope Research Division.

THE Challenger Society is prepared to make small grants for research in marine biology or oceanography at a recognized laboratory during the year June 1960/61. Applications, accompanied by details of the proposed research, should reach the Hon. Secretary, Challenger Society, National Institute of Oceanography, Wormley, Godalming, Surrey, not later than June 30.

"THE Register of Current Scientific Research at South African Universities, 1959" is based on replies to questionnaires, and the 587 entries are printed as received, English translations being provided for Afrikaan entries (edited by D. Ryle Masson. Pp. vii+113. Pretoria: South African Council for Scientific and Industrial Research, 1960). The material is arranged under nine main headings, with sub-divisions, and in the sub-divisions under the university alphabetically. The Register is well printed and most entries are provided with a brief description of the scope of the research. There are author and subject indexes.

A BOOKLET published by the Biochemical Society, copies of which are obtainable from Mr. R. E. Sherriff, 133–5 Oxford Street, London, W.1, explains for the benefit of school-leavers what biochemistry is about, how one can train to become a biochemist and the opportunities and prospects that exist for a biochemist (Careers in Biochemistry. Pp. 8. London: Biochemical Society, 1960. 8*d*.). Some of the information has already appeared in the publications, "Biology as a Career" and "Looking to Chemistry for a Career", of the Institute of Biology and the Royal Institute of Chemistry, respectively, and to these publications prospective biochemists are referred for fuller information.

"CIVILIAN Application Releases through 1959", issued by the Technical Information Division, Sandia Corporation, gives a cumulative bibliography of technical reports, memoranda and manuscripts, including a section on engineering materials (drawings and specifications) released from the Atomic Energy Corporation's Engineering Materials Branch at Oak Ridge (pp. 88. Washington, D.C.: Office of Technical Services, Department of Commerce, 1960. 2.25 dollars). Prices for printed, or photostat, or microfilm copies are listed for many of the entries. There are some 900 entries arranged numerically.

THE INTERNATIONAL ATOMIC ENERGY AGENCY

ASSISTANCE PROGRAMME

IT was decided at a recent session of the Board of Governors to the International Atomic Energy Agency to supply twenty scientists and legal experts, who would assist and advise in various projects being developed, to ten countries. This decision was taken when the Board of Governors was allocating 60 per cent of the Agency's own technical assistance fund for the current year. The countries to receive such support are Afghanistan, Austria, Brazil, Iran, Iraq, Korea, Philippines, Turkey, Venezuela and Yugoslavia. Of these countries, Austria, Iraq, Philippines and Yugoslavia will receive equipment to a total value of 47,200 dollars in connexion with the work to be undertaken. The allocation was made on the basis of requests for assistance under the 1960 programme received by the end of January, the remainder of the funds being left for requests received by the end of May. In addition, the Agency implements an assistance programme under the United Nations Expanded Programme of Technical Assistance.

Afghanistan

Progress in the nuclear development field in Afghanistan has been retarded by a lack of trained personnel and training facilities. Since experience in these fields is very limited in Afghanistan, the Government has requested the International Atomic Energy Agency to provide the services of a nuclear physicist to assist in drawing up a programme; he will also train staff and lecture at the Faculty of Science in the University of Kabul, and assist in establishing a nuclear physics laboratory within the University.

Austria

One biochemist will work at the Austrian Cancer Research Institute in Vienna to advise on the use of radioisotopes in cancer research and on the establishment of a radioisotope laboratory. He will train Austrian scientists in the techniques of determining the distribution of labelled tumour cells in experimental animals. The Agency will also provide some nuclear equipment for this project.

Brazil

One expert in prospecting for nuclear raw materials will visit Brazil to assist the Government's prospecting programme. He will also assist in organizing field training of geologists and prospectors. The Brazilian authorities plan to co-ordinate the country's activities in the field of radioactive minerals and prospecting. The Agency will provide the services of a nuclear geologist to assist in this project, and particularly in planning and organizing a large-scale geological programme.

In connexion with creating a division of nuclear metallurgy at the Institute of Atomic Energy in São Paolo, a nuclear metallurgy expert will be sent to Brazil. He will advise on the organization and working plans of metallurgical laboratories, on the training of specialists and on the co-ordination of work with other institutions in Brazil.

Another expert will work at the Institute of Atomic Energy at São Paolo and assist in training chemists in radiochemistry and isotope separation as applied to the production of radioisotopes. He will also be concerned with the organization and preparation of the research programme of the radiochemical laboratories, and assist in the activities of the Research Institute at Belo Horizonte and other research organizations in Brazil.

The Government of Brazil plans to work out legal rules on third-party liability and insurance for nuclear hazards in connexion with its nuclear power programme, and particularly the Mambucaba nuclear power project. A legal expert will be sent to Brazil to advise the authority for the Mambucaba project on these questions.

Iran

The National Iranian Atomic Energy Commission and the Ministry of Industry are conducting a thorough exploration of Iran's radioactive mineral resources and a survey of the possibilities of mining and producing uranium in the future. Two experts from the International Agency will be attached to this project. One of them will work at the Prospecting Section of the Geological Department of the Ministry of Industry and Mines and advise on organization and methods of radiometric surveys and give further training to the staff. The second expert will work at the Mining Section of the same Department and will assist in installing uranium ore processing equipment and instruct laboratory staff in methods of testing and processing uranium ores as well as in geochemical methods of prospecting for uranium.

Iraq

Two experts, one in the agricultural and one in medical applications of radioisotopes, will visit Iraq, and some equipment will be supplied.

One expert will work on investigations into soil reclamation, fertility surveys and crop improvement; he will also supervise the establishment of an agricultural radioisotope laboratory and direct the research work in the laboratory on soil–plant–water relationships.

The expert in the medical application of radioisotopes will work at the Radioisotope Department of the Republic Hospital in Baghdad and train new Iraqi staff in the medical uses of radioisotopes, in particular in their diagnostic and therapeutic applications.

Korea

The Korean authorities have established an Atomic Energy Research Institute near Seoul, where a swimming-pool reactor, *Triga Mark II*, will be put into operation during 1960. In connexion with the reactor project, the Government of Korea will be assisted by an Agency health physicist, who will advise on all health physics matters relating to the project.

Philippines

A radiochemist will be sent to the Philippines to advise the Atomic Energy Commission on the organization of radioisotope courses and on the radiochemical facilities of the reactor to be built at the projected nuclear research centre near the University of the Philippines.

The International Atomic Energy Agency will also provide some equipment, including counters, ionization chambers, rate-meters and other instruments.

Turkey

An expert in atomic energy planning will go to Turkey at the request of the Government to advise it on working out a detailed long-range atomic energy programme, on the establishment and operation of the necessary facilities and laboratories to implement this programme and on the setting up of new training and research centres.

A research and training reactor is under construction near Istanbul. To elaborate a detailed and effective research and utilization programme for the reactor the Turkish Atomic Energy Committee has established a committee of scientists and requested the International Atomic Energy Agency to provide the services of an expert on reactor utilization to assist in the activities of the Committee. In addition, the expert will advise on setting up and utilizing a sub-critical assembly in the Faculty of Science at the University of Ankara.

Venezuela

A legal expert will be sent to Venezuela to advise the Government on legislative and administrative problems relating to its atomic energy programmes, and assist in planning and drafting the required legislation as well as in training Venezuelan staff on legal matters.

Yugoslavia

An expert in the agricultural applications of isotopes will work at the Yugoslav Institute for the Application of Nuclear Energy in Agriculture, Veterinary Sciences and Forestry in Belgrade. He will assist in equipping the Institute and in the organization and development of a laboratory. To assist the expert in his work and to help in setting up the laboratory the Agency will provide counting and dosimetry equipment.

An expert in the medical uses of atomic energy will be sent to Yugoslavia to initiate clinical research work at the medical radioisotope laboratories in Belgrade, Ljubljana and Zagreb. He will also lecture on the applications of isotopes at a course organized by the Federal Nuclear Energy Commission and advise the Commission on future activities related to the medical applications of radioisotopes.

One biochemist will be attached to the Institute for Biology at Zagreb to help its staff to fight fasciolosis, a cattle disease which is estimated by the Government to cost Yugoslavia 8,000 million dinars annually. He will assist in equipping the radioisotope laboratory of the Institute and train the local staff in the applications of tracers to research. Some nuclear laboratory equipment will also be provided.

THE RESEARCH ASSOCIATION OF BRITISH FLOUR MILLERS

NEW LABORATORIES

CONSIDERABLE extensions to the laboratories of the Cereals Research Station, provided by the Millers Mutual Association, and which include new analytical and research laboratories, animal unit, workshop, committee, lecture and common rooms and canteen, were opened by Lord Rank on May 4. In his speech, he said that there was no need now to remind any industrialist that to be successful he must have the best scientific advice and stimulus at his elbow. While individual milling companies had their own scientific units, the industry looked to the Research Association for leads on major scientific developments; the Research Association was, in fact, the scientific headquarters of the milling industry. After stressing the importance of nutritional research, he went on to say that in Great Britain we had the best and probably the cheapest bread in the world, and in this achievement the Research Association had played a big part. He could say this with authority, because he was president of the Association during 1930–52.

At the luncheon that followed, the president, Mr. L. Hector Read, proposed the health of the guests. Before doing so, he thanked Lord Rank and his colleagues for providing the additions to the laboratories and he also expressed the indebtedness of the Research Association for the great help and encouragement received from the Department of Scientific and Industrial Research during the thirty-seven years since the Association was founded. In welcoming the principal guest, Lord Cohen of Birkenhead, he spoke of him as a leader in his profession, as one who has always been keenly interested in scientific and medical research, and as the outstanding medical statesman of the age. In replying, Lord Cohen pointed out that biology, of which medicine is simply an aspect, had advanced mainly by the application of physics and chemistry to the elucidation of complex biological phenomena. For this reason it was to him of immense significance to see such application being made by the Research Association to the problems of cereals. He noted, too, investigations involving engineering, bacteriology, mycology, entomology, zoology and genetics. With regard to the latter, "Bread and Breed" was indeed a most appropriate title. The æsthetics of bread, its palatability and appearance, and other fields of the arts also entered into the work of the Association, and he wondered whether here in these laboratories would be found the appropriate marriage of the two cultures, science and art, of which Sir Charles Snow spoke recently.

The laboratories were afterwards opened for inspection, and a number of demonstrations were given illustrating the current research programme. These included the structure and chemistry of the

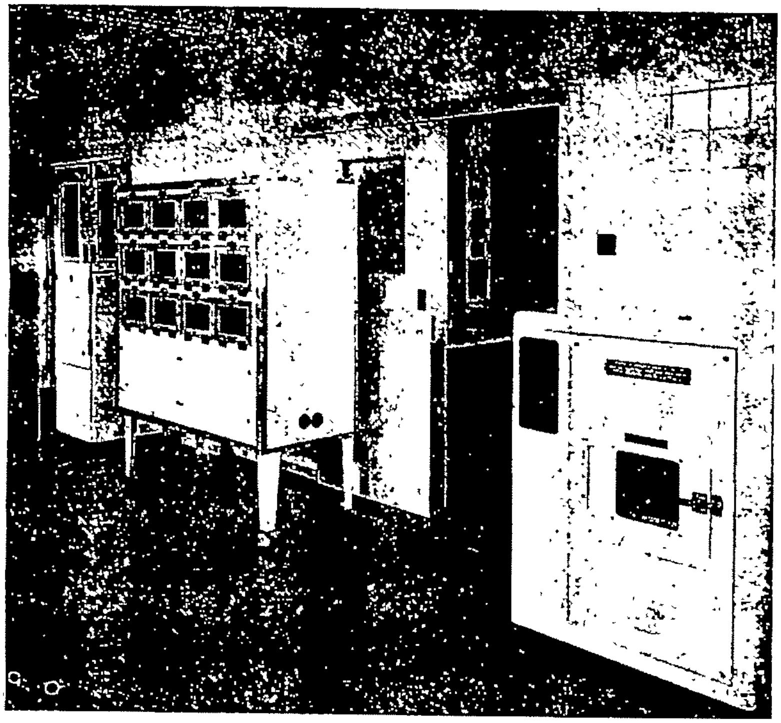


Fig. 1. Corner of Bread Bakery, Cereals Research Station, St. Albans, leading to the Constant Temperature Laboratory

wheat grain, with the distribution of the B vitamins and vitamin E, varietal differences in wheat and how they affect milling and baking properties, the chemistry of the wheat proteins, nutritional studies on wheat and flour as shown by experiments on the rat, experiments on dental caries, the chemistry of cereal lipids, certain aspects of flour milling technology, including the air classification of flour, rheological studies on dough, problems specific to oats and oat products and the avoidance of rodent contamination of cereals on the farm.

To mark the occasion, a book was prepared, entitled "The Research Association of British Flour Millers, 1923–1960", which includes abstracts of the 376 scientific and technical papers published by the Association. The abstracts are grouped in three categories—basic, agricultural and technological. In the introduction, the president writes: "Speaking for my Council, I would like to stress that in our opinion the main function of the Research Association is to carry out basal research. I would add, too, that in our experience the practical results that have followed amply justify this policy. That does not mean that some routine and *ad hoc* work is not necessary. It is, if only to keep the staff in touch and in sympathy with millers' day to day problems. Nor has research on flour milling as such been neglected. I have only to refer to our recent work on the separation from ordinary flour, by air classification, of fractions rich or poor in protein. This may be a major development in the history of flour milling. I believe therefore that the Research Association has for some years struck about the right balance between basal and applied research". T. MORAN

NATURE AND EXPLOITATION OF CROP PLANT RESISTANCE TO DISEASE

A SYMPOSIUM on the nature and exploitation of crop plant resistance to disease, organized jointly by the Association of Applied Biologists (president, Dr. R. V. Harris) and the British Mycological Society (president, Mr. E. C. Large), was held at the London School of Hygiene and Tropical Medicine during January 8–9.

The first day's proceedings were devoted to studies on the host plant, and, in a general introduction, Dr. G. D. H. Bell said how much he appreciated the initiative of the sponsors in arranging this important symposium. The efficient exploitation of disease resistance required the collaboration of both the pathologist and the plant breeder. Obviously the breeder tended to be more concerned with the host than with the pathogen, and although it was accepted as sound breeding policy to handle disease resistance in much the same way as other breeding characters, the genetics of the pathogen had to be considered as well as that of the host. Disease resistance was, of course, expressed in different ways, while various systems of genetic control were known. Major gene resistance in the host had been exploited extensively, but that based on minor genes was undoubtedly safer in many circumstances.

Dr. R. C. F. Macer (Plant Breeding Institute, Cambridge), who considered developments in breeding disease-resistant cereals, suggested that the problems were for the first time being dealt with adequately in Great Britain. The synthesis of wheat lines with genes for resistance to *Puccinia glumarum*, *Erysiphe graminis* and *Cercosporella herpotrichoides* were given as examples of progress being made; in some cases it had been found desirable to use sources of resistance found in allied species and genera. The closed-flowering character of barley was described as an escape mechanism giving protection from all races of *Ustilago nuda*.

Some of the difficulties in breeding for resistance to certain diseases in vegetable crops were outlined by Dr. J. C. Haigh (Wellesbourne), who described the present position in lettuce with regard to mosaic disease, downy mildew (*Bremia lactucae*) and mould (*Botrytis cinerea*). He also referred to the difficulties of using *Lycopersicum pimpinellifolium* and *L. hirsutum* as sources of resistance to *Cladosporium* *fulvum* and *Didymella lycopersici* in breeding outdoor tomatoes.

Dr. R. L. Knight, Miss E. Keep and Mr. J. B. Briggs (East Malling) gave an interesting account of the possible control of a disease by breeding for resistance to its vector. *Amphophora rubi* is the aphid vector of several raspberry viruses, and specific genes have been found in the hosts which give resistance to particular strains of the aphid. The authors considered that there was a good chance of the breeding work being able to keep ahead of the aphid for some time to come.

Dr. D. S. Kirkham and Dr. A. E. Flood (East Malling) discussed apple and pear scab, and they described a resistance mechanism based on biochemical differences. Characteristic phenolic substances were found to be present in the two-host species and quantitative differences in these have been demonstrated between resistant and susceptible varieties. Using the sporulation of the fungi (*Venturia inaequalis* and *V. pirina*) as a measure of biological activity, chlorogenic acid was found to have an inhibitory effect. These fungi have a narrow host specialization, and resistance to them can apparently be conferred by one or more major genes.

Another type of biochemical resistance, but in this case acting outside the plant through root exudates, was described by Dr. E. W. Buxton (Rothamsted) in relation to studies with pea wilt resistance. Pea varieties differ in their susceptibility to individual races of *Fusarium oxysporum* f. *pisi* and resistance appears to be associated with inhibition of growth by the root exudates. The exact nature of the exudate is unknown, but it probably took effect in the rhizosphere, acting either directly upon the parasite, or indirectly by first affecting the associated micro-organisms.

Prof. S. C. Harland, introducing the discussion, said that such joint meetings between scientists of different disciplines were long overdue. He believed that the fundamental information necessary in breeding for disease resistance was a knowledge of the breeding system and the genetic architecture of both the host and the pathogen. He felt that it was necessary, on a long-term basis, to recognize the fact that single major gene resistance was less stable than that based on a number of minor genes, and further consideration should be given to the exploitation of types of resistance known variously as field resistance and adult plant resistance. Prof. Harland wondered whether the time had not come to reconsider the use of induced mutations as a practical method of increasing the variability of the host plants.

The papers on the second day were introduced by Prof. D. Lewis, who briefly summarized the ways in which fungal variability may occur: by mutation, by genetic recombination in sexual reproduction, by segregation of nuclei from heterocaryons and by the parasexual phenomenon. Variation in pathogenicity was now known to occur so rapidly that it often seemed capable of overcoming resistance available to the plant breeder, particularly where reliance was placed upon major gene resistance, which exerted vigorous selection upon the pathogens. Prof. Lewis then contrasted the ability of fungi to break down the resistance of plants with their apparent failure to overcome the toxicity of fungicides.

The paper by Mr. A. C. Hastie (Rothamsted) on "Variation in *Verticillium albo-atrum* isolated from Hops" described experiments, using nutritionally deficient mutants, to determine the mechanisms responsible for variation in this imperfect fungus. Mixed inoculum of isolates differing in nutritional deficiencies, when grown on an unaugmented agar medium, resulted in heterocaryon formation. It may now be inferred that a system similar to parasexuality may give rise to novel progeny. This work is at present being extended to include an investigation of the possibility of these mechanisms also being responsible for variation in pathogenicity.

Dr. R. D. Tinline of the Canada Department of Agriculture, at present working at Rothamsted, reported in his paper "Pathogenic and Cultural Variation in *Cochliobolus sativus*" that variation in culture of this fungus was brought about by mutation, by heterokaryosis and by hybridization. He was, however, unable to demonstrate the existence of 'parasitic races' of this fungus; virulent isolates tended to be highly pathogenic on all thirty-six wheat varieties used in the tests.

In her paper "Interaction, or Genetic Recombination, between Potato Viruses *Y* and *C*", Dr. Marion Watson (Rothamsted) suggested that variation in the symptoms produced by inoculation of closely related virus strains may indicate the formation of mixed isolates of viruses. Experiments using potato viruses *Y* and *C*, which are serologically related, and are strains of the same virus, showed that viruses with attributes of both *Y* and *C* could be obtained from lesions produced by inoculating a mixture of viruses *Y* and *C*. Such new strains were obtained only when the viruses inoculated were related strains, and also possibly when the multiplication took place within the same host cells.

Physiological specialization in *Puccinia glumarum* and *Phytophthora infestans* was discussed by Dr. D. A. Doling (National Institute of Agricultural Botany, Cambridge) with particular reference to race surveys. Such surveys supply information upon the number of races present and their relative frequency and distribution in particular areas. The value of the information obtained, however, depends very much on the organization of the actual collections. The identification of races presents problems of selection of suitable differential host varieties and of methods of inoculation and incubation. The most satisfactory host varieties are those containing known combinations of resistance genes.

Dr. C. C. V. Batts (London) gave a historical account of the distribution of physiological races of *Puccinia glumarum* in Britain since 1946. During this period the number of races identified each year has declined, but new biotypes of two races were now important and were associated with the wheat varieties being grown. The system of international trials being carried out in Western Europe were an extension of the race survey technique discussed by Dr. Doling and were useful in determining the distribution of physiological races over a larger area and also in suggesting suitable resistant varieties. The race position in *Ustilago tritici* was discussed in relation to the reactions of differential varieties. The type of reaction produced is apparently dependent upon the location of the mycelium within the embryo.

The problem of resistance to potato blight (*Phytophthora infestans*) was discussed by Dr. W. Black (Scottish Plant Breeding Station). *Solanum demissum* was a valuable source of resistance due to the hypersensitivity reaction, but from 1932 onwards the fungus has produced new races (now numbering at least 20) which could attack seedlings containing the *R* genes from *S. demissum*. However, in addition to the *R* gene resistance, 'field resistance' was also known which is at present effective against all races. The approach now being made is to combine *R* genes with the 'field resistance', which is inherited polygenically, so that varieties could be produced with a high level of resistance to some, and 'field resistance' to all, races.

The final discussion was opened by Prof. C. T. Ingold who, after surveying the various methods used for identifying physiological races of pathogenic fungi, turned to the more genetical aspects of problems. He considered that the importance of the parasexual cycle was not fully appreciated and in the future needed further investigation on a broad front.

This symposium drew together geneticists, virologists, pathologists and plant breeders who were involved in improving the productivity of crop plants. It is to be hoped that this will be the first of a series of such joint meetings in which scientists of different disciplines can consider together topics of common interest. These discussions were, however, particularly opportune as the rapid advances made in microbial genetics, the information collected as a result of expanded breeding programmes and the experience gained in handling resistant varieties in the past decade, need careful integration if the undoubted benefits of disease resistance are to be fully exploited. Although few fundamentally new ideas emerged from the papers it was clear that the complexities of incorporating stable forms of resistance in commercially acceptable varieties were fully realized. There was nevertheless a feeling that, at least for some crops, the future promised an improved standard of disease resistance based largely upon mechanisms controlled by minor gene systems.

R. C. F. MACER

THE DEVELOPMENT OF SCIENCE IN SOUTH-EAST ASIA

A REGIONAL meeting, to discuss problems of organizing scientific research in South-East Asian countries, was held at Bandung, Indonesia, during December 9–12, 1959. It was organized jointly by the Unesco South-East Asia Science Co-operation Office and the Indonesian Council of Sciences, and was attended by senior representatives of the national research organizations or other appropriate bodies of the following countries: Australia, Hong Kong, India, Indonesia, Japan, Malaya, Philippines, Thailand, Republic of Vietnam, and New Zealand. The meeting was inaugurated with an opening address by the Minister of Education, Instruction and Culture of Indonesia, Prof. Prijono, in the National Planning Board building in Bandung, which had been the scene of the historic Afro-Asian Conference in 1955. Prof. Prijono emphasized that the development of science and technology has not always been accompanied by moral progress, and appealed to the delegates to apply their learning for universal development, based on the common needs of man. The president of the Council of Sciences of Indonesia, Prof. Sarwono Prawirohardjo, was elected chairman of the meeting.

The business sessions of the meeting were held in the impressive headquarters of the National Science Foundation of Indonesia. From the outset of the discussions, stress was laid on informality. It was believed that a frank exchange of views would be more beneficial than formal debates on a number of fixed points, and this indeed proved to be the case. The stages of scientific development of the countries attending the meeting varied considerably—some had long-established government scientific research organizations, whereas others had only recently set up such bodies. After a survey of the main features of government research organization in each country, delegates discussed some of the major organizational problems which they faced. One of these was to determine the optimum balance between fundamental and applied research which they should undertake. It was recognized that developing countries have many urgent problems requiring immediate practical solution, and that it is usually easier to persuade governments to provide funds for research which has a definite practical objective. The traditional role of the universities in research is also to undertake fundamental work. Nevertheless, the meeting felt most strongly that it is essential for the health of national research organizations that they should be free to undertake fundamental work as they think desirable, and to approach any applied problem as basically as is necessary.

Another problem was concerned with the proper responsibilities of a national research organization. These, of course, vary with the country concerned. In some countries of the region the national scientific organizations are operating bodies, maintaining their own laboratories and employing their own staff; in others they are co-ordinating bodies advising their governments on development of policy and distribution of funds. The meeting stressed that in either case it is essential that the national scientific organization should have the maximum possible degree of autonomy of operation and in administering the funds provided for it by its government.

The relative functions of universities and national research organizations were also discussed. It is essential that university research should be effective in training students in the practice and philosophy of research, and for this reason governments should be prepared to provide funds for university research without any conditions as to the projects on which they should be employed.

One particularly interesting discussion covered the conditions for attracting and holding good scientists in the service of national research organizations. This is a vital matter, particularly for countries with national organizations in the early stages of development. The meeting placed great weight on the need for providing as liberal employment conditions as possible. Scientists look for autonomy of the organization, and freedom from political interference and rigid departmental control; the provision of suitable salaries and other conditions of service such as adequate equipment and trained assistance; freedom of publication; liberal travel grants and study leave, etc. It was also agreed that it is most important that the management of scientific organizations should be in the hands of scientists.

As was inevitable at such a meeting, the provision of finance and resources for research came in for considerable discussion. It was recognized that the main burden for this falls on governments, particularly in developing countries where the situation is made more difficult because there is little or no industry to provide additional funds. It was suggested that countries providing assistance for developing countries should be prepared to allocate a larger proportion of their aid funds for scientific research. It is essential, however, that a proper balance should be maintained between the provision of training opportunities in the shape of fellowships, etc., and the provision of equipment and facilities. Training is useless if the trainees do not have equipment and facilities available on their return to their home countries; on the other hand, it is useless to provide expensive and complicated equipment if skilled staff is not available to use it properly.

The encouragement of scientific research in developing countries through regional collaboration in such activities as conferences, symposia and training courses was a major topic of discussion. This led naturally to a discussion of the programme of the Unesco South-East Asia Science Co-operation Office, which is already fulfilling such an important role in the region. In relation to the needs, however, its resources are much too limited, and the meeting agreed that Unesco should be asked to make a greatly increased budgetary provision for its work in the area. The meeting agreed that the following activities, which are all urgently needed in the region, could appropriately be undertaken by Unesco: the provision of information on research programmes being undertaken in the region and on facilities for training and technical assistance; the encouragement of symposia on scientific subjects of special interest to South-East Asia; the provision of training courses for technicians, and refresher courses for science teachers; the encouragement of more visits to the region by scientists. The meeting suggested that the Unesco South-East Asia Science Co-operation Office should consider the possibility of arranging a meeting of librarians and documentation experts of the area, and it recommended that the present and proposed programmes of the Office in the fields of science teacher training, marine science research and humid tropics research should be confirmed and strengthened.

The whole conference demonstrated clearly how effective international meetings on a limited scale can be in promoting understanding and friendship. I believe that the meeting will have valuable practical results in increasing active collaboration between countries of the region in scientific matters. Many of them have scientific problems in common, and it was clear from the discussions at Bandung that they face many similar organizational and administrative problems in building up and strengthening their scientific organizations. The Unesco South-East Asia Science Co-operation Office is to be congratulated in taking the initiative in arranging the meeting, and it is obvious from the discussions that it can play a much greater part in the scientific life of the region if it can be provided with greater support. Such increased activity would be welcomed by all countries represented at the meeting.

All the delegates to the meeting would agree that it was a most successful one, and they have carried away with them the happiest memories of the gracious hospitality of their Indonesian colleagues, and the exquisite beauty of the Java countryside.

GUY B. GRESFORD

RECENT ADVANCES IN COCONUT RESEARCH IN INDIA

THE Agricultural College, Vellayani, Trivandrum, was the venue of the first conference of the coconut research workers in India organized by the Indian Central Coconut Committee, Ernakulam. India is the second largest producer of coconuts, a commodity occupying an important place in international commerce. With the advent of the Indian Central Coconut Committee in 1945 and with the establishment of two Central Coconut Research Stations and seven Regional Research Stations in the different coconut-growing States of the country, coconut research has in recent years gained considerable impetus and it was therefore quite opportune that research workers engaged from all over India should meet and discuss recent advances achieved in their field of work. The Conference was held during December 21–23, 1959, and was attended by more than seventy research workers, representatives of the Kerala Department of Agriculture and the Agricultural College, and some prominent coconut growers. Prof. L. S. S. Kumar, principal of the Agricultural College, presided. Some forty-five papers were presented and discussed at the conference.

Eleven papers covered the subjects falling under the purview of agronomy and general plant nutrition. In the first paper, by Mr. M. M. Krishna Marar and Dr. K. M. Pandalai (Kasaragod), the results of observations made in some long-term (40-year) experimental plots on the coconut were presented. The more important of the conclusions drawn were that (1) regular inter-cultivation and manuring are necessary to step up and maintain the yield at high level, and (2) regular inter-cultivation by itself is highly effective in increasing the yields even in the absence of manuring.

The same authors discussed in another paper the beneficial effects of nitrogen, phosphorus and potassium manuring on inducing flowering and bearing in adult non-bearing palms. Messrs. C. M. John and K. Jacob (Bangalore) reviewed the results of the extensive fertilizer demonstration scheme on coconuts carried out in growers' holdings on the west coast of India and established that manuring with the standard dose of 0·75 lb. nitrogen, 0·75 lb. phosphate and 1·5 lb. potassium together with 50–100 lb. green leaves per tree per year resulted in an increase of 35 per cent in terms of nuts, or 44 per cent in terms of copra, providing a net profit of Rs. 88·00 per acre. Miss K. Vijayalakshmi (Kasaragod) dealt with the various factors regarding moisture in soils of coconut plantations and outlined the various steps to be taken to conserve it. Messrs. T. Kailas Rao and T. Srirama Rao (Ambajipet) showed that for the alluvial soils of the coconut areas of Andhra Pradesh, sunnhemp is the most suitable green manure crop. The practices that have to be tackled when introducing coconut cultivation on a large scale in new regions such as Assam were discussed by Mr. P. R. Nath (Kahikuchi).

Certain aspects of the nutrition of the coconut palm were discussed by Dr. K. M. Pandalai and co-workers (Kasaragod). Dr. Pandalai showed that in the disorders or abnormal conditions such as foliar yellowing, chlorotic condition of the seedlings, petiole breaking, barren nut production, etc., met with in the coconut palm, there is a characteristic accumulation of nitrogen, phosphorus and potassium, etc., as compared with healthy tissues, suggesting some disturbance of optimum nutrient ratios, consequent inadequate metabolism and/or impaired translocation. Mrs. C. K. Thankam (Kasaragod) provided relevant data to justify the above general biochemical pattern of nutrient maladjustment in respect of barren nuts. Mr. P. L. Ramanandan (Kasaragod) dealing with the foliar yellowing condition of the palms, showed that it could be ameliorated to some extent by balanced nitrogen, phosphorus and potassium manuring supplemented with micronutrients such as molybdenum, copper and boron. Mr. C. K. Balakrishnan Nambiar (Kasaragod) showed that, in coconut seedlings, growth as well as leaf composition was correlated to a large extent with the composition of the growth medium, and that unbalanced nitrogen, phosphorus and potassium supply decreased growth and vigour and produced characteristic deficiency symptoms. Mr. N. G. Pillai (Kasaragod) traced the changes in the mineral composition of the different parts of the nuts, such as husk, shell, kernel and nut water, in the course of development from the button stage to ripe nut.

Five papers dealt with subjects of botanical interest. Messrs. S. R. Gangolly, T. P. Gopalakrishnan and co-workers (Kasaragod) presented data to show that synthetic growth-promoting substances such as β-indole propionic acid, β-indole butyric acid in suitable concentrations can be used instead of coconut water along with 2,4-dichlorophenoxy acetic acid for arresting button shedding in the coconut and promoting satisfactory growth of nuts. In another paper Messrs. S. R. Gangolly, M. C. Nambiar, Rama Varma and K. M. Pandalai discussed the distribution of coconut pollen in the atmosphere in relation to weather factors such as humidity, maximum and minimum temperature, sunshine, etc. Mr. R. Gopinathan Nair (Kasaragod), in tracing the anatomical development of the coconut fibre, showed that the fibre strands begin to differentiate in the ovary wall of the female flowers four to five months prior to the opening of the spathes, and that they grow for the main part into typical fibrovascular bundles having a few xylem and phloem elements surrounded by a sheath of fibrous cells. Messrs. R. V. Pillai and K. Satyabalan (Kasaragod) in their paper described the seasonal variations in the yield and nut characteristics of thirteen exotic cultivars of the coconut, and showed the existence of inherent variations among them. Mr. Josy Joseph (Kasaragod) in his paper showed that F_2 progeny seedlings of $T \times D$ (open pollinated or control pollinated) were better than F_1 in vigour as judged by vegetative characters relating to growth.

As many as thirteen papers dealt with the different aspects of the investigations on the diseases of the coconut palm. Mr. U. K. Nair and Dr. K. Radha (Kayangulam) presented data to show that manuring and spraying were generally effective in reducing the adverse effects of the leaf disease. Miss T. O. Prasannakumari, Dr. K. Radha and Mr. V. C. Kurian (Kayangulam) dealing with the efficiency of different copper fungicides for the control of leaf disease concluded that Bordeaux mixture, Kirti copper and 'Fungimar' were more effective than the others tried.

Dr. P. Shanta, Dr. K. P. V. Menon and co-workers (Kayangulam) presented four papers dealing with their investigations on the virological aspects of the wilt disease of the coconut palm. In the first paper they presented results that tend to support the virus hypothesis of the wilt disease. In their second paper they described the host-range of the virus, and showed that the virus can be experimentally transmitted to cowpea seedlings by sap inoculation. In another paper Dr. P. Shanta, Dr. K. P. V. Menon and Mr. K. J. Thommen (Kayangulam) adduced evidence to show that chlorosis and flaccidity of the leaves in the diseased coconut palms are only secondary symptoms brought about by the formation and accumulation of toxic materials in the leaves. Dr. K. Radha and Mr. T. S. S. Rawther (Kayangulam) reported negative correlation between the rhizosphere fungi and rainfall conditions in their studies on the influence of seasonal factors on the rhizosphere microflora with reference to the wilt disease in the coconut palm.

A series of seven papers on the chemical studies on the leaf and wilt disease of the coconut were presented by Messrs. E. J. Verghese, M. P. Sankaranarayanan, S. Robert Cecil, M. K. C. Nair and A. S. Mathew (Kayangulam). In the first two papers they reiterated the salient features of observations made on the incidence of the root and leaf diseases of the palms, and provided data which confirmed the earlier findings regarding the accumulation of major nutritient factors in the diseased tissues. Different aspects relating to the changes in the concentration under water-logged conditions, particularly of possible toxic agents such as ferrous iron, aluminium, organic acids, etc., which could injure plant tissue, were discussed in the third paper. The results of soil survey of healthy and diseased coconut gardens to throw light on the influence of soil conditions in relation to the disease formed the subject of another paper. The ineffectiveness of lime, ash and Chilean nitrate to improve the condition of diseased trees was reported in two other papers by Messrs. M. R. Chettiar, E. J. Verghese, P. C. John, P. V. Channey and M. P. Sankaranarayanan. In the last paper of the series it was concluded that cadmium toxicity is not a factor associated with the disease condition of the coconut palm.

Six papers presented results of investigation on the pests of the coconut palm. Messrs. K. R. Mohan Rao and C. Seshagiri Rao (Ambajipet) described the different pests of the palm prevalent in the Andhra Pradesh, and gave an account of the biological method of control adopted by them against *Nephantis serinopa*. Mr. G. B. Pillai and Dr. C. Kurian (Kayangulam) in their work on the insecticidal efficiency of dieldrin concluded that 0·05 per cent is the optimum minimum concentration for use against *Nephantis serinopa*. Reporting the results of several insecticidal trials against *Rhynchophorus ferrugineus* F., Mr. K. Mathen and Dr. C. Kurian (Kayangulam) held the view that both larvæ and adults suffered 92 per cent mortality of grubs at 0·5 per cent and 100 per cent mortality of adults at 0·1 per cent, seven days after treatment, endrine giving best results.

The results of observation on the incidence of the rhinoceros beetle and the extent of damage done by it under field conditions were presented by Mr. C. P. Ramachandran and Dr. C. Kurian (Kayangulam). Detailed studies of *Perisierola nephantidis*, an ectophagous larval parasite of *Nephantis serinopa*, were reported by Mr. J. Antony and Dr. C. Kurian. Mr. K. V. Joseph (Vellayani), based on the work done by him, emphasized the need to exercise caution in the matter of using DDT for large-scale spraying in coconut areas because of the risk involves in adversely affecting the population of parasites and predators that normally help to keep pests under control in Nature.

Other papers were presented and discussed, and some were submitted only. All the papers submitted for the Conference are being printed as a special volume of the *Indian Coconut Journal* (published by the Indian Central Coconut Committee, Ernakulam, South India).

K. M. PANDALAI

MEDICAL RESEARCH IN THE BRITISH CARIBBEAN

THE fifth annual scientific conference organized by the Standing Advisory Committee for Medical Research in the British Caribbean was held at the University College of the West Indies, Jamaica, during April 2–4. The topic for the meeting was the application of the laboratory to problems of clinical medicine. Doctors from the Caribbean islands, British Guiana, British Honduras, the Bahamas, Great Britain and the United States attended. Thirty-five papers were read and discussed. Prof. A. C. Frazer (University of Birmingham) took the chair on the first day.

The first session was devoted to cardiovascular disorders. A number of hospital studies and field surveys were reported from Jamaica, Trinidad, British Guiana and St. Kitts, by Drs. J. A. Tulloch, G. Wattley, H. Hamilton and K. Stuart. Hypertensive heart disease was the most common cardiac cause for hospital admission followed by luetic and then rheumatic heart disease. Acute rheumatic fever was common, and in Trinidad affected the East Indian to a greater extent than the Negro. Cor pulmonale was uncommon in both Trinidad and Jamaica, but was seen with greater frequency in British Guiana. In British Guiana and Trinidad it occurred almost exclusively in the East Indian. No satisfactory explanation of this racial difference was forthcoming. Myocardial infarction was uncommon in all the territories. This was of interest as aortic atheroma is as common in Jamaica as in the United States of America, although coronary artery atheroma is less severe in Jamaica than in the United States. The association of aortic and coronary atheroma with essential hypertension, diabetes, age and sex was discussed by Dr. W. B. Robertson. The importance of heart disease in the general population was illustrated by the report from Barbados of a chest X-ray survey of 3,000 subjects. This showed a 10·7 per cent incidence of cardiovascular abnormality, and a considerable proportion of these had a positive serological test for syphilis. Yaws has not been recognized in Barbados for many years. This stressed the fact that symptomless cardiovascular syphilis may be more common than has been thought and therefore poses an important public health problem. In the discussion of this paper the urgent need for a test, serological or otherwise, that will differentiate syphilis from yaws was stressed.

Hypertension is common and field surveys carried out in Jamaica and St. Kitts were reported by Dr. K. L. Stuart. The levels of blood pressure in St. Kitts were slightly higher than those reported by the Medical Research Council team in South Wales, whereas in Jamaica the figures were comparable to those from South Wales. An investigation into the occurrence of significant bacilluria in the general population was also reported by Dr. Stuart. There was a considerably higher incidence of bacilluria in the hypertensive female, and this increased with parity. The relationship of bacilluria to hypertension was discussed, and the possibility that pyelonephritis was responsible for the greater incidence of hypertension in the elderly female was suggested. A post-mortem study of hypertensive cases reported by Drs. Ling and Stuart did show that renal hypertension was responsible for 50 per cent of the cases, and that chronic pyelonephritis accounted for one-third of the renal cases.

Diabetes mellitus was discussed at the second session. It was pointed out by Dr. J. A. Tulloch that the prevalence of diabetes in Jamaica was a little more than 1 per cent of the adult population, and that only about 40 per cent of the cases were already known to have diabetes. The ætiology was reviewed and was considered to be very similar to that reported from temperate countries. A consideration of the *J* type cases was reported by Drs. D. MacIntosh and J. Tulloch, which indicated that this was not a distinct type, but was a phase in the natural history of the badly treated type II patient. The results of treatment with chlorpropamide were reported from Trinidad by Dr. T. Poon-King. A considerable proportion of his cases responded satisfactorily. The distribution of blood groups in diabetic subjects was also reported from Trinidad. In both male and female cases there was a low incidence in group O. Males showed an excessive group B and females an excess of group A over that occurring in the local population. A study of liver enzymes in human diabetes was reported by Dr. S. J. Patrick. This largely confirmed animal experiments.

On the second day Prof. E. T. C. Spooner (London School of Hygiene and Tropical Medicine) took the chair. Dr. R. D. Montgomery of the Medical Research Council Tropical Metabolism Unit reported that the oxygen uptake per unit of body weight was not reduced even in severe malnutrition. During recovery the increase became much greater and evidence was given that this was related to thyroid activity. Drs. J. C. Waterlow and D. I. M. Picou reported preliminary observations from isotope studies that, in protein malnutrition, the economy of protein is achieved not by a decreased rate of katabolism but by an increased degree of re-utilization. Although the extent of protein synthesis may be reduced through shortage of supplies, the capacity for synthesis seemed in most cases to be unimpaired. The occurrence of magnesium deficiency in malnutrition was reported by Dr. R. D. Montgomery. This paralleled potassium deficiency and supported the concept of a primary loss of intra-cellular constituents. Further investigations into the megaloblastic anæmia noted in malnourished infants was reported by Drs. MacIver and Back. They showed that the cause was a dietary deficiency of folic acid, and vitamin B_{12} was not implicated. Dr. MacIver also reported on the nature of the severe anæmic episodes in sickle-cell disease and showed that these were of two types. In one folic acid deficiency was the ætiological factor and in the other there was an acute aplastic state. A possible relationship of this latter state to preceding infection was suggested. Non-Addisonian vitamin B_{12} deficiency in the adult was reported from Trinidad by Dr. G. Habib. All the cases were Hindus and with one exception they were strict vegetarians eating no eggs, meat, fowl or fish. It was considered that poverty and a vegetarian diet combined to produce this deficiency state.

A field survey on the size of liver in apparently healthy children was reported by Dr. C. G. Miller. Hepatomegaly was found in about 95 per cent of all children under the age of 12 years. Its presence was not related to malnutrition, but the possible role of infection was considered. The autopsy incidence of cirrhosis of the liver, as noted at the University College Hospital of the West Indies, was much the same as in America. One-third of all cirrhosis cases resulted from veno-occlusive disease of the liver. Liver cancer occurred with moderate frequency. This was a more common finding than in Denmark, but was much less common than in Africa. Hepatocellular carcinoma was more common than cholangio carcinoma and occurred particularly in the young adult male.

Virological investigation of human yellow fever cases in Trinidad was reported by Dr. W. G. Downs of the Trinidad Regional Virus Laboratory. The cases noted in 1959 were diagnosed by isolation of virus from the blood and the difficulty of serological diagnosis was stressed. The clinical occurrence of encephalitis in Jamaica was analysed by Dr. R. A. Irvine and it was noted that sequelæ were a common occurrence. The intra-dermal innoculation against Asian influenza was discussed by Drs. M. M. Sigel (Miami University) and L. S. Grant. In their opinion the intra-dermal injection of antigen would engender an antibody response and such a method could well be adopted in an emergency during epidemics before large supplies of suitable antigens became available.

Prof. G. Bras took the chair on the third day. The possibility that the unusual spastic neuropathies seen and reported from Jamaica were related to treponemal infection was considered by Dr. R. D. Montgomery (Medical Research Council). It was argued that the neuropathy could be a late manifestation of treponemal infection, whether venereal or otherwise, and that it could be due to a strain acting as a poor antigenic stimulus, but producing a typical meningo-vascular lesion in the nervous system. A second neurological disorder noted in Jamaica, that of spinal arachnoiditis, was reported by Prof. E. K. Cruickshank and Dr. P. E. Rodgers. The ætiology of the condition was largely unknown, but it had been found that cases seen early in the disease responded well to cortisone administration. An investigation into tropical plants used for medicinal purposes was reported by Prof. Haynes. It had been found that the breadfruit contained γ-aminobutyric acid, and this factor gave rise to a slight reduction of blood pressure in the anæsthetized dog. Other plants had also been shown to contain this substance.

The meeting was brought to a close by Prof. Bras who thanked all contributors and all visitors from the many islands, Great Britain and the United States for attending the conference.

J. A. Tulloch

ABUNDANCES OF THE RARE-EARTH ELEMENTS, LANTHANUM TO LUTETIUM, IN CHONDRITIC METEORITES

By Dr. R. A. SCHMITT, A. W. MOSEN, C. S. SUFFREDINI, J. E. LASCH,
Dr. R. A. SHARP* and D. A. OLEHY

John Jay Hopkins Laboratory for Pure and Applied Science, General Atomic
Division of General Dynamics Corporation, San Diego, California

THE abundance distribution of nuclear species is considered an important requisite for a satisfactory theory of nucleogenesis[1-3]. Compilations of cosmic abundances of the elements have been published by Goldschmidt, Brown, Urey, Aller, Suess and Urey[1], and Cameron[2], and others. It has been found that the relative cosmic abundances vary by a factor of $\sim 10^{13}$, and decrease logarithmically and rather smoothly from the lightest to the heaviest elements.

Rules of relative atomic abundances, for example, regular and smooth decrease in the abundances of those odd-mass-number nuclides which have masses greater than ~ 50, were assumed to be valid for all elements, because it had been observed that the rare-earth elements (lanthanum to lutetium) showed a regular and smooth decrease in their abundances[1]. Since it is well known that the fourteen rare earths possess a high degree of chemical similarity, because of the filling of the 4-*f* electron shell far inside the valence electrons, the rare earths are assumed to have migrated geochemically through time and space as an 'entity'[4]. Consequently, accurate determinations of the abundances of rare earths in primordial matter are required in order to establish empirical relationships among the abundances of elements formed in nucleogenesis.

Noddack, using X-ray spectroscopic techniques[5], has determined the abundances of the rare earths in composite mixtures of chondritic and achondritic meteorites (~ 9 parts of chondrite to 1 part of achondrite in the mixtures); and Minami[6] has used

---

* Present address: Sharp Laboratories, Inc., La Jolla, California.

Table 1. ABUNDANCES OF RARE EARTHS IN THE CHONDRITIC METEORITES: ALLEGAN AND RICHARDTON

Element	Isotope measured	Radioactive isotope	Isotopic abundance[a] (atoms/10^6 Si atoms)		Elemental abundances							
					Alleg.[b]	Rich.[b]	Alleg.[c]	Rich.[c]	Meteorites, by I. Noddack[d] (gm./10^6 gm.)[c]	Shales, by Minami[e] (gm./10^6 gm.)[c]	By Suess and Urey[f] (atoms/10^6 Si atoms)	By Cameron[g] (atoms/10^6 Si atoms)
			Allegan	Richardton	(atoms/10^6 Si atoms)		(gm./10^6 gm.)					
La-57	La-139	La-140	0·41 (±0·02)	0·39 (±0·02)	0·41	0·39	0·33	0·32	2·05	18·0	2·00	0·50
Ce-58	Ce-142	Ce-143	0·078 (±0·012)	0·063 (±0·006)	0·66[h]	0·57[h]	0·55	0·48	2·30	46·0	2·26	0·58
Pr-59	Pr-141	Pr-142	0·15 (±0·01)	0·14 (±0·02)	0·15	0·14	0·12	0·12	0·97	5·6	0·40	0·23
Nd-60	Nd-146	Nd-147	0·13 (±0·02)	0·12 (±0·01)	0·77	0·70	0·65	0·61	3·37	24·0	1·44	0·87
Sm-62	Sm-152	Sm-153	0·072 (±0·003)	0·058 (±0·002)	0·27	0·22	0·24	0·20	1·23	6·5	0·66	0·24
Eu-63	Eu-151[i]	Eu-152^m	0·050 (±0·002)	0·044 (±0·002)	0·105	0·092	0·091	0·081	0·80	1·2	0·19	0·12
	Eu-151[j]	Eu-152	0·046 (±0·002)	0·044 (±0·002)	0·096	0·092	0·083	0·079				
Gd-64	Gd-158	Gd-159	0·092 (±0·009)	0·074 (±0·015)	0·36	0·30	0·34	0·28	1·84	6·3	0·68	0·52
	Gd-160	Tb-161	0·080 (±0·012)	0·092 (±0·006)	0·36	0·42	0·34	0·40				
Tb-65	Tb-159	Tb-160	0·054 (±0·004)	0·057 (±0·003)	0·054	0·057	0·049	0·053	0·58	0·9	0·096	0·090
Dy-66	Dy-164	Dy-165	0·116 (±0·007)	0·100 (±0·005)	0·41	0·36	0·39	0·34	2·34	4·5	0·56	0·67
Ho-67	Ho-165	Ho-166	0·086 (±0·007)	0·070 (±0·009)	0·086	0·070	0·082	0·068	0·66	1·2	0·12	0·18
Er-68	Er-168	Er-169	—	0·058 (±0·008)	—	0·20	—	0·20	1·93	2·5	0·32	0·58
	Er-170	Er-171	0·034 (±0·004)	0·030 (±0·002)	0·23	0·21	0·22	0·21				
Tm-69	Tm-169	Tm-170	0·044 (±0·004)	0·038 (±0·002)	0·044	0·033	0·043	0·033	0·34	0·20	0·032	0·090
Yb-70	Yb-168	Yb-169	0·00026 (±0·00006)	0·00026 (±0·00001)	0·20	0·18	0·20	0·19	1·85	2·7	0·22	0·39
	Yb-174	Yb-175	0·064 (±0·004)	0·058 (±0·003)	0·19	0·19	0·19	0·19				
Lu-71	Lu-175	Lu-176	0·034 (±0·007)	—	0·035	—	0·035	—	0·60	0·7	0·050	0·036
	Lu-176[k]	Lu-177	0·00106 (±0·00010)	0·00085 (±0·00004)	0·041	0·038	0·041	0·038				

[a] Abundances are given for the isotopes listed in column 2. Measurements of the abundances of the isotopes in column 2 were obtained from the radioisotopes listed in column 3. Errors represent the over-all standard deviation error, which is primarily due to counting statistics.

[b] Elemental abundances were calculated by assuming that terrestrial isotopic ratios are identical to meteoritic isotopic ratios. Errors in the elemental abundances may be obtained from the isotopic abundance errors given in columns 4 and 5.

[c] Ratios are expressed as grams of element per 10^6 gm. of meteorite. Errors may be obtained from the isotopic abundance errors in columns 4 and 5.

[d] See ref. 5. Abundances are given only to significant values.

[e] See ref. 6. Abundances are given only to significant values.

[f] See ref. 1. Suess and Urey chose the rare-earth abundances of Minami (see ref. 6) for inclusion in their cosmic-abundance table. The abundances listed in column 12 are the Suess–Urey interpolated values which gave the best fit between lower and higher mass-elements immediately preceding and following the rare-earth elements.

[g] See ref. 2. Cameron chose the rare-earth abundances of Noddack (see ref. 5) for inclusion in his abundance table and normalized the Noddack abundances by fitting the lanthanum and barium abundances in an approximate manner. We have listed the values of Cameron to two significant numbers.

[h] Elemental abundances of cerium were also determined through the neutron-capture reaction Ce-140 (n,γ)32-day Ce-141 and were found to be 0·88 and 0·90 atoms/10^6 silicon atoms for Allegan and Richardton, respectively. These values may be high due to possible contamination. The abundances of cerium are being checked by different chemical manipulations. The abundance of cerium as determined through 33-hr. Ce-143 is considered to be reliable.

[i] Abundances were determined via the 9·3-hr. upper isomeric state of Eu-152^m.

[j] Abundances were determined via the 13-yr. lower isomeric state of Eu-152.

[k] It was calculated that the abundance of Lu-176 may be too high by ~5 per cent, because the Lu-176 abundance was determined through the radioisotope Lu-177, which is produced by two rare-earth neutron-capture reactions in Lu-176 and Yb-176, with the activated radioisotope Yb-177 decaying to Lu-177.

X-ray spectroscopy to ascertain the rare-earth abundances in shales ($\sim 10^8$ yr. old). If meteoritic and terrestrial matter originated from the same process, then the relative abundances of the rare earths in shales and in meteorites should be very similar. By comparing the data of Minami[6] and Noddack[5], it was found that the abundances of the light rare earths relative to those of the heavy rare earths were about eight times greater in shales than in meteorites (see Table 1).

In order to resolve this difference, it was suggested by Hans E. Suess, of the University of California, La Jolla, that the abundances of the rare earths in chondritic meteorites should be accurately determined by using the new and powerful technique of neutron activation.

At the initiation of the present work, chondritic meteorites had been considered by Urey[1] as most representative of the non-volatile primordial matter of the solar system. The feasibility and reliability of measuring the abundances of elements present in concentrations of one part per million or less in meteorites has been demonstrated by a great many geochemists[7].

Abundances of all the rare-earth elements (lanthanum to lutetium), with the exception of the unstable element promethium, were determined in two chondritic meteorites, Allegan and Richardton, by the neutron activation technique. Five-gram samples of the meteorites and all fourteen rare-earth standards (spectroscopic purity grade) were irradiated simultaneously in the General Atomic *Triga* reactor

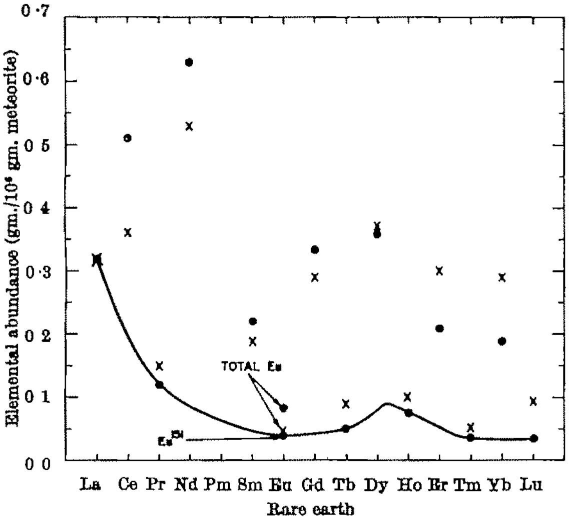


Fig. 1. Average elemental abundances (in gm. of rare earth per 10^6 gm. of meteorite) in the chondrites Allegan and Richardton. Solid circles are values of this work; crosses are values by Noddack (see ref. 5) normalized to the lanthanum abundance of this work. The solid curve connects the odd-*A* abundances of this work. The average standard deviation (*SD*) errors for average elemental abundances of this work are ±9 per cent; Noddack's errors are given as equal to or less than ±4 per cent as *SD*

in a neutron flux of about 2×10^{12} neutrons/cm.^{2}/sec. The meteoritic specimens and the rare-earth standards were placed in separate containers in a rotating circular rack in the reactor, so that all the containers were exposed to the same neutron flux. Subsidiary experiments showed that the neutron spectra were identical (± 3 per cent) in the flux for the pertinent neutron-capture energies in both the meteoritic specimens and in the standards.

After neutron irradiations of about 2 hr., the meteorite samples were immediately subjected to standard radiochemical manipulations in order to separate the activated rare earths resulting from neutron-capture reactions from other activated elements present in the highly radioactive meteoritic specimens. Pure rare-earth carriers in the form of rare-earth oxides were added to the irradiated meteorites before the sodium peroxide fusion of the meteoritic sample. After radiochemical decontamination, the activated rare earths were separated[8] by being passed through 'Dowex 50*W*' × 12, minus 400 mesh, ion-exchange resin. (The resin was especially prepared by Bio-Rad Laboratories, Richmond, California. The settling-rate of the fine resin was 0·5–2·0 cm./min.)

In the determination of the abundances, the final separated rare-earth carriers and the irradiated rare-earth standards were counted in both ordinary and automatically operated well-type scintillation spectrometers, with 1¾ in. × 2 in. sodium iodide (Tl) crystals. Almost all neutron-activated rare earths decay by negatron emission accompanied by gamma emission, and thus lend themselves to γ-ray spectroscopy. It was necessary to count only two of the rare earths by the standard beta-counting method—thulium-170 and erbium-169. Each of the rare earths was identified: (1) by observing the order of ion-exchange elution; (2) by comparing the rare-earth gamma spectra, taken by a 256-channel analyser, with the spectra of the rare-earth standards; and (3) by following the decay of the rare-earth elution peaks and of the rare-earth standards over a few half-lives, either by counting all gamma disintegrations (integral counting), or by counting selected gamma rays of the radioisotopes. The radiochemical yields of the rare-earth carriers were ascertained by comparing the activities resulting from neutron activation analysis of the decayed carriers with those resulting from analysis of a known amount of the individual rare earths.

Results of the determination of rare-earth abundances in the two chondritic meteorites, Allegan and Richardton, are given in columns 1–5 of Table 1. The elemental abundances have been calculated with the assumption of identical isotopic abundances for rare-earth elements in meteoritic and terrestrial matter and are given in columns 6–9 of Table 1. (The validity of this assumption is verified for the rare-earth region by comparing the meteoritic abundance ratios of the isotope pairs gadolinium-158/gadolinium-160, erbium-168/erbium-170, ytterbium-168/ytterbium-174 and lutetium-175/lutetium-176 with terrestrial abundance ratios.) For comparative purposes, the X-ray spectroscopic elemental abundances in meteorites, as determined by Noddack, and in shales, as determined by Minami, are included in the table. Also included are the values given by Suess and Urey[1] and by Cameron[2] in their cosmic abundance compilations.

The average elemental abundances in the chondrites Allegan and Richardton, expressed in grams of rare earth per 10^6 gm. of meteorite (p.p.m.), are plotted in Fig. 1 as solid circles. For comparison, Noddack's meteoritic values (crosses) have been

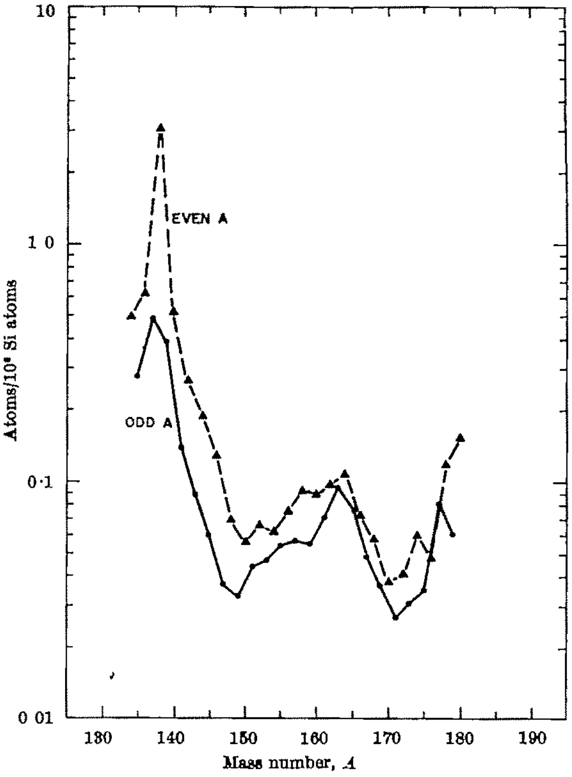


Fig. 2. Average abundances (in atoms per 10^6 silicon atoms of the rare earths) in the chondrites Allegan and Richardton, for both even *A* and odd *A*. Solid circles are odd-*A* and solid triangles are total even-*A* abundances. Solid and dashed lines connect the odd-*A* and total even-*A* abundances, respectively. Average errors of abundances for $A < 176$ are ~10 per cent as *SD*. Errors for $A > 177$ are somewhat indeterminate

included in the figure and are normalized to our lanthanum abundance. A solid curve has been drawn through the odd-mass abundances in Fig. 1.

Again assuming terrestrial isotopic abundances for the rare earths in meteorites, the abundances for all rare-earth isotopes were calculated. These were then used to calculate total isobaric abundances of even A and odd A and were incorporated with the abundances for elements immediately preceding and following the rare-earth group. The abundances plotted in Fig. 2 are the average values for the chondrites Allegan and Richardton and are expressed in units of atoms per 10^6 silicon atom. The elemental abundance peaks at $A = 137$ and 138 were calculated from the recent barium abundance values in 'ordinary' chondrites given by G. W. Reed *et al.*[8]. Values for $A \leqslant 138$ and $A \geqslant 176$ are those of G. W. Reed *et al.*[9], and of Suess and Urey[1]. The solid line in Fig. 2 connects the odd-A abundances and the dashed line connects the total even-A abundances.

From the data presented in Table 1 and in Figs. 1 and 2, the following observations are noted. First, after normalization of the Noddack data to these data, the X-ray spectroscopic data are about ± 30 per cent at variance with the abundances of the present work. Secondly, the abundances of even-atomic-number elements are indeed larger, by roughly a factor of four, than those of the odd-atomic-number elements. Thirdly, the elemental abundance of europium in Richardton (0·080 p.p.m.) as determined in this work agrees well with the abundance of europium in Richardton (0·079 p.p.m.) found by Bate *et al.*[10]. Fourthly, a smooth decrease in abundances is found for both odd A and total even A from $A \approx 137$ to $A \approx 150$. A smooth perturbation in the gradual decline in abundance of both odd A and total even A is noted between $A \approx 150$ and $A \approx 170$, with a peak at $A \approx 163$. This has been explained by Becker and Fowler[11] from considerations of the rapid neutron-capture process in supernovæ and the spheroidal nuclear deformations in the rare-earth region. Fifthly, the meteoritic isotopic ratios of gadolinium-158/gadolinium-160, erbium-168/erbium-170, ytterbium-168/ytterbium-174 and lutetium-175/lutetium-176 agree, within experimental error, with the corresponding terrestrial abundances.

At General Atomic, work is in progress to re-determine the cerium-140/cerium-142 isotopic ratio in chondritic meteorites, and it is planned to ascertain the rare-earth abundances in achondrites and irons. Complete details of this work will be published elsewhere.

We wish to thank Prof. Hans E. Suess, of the University of California, La Jolla, for suggesting this problem and for helpful discussions. Also, we thank Prof. Harold C. Urey, of the University of California, La Jolla, and Prof. John W. Irvine, jun., of the Massachusetts Institute of Technology, for their suggestions. The Allegan meteorite was obtained through the courtesy of Prof. Hans E. Suess; Richardton was obtained through the courtesy of Dr. Brian Mason, of the American Museum of Natural History.

[1] Suess, H. E., and Urey, H. C., *Revs. Mod. Phys.*, 28, 53 (1956); compilations of Goldschmidt, Brown, Urey and Aller are included in this work.

[2] Cameron, A. G. W., *Astrophys. J.*, 129, 676 (1959).

[3] Burbidge, E. M., Burbidge, G. R., Fowler, W. A., and Hoyle, F., *Revs. Mod. Phys.*, 29, 547 (1957).

[4] Goldschmidt, V. M., "Geochemistry", 313 (Clarendon Press, Oxford, 1954).

[5] Noddack, I., *Z. anorg. u. allgem. Chem.*, 225, 337 (1937).

[6] Minami, E., *Nachr. Ges. Wiss. Göttingen, Math.-physik Klasse*, 1, 143 (1935).

[7] Reed, G. W., in "Researches in Geochemistry", P. H. Abelson (ed.), 458 (John Wiley and Sons, Inc., New York, 1959).

[8] Nervik, W. E., *J. Phys. Chem.*, 59, 690 (1955).

[9] Reed, G. W., Kigoshi, K., and Turkevich, A., "Concentrations of Some Heavy Elements in Meteorites by Activation Analysis" (submitted for publication in *Geochimica et Cosmochimica Acta*).

[10] Bate, G. L., Potratz, H. A., and Huizenga, J. R., *Geochim. et Cosmochim. Acta*, 18, 101 (1960).

[11] Becker, R. A., and Fowler, W. A., *Phys. Rev.*, 115, 1410 (1959).

INHIBITION OF THE ANAPHYLACTIC RELEASE OF HISTAMINE FROM CHOPPED GUINEA PIG LUNG BY CHYMOTRYPSIN SUBSTRATES AND INHIBITORS

By DR. K. F. AUSTEN* and DR. W. E. BROCKLEHURST

National Institute for Medical Research, Mill Hill, London, N.W.7

IT has been observed that the anaphylactic release of histamine from sensitized guinea pig lung requires a heat-labile factor[1], which is probably enzymic, and can be inhibited by di*iso*propylfluorophosphate[2]. These findings prompted us to study the effect of peptidase substrates and inhibitors on the anaphylactic release of histamine from sensitized guinea pig lung.

Guinea pigs were sensitized by injection of 10 per cent egg albumin in 0·5 per cent phenol, 1 ml. intraperitoneally and 1 ml. subcutaneously. Approximately three weeks later the lungs were excised and blood was removed by perfusion through the pulmonary artery for 10 min. with Tyrode's solution at 37° C. The lung tissue was chopped into rods 0·4 mm. × 0·4 mm. × 5 mm., washed, and divided into some 24 samples of about 100 mgm. wet weight. These were incubated in Tyrode's solution at 37° C. for 45 min. and then washed twice with Tyrode's solution. Immediately after the second wash each sample of tissue was immersed in 3·0 ml. Tyrode's solution with or without the potential inhibitor and 10 sec. later the antigen, 0·1 mgm. ovalbumin per ml. reaction mixture, was added. After incubation for 15 min. at 37° C. the supernatant fluid was removed from the tissue and kept at 0° C. until it was assayed the same day using the isolated ileum of the guinea pig. Addition of antigen caused the release of 0·3–0·6 μgm. histamine per sample. Any potential inhibitor was always studied in four replicate tubes; three of the samples received antigen and the fourth served as a control for spontaneous release of histamine.

---

* U.S. Public Health Service Postdoctoral Research Fellow.

Table 1. COMPOUNDS WHICH FAIL TO INHIBIT THE ANAPHYLACTIC RELEASE OF HISTAMINE FROM CHOPPED, SENSITIZED GUINEA PIG LUNG*

Amino-acids	Esters, amides and hydrazides	Peptides and polypeptides
L-Tryptophan L-Tyrosine** L-Phenylalanine L-Arginine L-Lysine L-Leucine L-Valine L-Glutamic acid L-Cysteine Glycine DL-Alanine DL-Aspartic acid	Benzoyl-L-arginine methyl ester Benzoyl-L-argininamide L-Lysine methyl ester Diacetyl L-lysine ethyl ester† Diacetyl L-lysine hydrazide† L-Glutamic ethyl ester	Glycylglycine DL-Alanylglycine Acetylglycine Acetyl-L-lysine L-Glutathione (reduced) Soy bean trypsin inhibitor‡

* Compounds producing less than 25 per cent inhibition at a concentration of 20 m*M* were termed non-inhibitory.

** Because of water insolubility L-tyrosine could not be tested at greater than 5 m*M*.

† Because of limited supply these compounds could not be tested at greater than 10 m*M*.

‡ Test concentration was 2 mgm./ml. reaction mixture.

In Table 1 are listed the compounds which failed to inhibit histamine release at a concentration of 20 m*M*. The lævorotatory forms of all amino-acids studied were non-inhibitory. The esters and amides of arginine and lysine, which are specific trypsin substrates[3], were not inhibitory, and neither was soy bean trypsin inhibitor at 2 mgm./ml. In addition, γ-glutamylcysteinylglycine (glutathione), and several dipeptides and N-acetyl amino-acids were non-inhibitory.

The compounds which consistently produced more than 50 per cent inhibition of the anaphylactic release of histamine are recorded in Table 2. The first group are esters or amides of L-tyrosine and L-phenylalanine which are typical chymotrypsin substrates[3]. The observation that the esters are better inhibitors than the amide is consistent with the fact that the esters are much more susceptible substrates than the amide[3]. The bifunctional chymotrypsin inhibitors β-phenyl-propionic acid, β-indoleacetic acid and β-(β-indole)propionic acid produced more than 50 per cent inhibition at 2·5 m*M* while the racemic aromatic amino-acids and their dipeptides or N-acetyl derivatives required a concentration of eight times as much to accomplish the same inhibition. Indole, the most potent monofunctional chymotrypsin inhibitor studied by Huang and Niemann[4], was also the most effective inhibitor of histamine release. A concentration of indole of 0·5 m*M* gave more than 50 per cent inhibition whereas virtually total inhibition was obtained with 2·0 m*M*. Di*iso*propylfluorophosphate which is capable of inhibiting chymotrypsin[5], as well as a variety of other esterases, was very effective at 5 m*M*. The finding that di*iso*propylfluorophosphate, which is capable of inhibiting purified chymotrypsin on a 1 : 1 molar basis[6], was not more effective, may be explained by the fact that di*iso*propylfluorophosphate had a relatively short time to inhibit the antigen-activated enzyme and had to do so in the presence of substrate for that enzyme. Histamine release begins within 15 sec. of antigen addition and reaches a maximum rate within 100 sec. Furthermore, the effective concentration of di*iso*propylfluorophosphate may have been significantly diminished by binding to other proteins[7].

In order to ascertain that the inhibitors did not destroy or release antibody, or otherwise impair the ability of the sensitized tissue to respond to antigen, the sensitized tissue was incubated with several of the most potent inhibitors for 15 min. and then thoroughly washed before addition of antigen. The concentration of the inhibitors, L-phenylalanine ethyl ester, phenylacetic acid, indole and di*iso*propylfluorophosphate was selected so as to give more than 80 per cent inhibition. In each instance, after removal of the inhibitor and the addition of antigen, the tissue gave the same histamine release as control tissue treated in a similar fashion with Tyrode's solution. This indicates that the inhibitors are acting exclusively on a reaction activated by the antigen. Furthermore, the failure of di*iso*propylfluorophosphate to inhibit when added and removed before antigen addition implies that the antigen-activated enzyme is present in an inactive precursor form which, like trypsinogen and chymotrypsinogen, is resistant to di*iso*propylfluorophosphate[5].

The failure of trypsin substrates and the soy bean trypsin inhibitor to prevent anaphylactic release of histamine from sensitized guinea pig lung is consistent with the observation that soy bean trypsin inhibitor fails to prevent the antigen-induced histamine release from sensitized rabbit blood[8].

It has been demonstrated that the first component of complement ($C'1$) is capable of exhibiting esterase activity against esters of arginine and tyrosine[9], and is inhibited by di*iso*propylfluorophosphate[9] or sulphydryl-containing compounds like cysteine or reduced glutathione[10]. In our system esters of tyrosine are inhibitory, but esters of arginine or sulphydryl compounds are not; this suggests that $C'1$ is not directly involved. It has also been observed that immune hæmolysis can be inhibited by sulphydryl compounds, esters of arginine and lysine, amides and esters of tyrosine, and peptides with a terminal aromatic amino-acid exhibiting a free carboxyl group[11]. Although sulphydryl compounds and esters of arginine and lysine were not inhibitory in our system, esters of aromatic amino-acids or compounds ending with an aromatic amino-acid with a free carboxyl group were inhibitory. There is thus only partial correspondence between immune hæmolysis and anaphylactic release of histamine. This would be most readily explained by the participation in anaphylaxis of a factor with a substrate specificity similar to that of one of the components of complement.

Table 2. COMPOUNDS WHICH INHIBIT THE ANAPHYLACTIC RELEASE OF HISTAMINE FROM CHOPPED, SENSITIZED GUINEA PIG LUNG

Class of inhibitor	Minimal concentration in m*M* giving greater than 50 per cent inhibition
I. *Chymotrypsin substrates*	
Glycyl-L-tyrosinamide	20
L-Tyrosine ethyl ester	5
N-Acetyl-L-tyrosine ethyl ester	5
L-Phenylalanine ethyl ester	5
II. *Bifunctional chymotrypsin inhibitors*	
DL-Phenylalanine	20
DL-Tryptophan	20
Acetyl-DL-phenylalanine	20
Glycyl-DL-phenylalanine	20
Acetyl-DL-tryptophan	20
Phenylacetic acid	5
β-Phenylpropionic acid	2·5
β-Indoleacetic acid	2·5
β-(β-Indole)propionic acid	2·5
III. *Monofunctional chymotrypsin inhibitors*	
Phenol	1
Skatole	1
Indole	0·5
IV. *Organophosphorus esterase inhibitor*	
Di*iso*propylfluorophosphate	5

The fact that cysteine does not release histamine or enhance antigenic release of histamine suggests that the chymotrypsin-like step is not a simple activation of the intracellular peptidase, cathepsin *C*; furthermore, cathepsin *C* is not inhibited by di*iso*propylfluorophosphate[12]. On the other hand, the chymotrypsin-like activity which is exhibited by suspensions of isolated, intact mast cells from non-sensitized rats is different from cathepsin *C* in that it does not require dipeptide substrates and is inhibited by di*iso*propylfluorophosphate[13]. The participation of such a chymotrypsin-like enzyme in histamine release is compatible with our findings. However, the rat mast cell activity was demonstrated without prior activation by an antigen-antibody reaction. Thus, unless the enzyme was activated during isolation or assay, it follows that the rat mast cells do not contain the inactive precursor form which appears to exist in guinea pig lung tissue.

The observation that the anaphylactic release of histamine from sensitized guinea pig lung is prevented by chymotrypsin substrates and inhibitors but not by trypsin substrates and inhibitors implies that activation of a chymotrypsin-like enzyme is a necessary condition for the anaphylactic release of histamine from guinea pig lung. It does not imply, however, that this alone is a sufficient condition. Indeed, since bifunctional chymotrypsin inhibitors are also effective carboxypeptidase inhibitors, enzymes of the latter group could also play a part in the guinea pig system studied. All our evidence is against a trypsin-like enzyme being involved and, contrary to previous reports[14], trypsin (Armour crystalline trypsin 1,600 μgm./ml. reaction mixture) did not release histamine from the blood-free tissue used in these experiments. Chymotrypsin (Armour crystalline chymotrypsin 1,600 μgm./ml. reaction mixture) also failed to release significant quantities of histamine, but this simply means that extracellular chymotrypsin of pancreatic origin is not an adequate substitute for the antigen-activated chymotrypsin-like enzyme.

[1] Mongar, J. L , and Schild, H. O., *J. Physiol.*, **135**, 320 (1957).

[2] Brocklehurst, W. E (reported by Becker, E. L., in "Mechanisms of Hypersensitivity", ed. by Shaffer, J. H., Logrippo, G A., Chase, M. W , 305 (Little, Brown and Co., Boston, 1959)

[3] Green, N. M., and Neurath, H., in "The Proteins", ed. Neurath, H., and Baily, K , II B, 1057 (Academic Press Inc., New York, 1954).

[4] Huang, H. T., and Niemann, J., *J. Amer. Chem. Soc.*, **75**, 1395 (1953).

[5] Cunningham, L. W., *J. Biol. Chem.*, **207**, 443 (1954).

[6] Jansen, E. F., Fellows Nutting, M. D., Jang, R., and Balls, A. K., *J. Biol. Chem.*, **179**, 189 (1949).

[7] Heinicke, R. M., and Mori, R., *Science*, **129**, 1678 (1959).

[8] McIntire, F. C., in "Histamine", ed. Wolstenholme, G. E. W , and O'Connor, C. M., 416 (J. and A. Churchill, Ltd., London, 1956).

[9] Becker, E. L., *J. Immunol.*, **77**, 462 (1956).

[10] Ratnoff, O. D , and Lepow, I. H , *J. Exp. Med.*, **106**, 327 (1957).

[11] Cushman, W. F , Becker, E. L , and Wirtz, G., *J. Immunol.*, **79**, 80 (1957).

[12] Fruton, J. S , and Mycek, M. J., *Arch. Biochem. Biophys.*, **65**, 11 (1956).

[13] Benditt, E. P., and Arase, M., *J. Exp. Med.*, **110**, 451 (1959).

[14] Rocha e Silva, M., in "Histamine", ed. Wolstenholme, G. E. W., and O'Connor, C. M., 124 (J. and A. Churchill, Ltd., London, 1956).

HERITABLE CHANGES IN LACTIC STREPTOCOCCI INDUCED BY PHYSICAL TREATMENTS

By B. S. GOSSLING

Research Laboratories of the General Electric Co., Ltd., Wembley, England

LYSIS of cultures of lactic streptococci by bacteriophage was unexpectedly found to be prevented by a violent electrical treatment of the host alone, and this resistance was heritable. In further investigations other physical treatments were similarly effective, and all treatments produced additional heritable changes, two of which were common to the whole surviving population.

The strains of lactic streptococci used were all received by courtesy of Dr. A. A. Nichols of United Dairies, Ltd., and had been selected for early and rapid production of lactic acid from milk. Each responded to a specific phage preparation provided with it.

Six methods of treatment were used, though most of the work was done with the first and sixth to be described.

(1) By strong pulses of ionic current as described in a previous communication[1] and shown in Fig. 1; the lethal effects of this can be ascribed to violent disturbances of the ionic double-layer at the surface of the organism. This was the treatment which first revealed the main effects.

(2) Change of ionic environment[2] following resuspension in phosphate buffer of a deposit centrifuged from Ringer's solution, or vice versa; the resulting sudden disturbance of the double-layer reproduces several of the lethal effects of the more violent ionic currents[1].

(3) Irradiation with germicidal ultra-violet light.

(4) Thermal shock by moderate rapid heating with a rise of 10–15 deg. C. in 5 sec. in a heat-exchanger, repeated 15 or 20 times after intermediate coolings.

(5) Similar repeated heating in 1/50 sec. by 1,500 c./s. alternating current, the small lethal effects of which are not electrical[1].

(6) Heating to a near-lethal temperature reached in 4 min. and thereafter held constant for 5–35 min. according to the strain used and to the severity desired.

In spite of their variety, all these kinds of treatment produced substantially the same effects on all strains tested, provided they were carried to a point where a considerable fraction had lost viability; differences between strains were in degree and not in kind.

Besides suppressing lysis, all the treatments caused other properties of the culture to change, all changes showing continuously progressive development according to the amount or severity of the treatment. Most of the characteristic changes are illustrated in Figs. 1 and 2.

Fig. 1 shows what can be learnt from turbidimetric growth curves[3]. The 'control' curve shows the growth of the untreated culture, and the increasing mortality in the uninfected samples is indicated by the progressive displacements of curves 1–6, curve 6 corresponding to about 10 per cent survival. The 'infected control' curve shows the lysis loss on infection, with a final rise which is the growth of

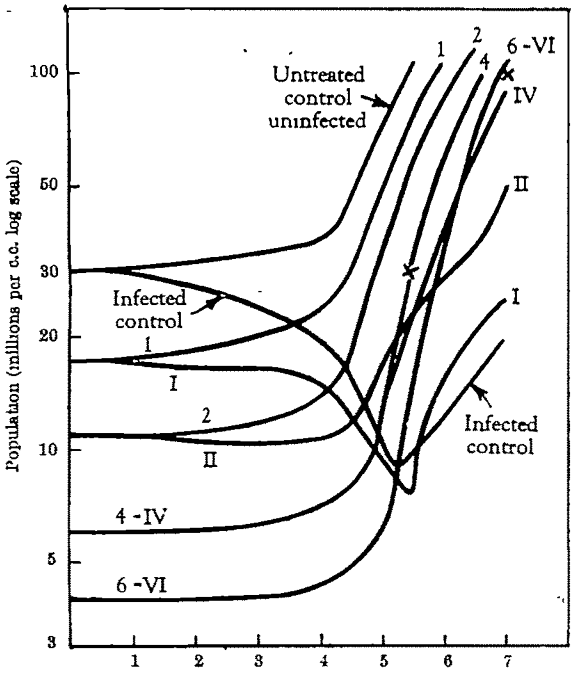


Fig. 1. Turbidimetric growth curves for *Str. lactis* strain M_1S_1 after treatment by pulses of current. Samples taken at six stages of treatment in yeast–dextrose broth with 1·8 μsec. current pulses, 10 per stage, at 53 amp. per sq. cm., 18·5 kV. per cm., that is, power-density 750 kW. per c.c.; temperature rise, 3 deg. C. per stage, annulled by cooling between stages. Control curves from the same culture untreated, curves 1–6 treated but uninfected, curves I–VI infected after treatment, curves 6 and VI are coincident. The points × × exemplify the log-phase growth of the 1/10 dilution of the control; hence curve 6 represents about 10 per cent survival (ref. 2)

A near-lethal heat-treatment gave after 8 min. at 55° C. curves identical with curves 1 and I, and after 25 min. at 55° C. curves identical with curves 6 and VI

the unlysable fraction, 1 in 5,000 by colony counts, of the culture. After the first stage, curve I, there is less lysis, after the second, curve II, scarcely any; but with this strain, though not with some others, growth is delayed by infection and displacements of growth curves are the inverse of those of the uninfected until, after the sixth stage, infection has no effect. This phase of delayed growth does not imply loss of viability, for samples 2–6 give the same colony counts after infection as before. It was the observation of a curve such as VI and later of the coincidence of curves such as 6 and VI that initiated the work.

The growth of the survivors in curve VI, some 10 per cent of the original culture, greatly exceeds the after-growth of the infected control, leaving out of account probable mortality[1] in the treated unlysables, which have been identified as streptococcal. This excess is more clearly shown when survivals and the effects of infection are determined by colony counts; infection which only 0·02 per cent of the control survive has negligible effect on the 10 per cent of the culture which are viable after treatment.

From these quantitative considerations, which are universally applicable to the results of experiments using all the methods of treatment, it is inferred that resistance to lysis has been induced in the entire surviving population and in their descendants, whether during the 7-hr. incubation of Fig. 1 or on the plates. This heritable change has been found to persist during as many as eighty subculturings of one strain, M_1S_1 (Nichols).

Fig. 2, typical of all observed cases, shows by fall of *p*H the progressive changes in acid production from milk inoculated from over-night subcultures from the uninfected samples of Fig. 1: tests by titration or clotting time are concordant. The treatment itself, curves 1–6, causes a progressive slowing of acid production; infection increases this greatly at first, but thereafter less and less until the coincidence of curves 6 and VI shows its effect to have vanished. Later subcultures, again up to 80, have yielded identical curves. One strain susceptible to two phages has had this response to both phages similarly modified by treatment.

The complex process of spontaneous reproduction can apparently be interrupted without the simpler process of acid production being affected, for when tests immediately after treatment are compared with those after subculture, it is always found that mortalities of well over 90 per cent in the first test do not prevent the production of just as much acid as does the restored fully viable population in the subculture. Again, revival of half the non-viables by visible light (after ultra-violet irradiation), or by addition of sodium thioglycollate except after near-lethal heating, produces little or no more acid.

The simultaneous disappearances of the slowing of acid production in all strains, Fig. 2, and of the delay in growth, Fig. 1, of some only, may represent suppression of non-lethal 'reversible' phage-attachments at different sites. Some sites for acid-slowing can be restored by subculture in presence of whey, autolytic products, or even live organisms of the same strain, but not by those from a different strain.

Acid production being a quantitative property, not 'all or nothing' like lysis, the distributions of heritable changes in acid production among the population have been studied by the method of colony isolations.

In Figs. 3*a*, *b* and *c*, typical histograms show no great departures from homogeneity at all stages of a rather gentle heat treatment. Fig. 3*b* represents isolations after a first treatment in bulk of the culture which gave Fig. 3*a*. Further treatments followed, each of a culture from a single average isolation from the preceding. Fig. 3*c* shows the histograms after the third treatment, the majority being then unchanged by infection.

The compact groups of Fig. 3*b* have moved as did the 5-hr. points for a bulk culture in curves 1 and I of Fig. 2, but there are no overlaps with the groups of Fig. 3*a*. This cannot be ascribed to selective elimination of all trace of representatives of the

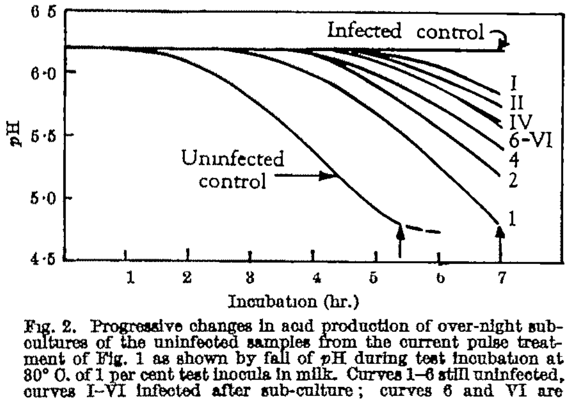


Fig. 2. Progressive changes in acid production of over-night subcultures of the uninfected samples from the current pulse treatment of Fig. 1 as shown by fall of *p*H during test incubation at 30° C. of 1 per cent test inocula in milk. Curves 1–6 still uninfected, curves I–VI infected after sub-culture; curves 6 and VI are coincident. ↑ ↑, clotting points

The near-lethal heat-treatment gave after 8 min. at 55° C. curves identical with curves 1 and I, and after 25 min. at 55° C curves identical with curves 4 and IV

Fig. 3a

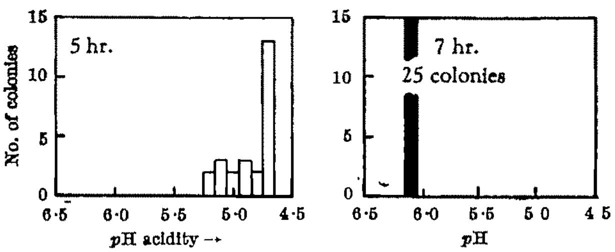


Fig. 3b

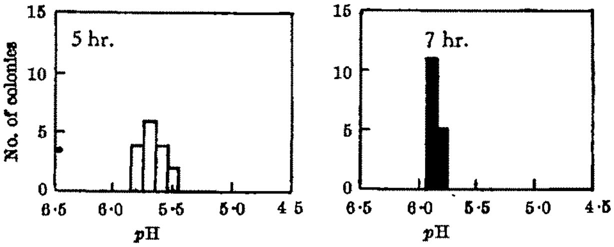
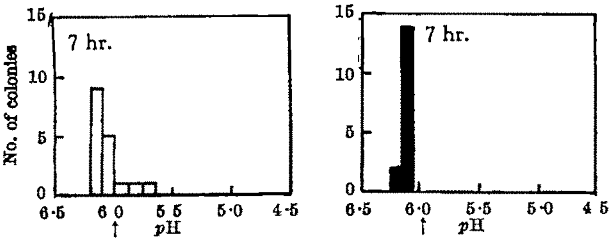


Fig. 3c



Figs. 3*a*, 3*b*, 3*c*. Distributions of acid production among random colony isolations from cultures of *Str. lactis* strain *U.D.* 852, both untreated and after successive near-lethal heat-treatments, each of 25 min. at 55° C. The number of hours of incubation before test is shown for each distribution on its diagram; in Fig. 3*c* uninfected this was 2 hr. longer. Infections come immediately before incubation

(*a*) Untreated. (*b*) after first treatment; (*c*) after third treatment.
↑ ↑ Repeat of *p*H test after nine subcultures, showing some recovery from slowing due to repeated plating

untreated distribution: the mortality was much too small for that.

For the changes in acid production, the inference is again that the entire population, whether infected or uninfected, has experienced continuous changes, the heritability of which is exemplified by the arrows below Fig. 3c after nine subcultures of a single isolation, supported by other cases of continued subculture of isolations from earlier stages of treatment.

The comprehensiveness of the changes is supported by 198 untreated isolations, and by 106 treated, all showing similar compact distributions and displacements after treatment. The original objective of the isolations was to locate individuals the acid production of which was less seriously impaired, but in the event there was little promise of that.

Many of the tests were made using dispersed colonies as the inocula. This was done to avoid any changes of the distributions during subculture. However, when in a number of cases tests were repeated after a subculture, the difference in the results for each isolation was insignificant.

It is common experience that the selected property of rapid production of acid is usually retained only if daily subculturing is not interrupted for more than two days. After freeze-drying it is also lost, but only transitorily, being restored after a few subculturings[3]. In contrast, the modifications induced in the degree of lysis and in acid production by the more drastic physical treatments described here are much more persistent, and are found in all members of the surviving population, perhaps because propagation has been by binary fission[4]. Since other properties besides these are also heritably affected, it would seem that these sensitive strains of lactic streptococci provide a field for the study of induced heritable changes which may prove to be of similar universal incidence.

A detailed account of this work has been prepared for publication.

[1] Gossling, *Nature*, 184, 1881 (1959).

[2] Gossling, *J. Appl. Bact.*, 21 (2), 220 (1958).

[3] Nichols and Hoyle, *J. Dairy Res.*, 16, 167 (1949).

[4] Hinshelwood, *Nature*, 178, 1261 (1956).

INCREASE OF SETTLEMENT SIZE AND POPULATION SINCE THE INCEPTION OF AGRICULTURE

By Dr. MAX PETTERSSON
Brunel College of Technology, London, W.3

THE encampments of mesolithic food-gatherers commonly occupied no more than 500 m.^{2}; and the first agricultural settlement was probably about that size. To-day, Greater London occupies more than 10^9 m.^{2}. How has 'maximum size of settlement' varied, during the long period in between? Some relevant data are assembled in Table 1. Most are from the late Prof. V. Gordon Childe. It will be seen that the criteria which he employs lead to estimates which are somewhat on the low side. The logarithms of the area of the largest of these settlements at each period (with asterisk) are plotted in Fig. 1. Hence during the proto-agricultural stage[1], maximum settlement size has, as a first approximation, increased exponentially. Its doubling time is about 600 years; and there seems little doubt that this upsurge is primarily due to the inception and development of food-production, by farming. Since about A.D. 1500, however, in the scientific stage of social evolution[1], maximum settlement area seems (Fig. 1) to have increased still more steeply.

One may, of course, estimate the coefficient of correlation between maximum settlement size and time. For this purpose, the following points were used: Greater London, Greater Rome, Alexandria, Ninevah, Erech, Ur, Naqada, Merimde, Jericho, and a mesolithic camp as at 9000 B.C. A significant coefficient of $+0.96$ was obtained, with $P \ll 0.01$.

The inception of agriculture (*sens. lat.*), in the form of vegeculture[2], may well have been effected by a

Table 1. AREA AND POPULATION OF SETTLEMENTS

Emphasis is on the largest settlements of each period, but a few smaller settlements are included to give perspective. The terms used in columns 8 and 9 are explained in the text

1	2	3	4	5	6	7	8	9	10
			Area estimate		Population estimate				
Cultural stage	Date (approx.)	Settlement and location	Area (hectares)	Log (based on sq. m.)	Population (in thousands)	Log pop.	Probable category	Hence probable class of settlement	Authority for area or population
Food-gathering stage	ancient	known mesolithic encampment, larger, Old World	0 05	2·7*		[? 1·4]			Clark (ref. 3, p. 197)
	recent	camp of wandering band, ? modal	[? 0·05]	[? 2·7]	0·025	1·4*	power-1	monopol	Goldschmidt (ref. 4, p. 187)
	recent	permanent village, larger, North America	[? 0·20]	[? 3·3]*	0·1	2*	power-2	dipol	(ref. 4, p. 191)
Proto-agricultural stage	10,000–8000 B.C.	inferred earliest agricultural settlement	c. 0·05	2·7	c. 0 025	1 4	power-1	monopol	
	7000–6000 B.C.	Jericho I, Jordan	2·43	4·4*		[? 3]*	power-3	tripol	Childe (ref. 5, p. 36)
	5000–4000 B.C.	Merimde, Egypt	2·43	4 4*			power-3	tripol	(ref. 6, p. 140)
	4000–3000 B.C.	Naqada, Egypt	12·1	5 1 }*			? power-4	? tetrapol	(ref. 6, p. 141)
	4000–3000 B.C.	Halafian, larger, Iraq	12·1	5·1 }			? power-4	? tetrapol	(ref. 6, p. 155)
	3000–2000 B.C.	Ur, Iraq	60·7	5 8*	24	4·4*	power-4	tetrapol	(ref. 7, p. 94)
	3000–2000 B.C.	Khafajah, Iraq			12	4·1	power-4	tetrapol	(ref. 7, p. 94)
	2000 B C.	Erech, Iraq	520	6·7*			power-5	pentapol	(ref. 6, p. 155)
	2000 B.C.	Mohenjodaro, Pakistan	260	6·4			power-5	pentapol	(ref. 7, p. 125)
	2000 B C.	Ur, Iraq	89	5 9			? power-5	? pentapol	(ref. 6, p. 155)
	1500–1000 B.C.	Mycenæ, Greece, within wall	4 8	4·7			power-3	tripol	(ref. 6, p. 46)
	1500–1000 B.C.	Mycenæ, Greater	? 9	5·0			power-3	tripol	(ref. 6, p. 46)
	1500–1000 B.C.	Troy VII *A*, Turkey, within wall	? 2·7	4·4					Lloyd (ref. 8, p. 151)
+ Iron	700–600 B.C.	Ninevah, Iraq	728	6 9*			? power-5	? pentapol	Childe (ref. 7, p. 194)
	500–400 B.C.	Athens, Greece			300	5·48*	? power-5	? pentapol	(ref. 7, p. 198)
	100 B.C.	Seleucia, Iraq			600	5·8*	power-6	hexapol	(ref. 7, p. 232)
	100 B.C.	Alexandria, Egypt	890	6 9*			? power-6	? hexapol	(ref. 7, p. 232)
	A.D. 200	Rome, Italy	1,240	7·1*			power-6	hexapol	(ref. 7, p. 262)
	A.D. 200	Rome, within Aurelian wall	1,390	7 1			power-6	hexapol	Carcopino (ref. 9, p. 24)
	A.D. 200	Rome, within toll cordon	2,010	7·3			power-6	hexapol	(ref. 9, p. 25)
	A.D. 200	Rome, Greater	[? 3,000]	[? 7·5]*	1,200	6 1*	power-6	hexapol	(ref. 9, p. 31)
	A.D. 200	London, U.K.	121	6 1					Childe, (ref. 7, p. 262)
	A.D. 200	London, U.K.	131	6·1					Richmond (ref. 10, p. 74)
	A.D. 200	London, U.K.			20	4 8	power-4	tetrapol	Fleure (ref. 11, p. 316)
	A.D. 200	Cirencester, U.K.	101	6·0			power-4	tetrapol	Childe (ref. 7, p. 262)
	A.D. 200	Caerwent, Mon., U.K.	17·8	5 3			? power-3	? tripol	(ref. 7, p. 262)
Scientific stage	A.D. 1500	London, U.K.			75	4·9	power-5	pentapol	Bindoff (ref. 12, p. 40)
	A.D. 1750	London, U.K.			750	5 9	power-6	hexapol	Carter and Goldfinger (ref. 13, p. 14)
	A.D. 1936	London, U K., L.C.C.	30,300	8 5*	4,140	6 6	power-7	heptapol	(ref. 13, p. 2)
	A.D. 1931	London, Postal area	60,600	8·8*	6,410	6·8	power-7	heptapol	(ref. 13, p. 2)
	A.D. 1936	London, Greater	179,000	9 3*	8,580	6 9*	power-7	heptapol	(ref. 13, p. 2)
	A.D. 1936	London, Metropolitan traffic area	626,000	9 8*	10,010	7 0	power-7	heptapol	(ref. 13, p. 2)
	A.D. 1955	Cirencester, U K.			11·7	4 1	power-4	tetrapol	A.A. Handbook, 1956, p. 88
	A.D. 1955	Caerwent, Mon., U.K.			1 33	3 1	power-3	tripol	A.A. Handbook, 1956, p. 74

hitherto mesolithic group of only some 25 persons. Agriculture presumably arose in the parallelograms of Figs. 1 and 2; and probably between 8,000 and 10,000 B.C.

The estimates of the populations of ancient settlements are still more tentative than those of their area. Even for modern settlements, regions and countries, we seem to need, for conceptual purposes, some more precise way of expressing the order of magnitude of their populations. Hence let any number between $10^{2\cdot5}$ and $10^{3\cdot5}$ be regarded as a 'power-3' number, and so forth. (Compare *p*H and *pF*.) Then, with regard to their populations, the Vatican State or City and the village of Caerwent in Monmouthshire are both power-3; while London and the Netherlands are both power-7. Over a range of time, there is the notorious difficulty that what is called a city in one age would be called a town, or merely a village, in another. Hence let a 'settlement of power-4-population', such as Third Millenium Ur or Roman London, be regarded as a 'tetrapol', and so forth, as in Table 1. (Gr. *polis*, a city; and compare tetravalent and tetraploid.) 'Power-3' is a much wider category than 'about a thousand'; yet also a precise category. Due to this great width, or 'height', of category, far more than half the entries in columns 8 and 9 of Table 1 will be correct. For the proto-agricultural stage, though not for modern industrial society, column 7 entries can, very roughly, be obtained by subtracting 1·5 from those in column 5. But for the climatic zone containing the Near East[7] it is an improvement to use 1·4, and for the more northerly zone[11] evidently 1·7 or so.

An interesting by-product of this study is an elucidation of the status of Mycenæ, the capital of 'King Agamemnon', and of the Troy of 'King Priam'

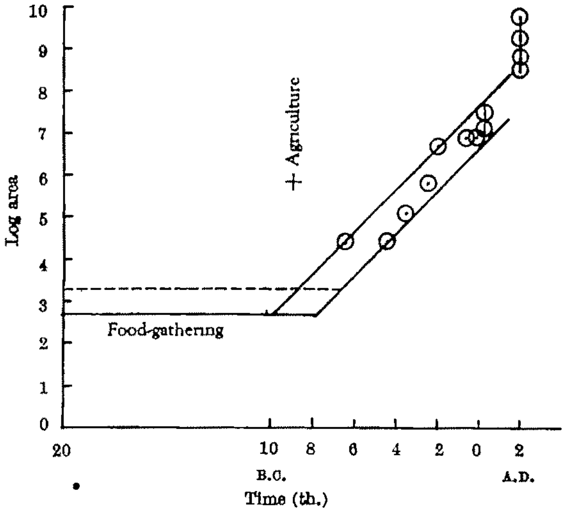


Fig 1. Logarithm of maximum settlement, against time. The levels and points plotted may be identified from Table 1, where they are marked by an asterisk. The two points for Rome have been linked, as also the four points for modern London

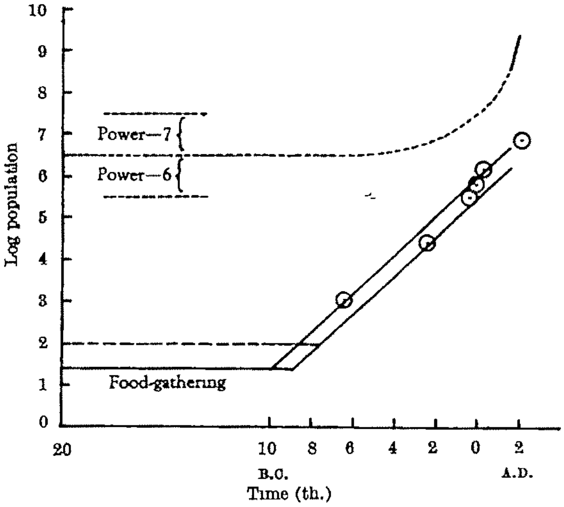


Fig. 2. Logarithm of population, against time. Below, the levels and points plotted refer to maximum settlements, and may be identified from Table 1. Above, the probable course of world population, little known before A.D. 1500

and Homer's "Iliad". Intramural Mycenæ and the famous Troy were—like Caerwent, Aldeburgh and the Vatican City—both tripols.

What is the commonest or modal settlement size at different periods ? Data on England and Wales to-day are provided by the Automobile Association Handbook. Making allowance for conurbations, a sample of 300 settlements was grouped logarithmically according to population, and showed the following distribution of frequencies :

Hexapols		1 per cent
Pentapols		7 ,,
Tetrapols		25 ,,
Tripols		44 ,,
Dipols	? 21	23 ,,
Monopols	? 2	

Thus the modal category is that centred at 10^3 ; and the population of the modal settlement is rather less than the square root of that of the region's largest. But a more exhaustive enumeration of smaller settlements might well take the mode down towards $10^{2.5}$. Hence in England and Wales at A.D. 1500, the modal settlement is likely to have had not more than some $10^{2.5}$ inhabitants. But in mesolithic times, the modal settlement seems likely to have had at least $10^{1.4}$ members[4]. Thus throughout the long proto-agricultural period, the modal settlement population seems to have increased by a factor of only about 10. In contrast, maximum settlements have increased by a factor of about 10^5 (Figs. 1 and 2), and at a far greater rate than total population.

A fairly firm estimate can be deduced for world population in A.D. 1500, being $10^{8.5}$, or about 350 million[14]. A tentative estimate of the population of mesolithic England and Wales is $10^{3.5}$, or about 3,250 (ref. 3, 1). The world population of food-gathering *Homo sapiens* at 10,000 B.C. will, clearly, be between these two limits. The world land area happens to be 10^3 times that of England and Wales. Thus if England and Wales were an averagely populated mesolithic habitat, the pre-agricultural world population would be about $10^{3.5+3} = 10^{6.5}$. On the other hand, if the proto-agricultural increase in total population were by 10^2, or by about the square of increase in modal settlement, the world population at 10,000 B.C. would be $10^{8.5-2}$; and thus also $10^{6.5}$. Hence the population at 10,000 B.C. seems likely to have been somewhere between one million and ten million ; and *Homo sapiens* is almost certain to have been, at that time, either a power-6 or power-7 species (Fig. 2).

The curve of world population in the upper part of Fig. 2 would scarcely be expected to be step-like, due to the relatively slow diffusion of cultural innovations from their centres of origin. For example, South Africa was still mesolithic at the time that Britain was neolithic and when Iraq and Egypt had many tetrapol cities. But the three main stages[1] may be characterized thus :

(1) *Food-gathering.* In the half-million years up to 10,000 B.C., world population may possibly have increased overall by a factor of about 10^2, or less, corresponding to a doubling time of at least 75,000 years.

(2) *Proto-agricultural.* From 10,000 B.C. to A.D. 1500, world population probably increased overall by a factor of about 10^2, corresponding to a doubling time of about 1,730 years ; and during this period, the maximum size of settlement increased by a factor of about 10^5.

(3) *Early part of Scientific stage.* From 1500 to 1950, world population increased overall by a factor of about $10^{0.82}$, corresponding to a doubling time of about 164 years.

With regard to doubling time of population, the greater change is between (1) and (2), rather than (2) and (3).

---

[1] Pettersson, M., *Nature*, **184**, 481 (1959).

[2] Braidwood, R. J., and Reed, C. A., *Cold Spring Harbor Symp.*, **22**, 19 (1957).

[3] Clark, J. G. D., "Archæology and Society" (London, 1957).

[4] Goldschmidt, W., "Understanding Human Society" (London, 1960).

[5] Childe, V. G., "Prehistory of European Society" (Harmondsworth, 1958).

[6] Childe, V. G., "Social Evolution" (London, 1951).

[7] Childe, V. G., "What Happened in History" (Harmondsworth, 1954).

[8] Lloyd, S., "Early Anatolia" (Harmondsworth, 1956).

[9] Carcopino, J., "Daily Life in Ancient Rome" (Harmondsworth, 1956).

[10] Richmond, I. A., "Roman Britain" (Harmondsworth, 1955).

[11] Fleure, H. J., "Natural History of Man in Britain" (London, 1951).

[12] Bindoff, T. S., "Tudor England" (Harmondsworth, 1950).

[13] Carter, E. J., and Goldfinger, E., "County of London Plan" (Harmondsworth, 1945).

[14] Bowen, I., "Population" (Cambridge, 1954).

LETTERS TO THE EDITORS

RADIOASTRONOMY

Roughness of the Moon as a Radar Reflector

THE early work on radar reflexions from the Moon was carried out at metre wave-lengths with long pulses or with continuous wave giving a returned signal which was the total scattering from the lunar surface. Measurements showed that apart from a long-period fading produced by Faraday rotation of the linearly polarized waves in passing through the ionosphere, the reflected signal also had a short-period amplitude modulation produced by lunar libration. If a frequency analysis is carried out on these more rapid fluctuations, the different frequency components can be related to the Doppler frequency from the various regions on the Moon[1], and in this way Evans[2] indicated that most of the radiation was scattered from a central part of the optical disk of a radius only one-third of the lunar radius. More recently, with radars of higher peak power and μsec. pulse-lengths, it has been possible to confirm this result by direct measurement over the wave-length range of at least 10 cm. to 1·5 m. (refs. 3–5).

Senior and Siegel[6] have attempted to explain the radar echo as due mainly to specular reflexions from four or five regions concentrated towards the centre of the Moon which have dimensions comparable to a Fresnel zone and which are smooth to a fraction of a wave-length. To account for the shape of the radar echo each of these regions would have to reflect a signal comparable in amplitude to the signal that would be reflected from a smooth sphere of diameter equal to that of the Moon, and the leading edge of the echo would then remain sensibly constant in amplitude. However, the amplitude of the leading edge of the Moon echo as measured in Malvern with a 5-μsec. pulse-length shows no steady component but fluctuates in a random fashion with period closely related to the Doppler fading; also, a comparison of the signal at the leading edge with that obtained by Yaplee[4] using a 2-μsec. pulse-length shows that the mean amplitude is proportional to the pulse-length and hence to the area of surface illuminated. Further confirmation of the lack of single specular region from the near surface was obtained in a joint experiment with Straiton and Tolbert of the University of Texas[7], who received the pulses transmitted from Malvern after reflexion from the Moon. In this case the mean amplitude of the echo showed a gradual increase reaching a maximum after a time corresponding to a distance of 7·5 km. from the start of the echo. If the lunar surface consists of a large number of small random scatterers such as would be the case of an irregular surface, the expected delay would be about 9 km., in reasonable agreement with the observations, especially as the small difference could be accounted for by the initial rise being lost in the noise-level.

There is thus no evidence that the whole of the echo is due to components from a few large and comparatively smooth regions on the surface of the Moon, but rather that the echo is the result of scattering from a rough surface such that many irregularities contribute. It may be assumed that the surface has vertical irregularities which are greater than a wave-length and a horizontal scale which is considerably larger. If the scale of the irregularities were to increase or their amplitude to decrease, the surface would become smoother and the resulting scattering would tend more towards specular. If the scale were smaller then the scattering would become more isotropic. This latter type of surface would account for the nearly uniform scattering that we see at optical wave-lengths, but in this case it is the microscopic variation in the surface with scales measured in microns or less that predominates. The intermediate case would appear to represent the behaviour of the lunar surface at radio wave-lengths.

To determine the order of magnitude for the roughness, it was decided to measure more accurately the angular scattering properties of the lunar surface at the wave-length of 10 cm., using the 2-MW. radar transmitter in the 45-ft. diameter radio telescope and a pulse-length of 5 μsec. corresponding to a range-resolution of 0·75 km. Since the area of the lunar surface illuminated by the pulse at any one time is constant, the angular scattering law may be obtained by converting the distance travelled by the pulse after first contact with the Moon to angle of incidence at the surface. Because the maximum signal is only a few times greater than the noise-level, a 'range gate' was constructed which enables part of the echo to pass through an integrating stage; the range gate is automatically swept across the echo and the output of the integrator is displayed on a recorder. The duration of the gate was 20 μsec. and with an integration time of 2 sec. it was possible to measure signals which were about 3 per cent of the noise-level.

Thirty-one runs were obtained during the period November 27–December 11, and the mean of these, with corrections for finite width of the gate, shows a very close fit to an exponential law over a range of angles from about 3° to at least 14°. The ratio of the scattered power per unit surface area to the incident power flux, which we define as the effective scattering area per unit surface area, is given by:

$$\sigma = \sigma_0 \exp\{-10\,\theta\}$$

where θ is the angle of incidence and σ_0 is about 0·7.

This law of scattering is consistent with scattering from a rough surface which has irregularities much greater than a wave-length and a horizontal scale equivalent to about twenty times the vertical deviations. We can say that over representative areas of 8,000 km.^{2}, corresponding to the area of the Moon illuminated by a 5-μsec. pulse, the slope would appear to have a random distribution with a root mean square value of about 1 in 20. It is of interest that if we compare the scattering law of the lunar surface with that for the Sea[8] a similar high directivity is observed, but the value of σ_0 is of the order 10 to 100 depending on the state of the Sea. Since the dielectric constant of the Sea is high, and hence the reflectivity of the surface will be close to unity, this would indicate that the reflectivity of the surface of the Moon lies between 10^{-1} and 10^{-2}.

It may be possible to extend these results to the case of radar echoes from planets; but since the planets from which it is most likely that radar echoes can be obtained, Venus, Mars and Jupiter, probably have surfaces of much higher dielectric constant than the Moon, the value of σ_0 at normal incidence is expected to be greater by a factor of 10–100. On the other hand, σ_0 may be modified if the scattering law is appreciably different from that of the Moon, or if there is appreciable absorption due to ionization in the atmosphere of the planet. The total scattering area of the Moon, σ_T, is given by integrating σ over the whole of the surface and we get $\sigma_T = 1{\cdot}4 \times 10^{-2}\pi a^2$, where a is the lunar radius. The total scattering area of a planet would then be approximately equal to the projected area.

V. A. HUGHES

Royal Radar Establishment,
Malvern.

[1] Browne, I. C., *et al.*, *Proc. Phys. Soc.*, 69, 901 (1956).
[2] Evans, J. V., *Proc. Phys. Soc.*, 70, 1105 (1957).
[3] Trexler, J. H., *Proc. Inst. Rad. Eng.*, 46, 286 (1958).
[4] Yaplee, B. S., *et al.*, *Proc. Inst. Rad. Eng.*, 46, 293 (1958).
[5] Hey, J. S., and Hughes, V. A., I.A.U.—U.R.S.I. Paris Symposium on Radio Astronomy, 13 (Stanford University Press, 1959).
[6] Senior, T. B. A., and Siegel, K. M., I.A.U.—U.R.S.I. Paris Symposium on Radio Astronomy, 29 (Stanford University Press, 1959).
[7] Straiton, A. W., and Tolbert, C. W., University of Texas, Electrical Engineering Research Laboratory, Rep. No. 5–38 (1959).
[8] Grant, C. R., and Yaplee, B. S., *Proc. Inst. Rad. Eng.*, 45, 976 (1957).

ASTROPHYSICS

Solar Terrestrial Relationships

THE proper formulation of a theory of propagation of disturbance from the Sun to Earth must rest upon knowledge of the magnetic field and material density of the intervening space. An interplanetary density, at the Earth's orbit, of order 10^3 protons and electrons per cm.^{3} has been frequently assumed for theoretical purposes. There is now growing evidence that the density is considerably lower than this.

Recently, Sonett *et al.*[1] reported a rocket survey of the distant geomagnetic field carried out on a magnetically quiet day, October 11, 1958. They reported an inverse cube variation of field-strength out to 13·6 Earth radii, suggesting that at most the proton density in interplanetary space is 10^2 per cm.^{3}. However, disturbance recorded in the region 12·3–14·8 Earth radii may be explicable in terms of tangling of the geomagnetic field with an interplanetary magnetic field of order 10^{-4} gauss. In this case the estimate of 10^2 per cm.^{3} could be significantly reduced. Support for this view is found in the work of Block[2], who considers that a solar magnetic field of 10^{-4} gauss may exist in the vicinity of the Earth and that the proton density may be as low as 10^{-1} per cm.^{3}.

Pope[3] recently determined from a study of whistlers an electron density of 80 per cm.^{3} at 4 Earth radii, decreasing steadily to 15 per cm.^{3} at 5·8 Earth radii. This trend indicates lower values farther out. Allcock's[4] distribution of electron density determined from whistler observations extrapolates to 5 electrons per cm.^{3} at 5 Earth radii. Obayashi and Jacobs[5] have inferred from micropulsation studies that the interplanetary density may be of order 1 per cm.^{3}.

Lyman α observations have led Kupperian *et al.*[6] to a determination of between 15 and 45 protons per cm.^{3} in interplanetary space, while Shklovsky[7] derives an upper limit of 200. The latter points out that we cannot be certain whether the scattered Lyman α arises chiefly in the Earth's exosphere or in interplanetary space.

Considerable evidence then exists in favour of much lower proton densities in interplanetary space than was commonly assumed. Should the interplanetary density be as low as 1 proton per cm.^{3} and the resident magnetic field of order 10^{-4} gauss then hydromagnetic waves may be propagated from Sun to Earth all the time. It is just some such constant source of energy which is required to explain the quasi-permanence of magnetic disturbance and auroræ in high latitudes. I have initiated a theory[8,9] of solar terrestrial relationships based upon such a model. Hydromagnetic waves traverse 1 A.U. of such a medium in about a day.

One would expect the Earth to present a large capture cross-section to these waves (perhaps > 10 Earth diameters), for on reaching the vicinity of the Earth where the Earth's field is the same value as the interplanetary field, the waves may be guided down the geomagnetic field lines in the ordinary mode while suffering considerable refraction towards the Earth in the extraordinary mode. Moreover, these waves can cause corpuscular bombardment of the atmosphere[8]. In this way energy may be transmitted from the Sun to the Earth without actual transit of particles. Certainly the Earth may capture enough energy by this means to explain magnetic disturbance and auroræ. Assuming a perturbation magnetic field of a few gammas in interplanetary space, the Alfvén speed 10^8 cm. per sec. and a capture cross-section of 10 Earth diameters, then the rate of delivery of energy to the Earth is 10^{18} ergs per sec. This is adequate to explain intense magnetic disturbance.

I thank Dr. F. Jacka, chief physicist of this Division, for criticism.

K. D. COLE

Antarctic Division,
Department of External Affairs,
Melbourne.

[1] Sonett, C. P., Judge, D. L., Sims, A. R., and Kelso, J. M., *J. Geophys. Res.*, 65, 55 (1960).
[2] Block, L., *Arkiv for Fysik*, 14, 179 (1958).
[3] Pope, J. H., Final Rep. Contract *AF*19(604)-1859, Geophysical Institute of the University of Alaska (1959).
[4] Allcock, G. McK., *J. Atmos. Terr. Phys.*, 14, 185 (1959).
[5] Obayashi, T., and Jacobs, J. A., *Geophys. J.*, 1, 53 (1958).
[6] Kupperian, jun., J. E., Byram, E. T., Chubb, T. A., and Friedman, H., *Planet. Space Sci.*, 1, 3 (1959).
[7] Shklovsky, I. S., *Planet. Space Sci.*, 1, 63 (1959).
[8] Cole, K. D., *Planet. Space Sci.*, 1, 319 (1959). A weakness (not relevant to the above considerations) in this paper is corrected in a sequel paper in preparation.
[9] Cole, K. D., *Aust. J. Phys.* (in the press).

Secular and Periodic Motions of the Node of an Artificial Earth-Satellite

IN a recent paper on the effect of the Earth's oblateness on the orbit of a near satellite, King-Hele[1] mars an otherwise commendable presentation by abundant criticism of some earlier papers on this subject by myself and collaborators[2,3]. Although King-Hele's remarks were not so intended, his statements have had the effect of raising serious doubts about the validity of my early solutions and in particular about the usefulness of my approach to the problem of satellite orbit perturbations.

The particular comments by King-Hele that give cause for concern are: "Furthermore, the solution given by Blitzer *et al.* would seem to be incorrect, since a term is omitted in the equations leading up to it. Correct or not, the solution is so lengthy that no progress can be made towards higher-order solutions, and the rotation of the major axis is not obtained".

To set the record straight: (i) The solution referred to is quite correct, as a simple check against the differential equation would show. It so happens that a term in an intermediate step was inadvertently omitted—a mere typographical error. (ii) Concerning the rotation of the major axis, suffice it to say that this had been obtained and the result published[4] almost a year prior to publication of King-Hele's paper, which I now understand was written in 1957. (iii) I am glad to state that the extension of the method to include the higher-order terms proceeds in a direct and straightforward manner. Moreover, the procedure yields detailed information not only regarding the secular motions of the node and perigee but also for the periodic terms, including orbit inclination, major axis and eccentricity.

Due to space limitations only the following expression for the regression of the nodes (those points on the celestial sphere where the satellite crosses the equator) is presented at this time, because of its relevance to determination of the oblateness parameters from satellite observations.

$$\Delta\varphi = \frac{2\pi JR^2\cos i}{a^2(1-e^2)^2}\left\{1 - \frac{JR^2}{24a^2(1-e^2)^2}\left[4(3-20\sin^2 i) - e^2(4 + 5\sin^2 i)\right]\right.$$

$$\left. - \frac{JR^2}{12a^2(1-e^2)^2}\left[16(2-5\sin^2 i)e\cos\omega - (7-15\sin^2 i)e^2\cos 2\omega\right]\right\}$$

$$+ \frac{3\pi DR^4\cos i}{7a^4(1-e^2)^4}\left[(1+\frac{3}{2}e^2)(4-7\sin^2 i) - (3-7\sin^2 i)e^2\cos 2\omega\right]$$

Here $\Delta\varphi$ is the difference in right ascension between two successive ascending nodes, J and D are the coefficients of the second- and fourth-order harmonics in the potential function for the oblate Earth[5], R is the equatorial radius of the Earth, i is the inclination of the orbit to the equator, a and e are the semi-major axis and eccentricity of the osculating ellipse corresponding to the satellite at the node, and ω is the argument of perigee (angular distance from the node to perigee).

Note that: (1) The above expression is valid for arbitrary orbit inclination and eccentricity. (2) The linear term in J contributes only to the secular motion of the node. (3) The quadratic J^2-term contributes a constant (secular) plus two periodic terms; one periodic term has the period of precession of perigee, the other is a smaller term with half the period of perigee motion. (4) The D-term also contributes a constant (secular) term plus a periodic term having half the period of perigee motion. (5) The secular contribution of the D-term is a regression of the nodes for orbit inclinations less than 49·1° ($\sin^2 i = 4/7$); while for $i > 49{\cdot}1°$, the nodes advance. However, this motion is overshadowed by the dominant J-term.

It is of interest to calculate the magnitudes of the secular and periodic terms for satellite 1958β2 (*Vanguard* I). On the basis of the following data[6,7]: $(a/R) = 1{\cdot}3603$; $i = 34{\cdot}26°$; $e = 0{\cdot}1896$; $J = 1{\cdot}6232 \times 10^{-3}$; $D = 0{\cdot}885 = 10^{-5}$; we find the separate contributions of the J and D terms to be:

$$\Delta\varphi \text{ (deg./rev.)} = (0{\cdot}281 - 2{\cdot}79 \times 10^{-4}\cos\omega + 1{\cdot}79 \times 10^{-6}\cos 2\omega)_J + (3{\cdot}58 \times 10^{-4} - 5{\cdot}37 \times 10^{-6}\cos 2\omega)_D.$$

The dominance of the linear (secular) term in J is quite evident.

LEON BLITZER

Department of Physics,
University of Arizona,
Tucson, Arizona.

---

[1] King-Hele, D. G., *Proc. Roy. Soc.*, A, **247**, 49 (1958).

[2] Blitzer, L., Weisfeld, M., and Wheelon, A. D., *J. App. Phys.*, **27**, 1141 (1956).

[3] Blitzer, L., and Wheelon, A. D., *J. App. Phys.*, **28**, 279 (1957).

[4] Blitzer, L., *J. App. Phys.*, **28** 1362 (1957).

[5] Jeffreys, H., "The Earth", fourth edit., chapter 4 (Camb. Univ. Press, 1959).

[6] Orbital data as issued by *NASA* on Jan. 20, 1960.

[7] Values of J and D from Lecar, Sorenson and Eckels, *J. Geophys. Res.*, **64**, 209 (1959).

PROF. BLITZER has, I fear, misinterpreted my comments on his papers. First, I am glad to know that his solution for radial distance was correct. When I found the error in the intermediate equation, it did not seem worth carrying on with checking the analysis, which was extremely lengthy. I made it clear that my doubts about the correctness of the solution were based solely on the error in the intermediate equation. I then went on to say, "the solution is so lengthy that no progress can be made towards higher-order solutions, and the rotation of the major axis is not obtained". Here I was not making a prophecy but only a statement of fact: in the papers I was referring to, there was no progress towards a higher-order solution, and the rotation of the major axis was not obtained. My statement was therefore correct. Next, as is clearly stated on its second page, my paper was "a shortened version of a Ministry of Supply report issued in October 1957", and was written in the summer of 1957. It is therefore scarcely surprising that I made no reference to the paper (his ref. 4) by Prof. Blitzer, which was not published until November 1957.

Finally, Prof. Blitzer may be glad to know that I believe his equation for $\Delta\varphi$ is correct, if osculating elements are used, since it agrees with results obtained by other authors.

D. G. KING-HELE

Royal Aircraft Establishment,
Farnborough, Hants.

PHYSICS

Reduced Temperatures for Nucleation in Supercooled Liquids

THE various methods available for detecting a phase change may depend on spontaneous nucleation-rates which differ greatly in magnitude. Thus although, as nucleation theory shows, critical conditions for the threshold of change may be much the same for methods of widely different sensitivity they are nevertheless quite arbitrary. It therefore seems particularly interesting that critical supercoolings θ for droplets of molten metals and molecular liquids are roughly proportional to the absolute melting temperatures T_f (refs. 1, 2, and 3). Thus where $T_s = T_f - \theta$ is the freezing threshold these results indicate a value of about 0·8 for the reduced tempera-

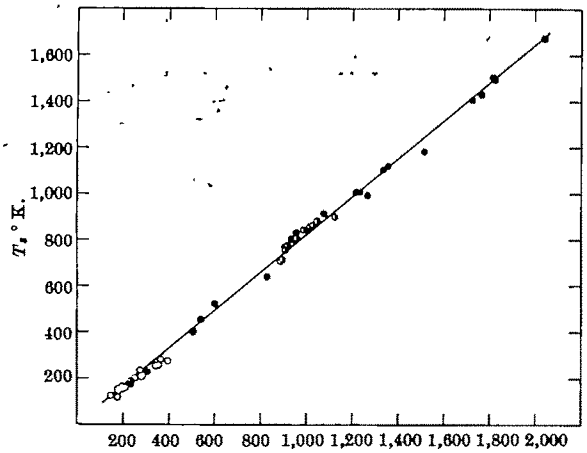


Fig. 1. Threshold of nucleation in supercooled liquids. ○, Molecular compounds (Staveley *et al.*, refs. 2 and 8); ◐, alkali halides (Buckle and Ubbelohde, refs. 4 and 5); ●, metals (Turnbull and Cech, ref. 1, and Turnbull, ref. 8)

ture $\theta = T_s/T_f$. Recent results for alkali halides[4,5] show that for these compounds $\theta \sim 0{\cdot}85$. In all these experiments the observation time was about 10 sec. irrespective of drop size. Collectively the results indicate a value of θ close to 0·82 (Fig. 1).

The parallelism between T_s and T_f, which extends over a very large range of temperature, does not seem to have been previously noted. It suggests some underlying connexion between the irreversible transformation of liquid to solid at the freezing point and the stable co-existence of these phases at the melting point. The value $\theta = 0{\cdot}82$ refers to the quite arbitrary limitations of present methods of observing nucleation. It therefore appears likely that θ will be constant at any given nucleation-rate.

In view of current interest in the problem of liquid structure it seems important to point out that the constancy of θ also shows that the sizes of crystal nuclei, as measured by the number of molecules g^* comprising them, are the same to within an order of magnitude for all the compounds examined. The specific rate of nucleation in supercooled liquids may be written[6]:

$$J = K\exp(-\Delta\Phi^*/kT)\ \text{sec.}^{-1}\ \text{cm.}^{-3}$$

where $\Delta\Phi^*$ is the free energy of nucleation and K is a factor which is relatively insensitive to temperature for liquids which do not form glasses. By specifying the rate J the values of both θ and $\Delta\Phi^*/kT$ are determined for any such liquid. For the nucleation threshold, therefore:

$$\Delta\Phi^*/kT_s = \ln(K/J_s) = c_s \text{ (a constant)};$$
$$\Delta\Phi^* = c_s\theta kT_f$$

Assuming that a crystal nucleus is adequately described by a simple model of the Volmer type[7]:

$$g^* = 2\Delta\Phi^*/\Delta\psi$$

where $\Delta\psi$ is the decrease of free energy per bulk molecule. By means of the relation[4]:

$$N\Delta\psi = \theta\Delta S_f$$

where ΔS_f is the molar entropy of fusion, the following expression is obtained for the number of molecules in the threshold nucleus:

$$g_s^* = 2c_sR\theta/[(1-\theta)\Delta S_f]$$

As c_s is roughly 60 (refs. 2, 4 and 8) a rule of thumb is:

$$g_s^* \sim 1{,}000/\Delta S_f$$

Metallic nuclei contain 200–400 atoms, while for molecular compounds g_s^* is mostly less than 200. Previous estimates of g_s^* for alkali halides[4] were based on inadequate fusion data. Recent determinations[9] of entropies of fusion show that the nuclei contain about 300 ions.

E. R. Buckle

Department of Chemical Engineering,
Imperial College of Science and Technology,
London, S.W.7.

[1] Turnbull, D., and Cech, R. E., *J. App. Phys.*, 21, 804 (1950).
[2] Thomas, D. G., and Staveley, L. A. K., *J. Chem. Soc.*, 4569 (1952).
[3] De Nordwall, H. J., and Staveley, L. A. K., *J. Chem. Soc.*, 224 (1954).
[4] Buckle, E. R., and Ubbelohde, A. R., Proc. I.U.P.A.C. Symp. on Thermodynamics (1959).
[5] Buckle, E. R., and Ubbelohde, A. R. (to be published).
[6] Turnbull, D., and Fisher, J. C., *J. Chem. Phys.*, 17, 71 (1949).
[7] Dunning, W., "Chemistry of the Solid State", ed. by Garner (Butterworths, London, 1955).
[8] Turnbull, D., *J. App. Phys.*, 21, 1022 (1950).
[9] Dworkin, A. S., and Bredig, M. A., *J. Phys. Chem.*, 64, 269 (1960).

Self-Quenching Geiger Counters containing Mixtures of Permanent Gases

In a recent communication, Collinson, Demetsopoullos, Dennis and Zarzycki[1] refer to a paper of mine[2] as negating the earlier work of Shore[3].

My paper, it is true, reports the failure of a mixture composed according to Shore's prescription, but it also states that xenon–oxygen fillings worked very well if a low oxygen content was chosen. Besides that, the paper says that no harm was done even by a continuous discharge, running for 1 hr. at 50 μamp. The startling quenching mechanism was explained by me as due to a certain resonance phenomenon, which had been found by the spectroscopists[4] and which occurs at very low oxygen contents only.

Perhaps the addition of nitrogen or argon results in a still unknown, but no less effectual mechanism, even at higher oxygen contents. Only by 'burning out' in a continuous discharge, however, can it be certain that no unintentional admixture of other gases or vapours provokes self-quenching behaviour in apparently pure permanent gases, as discovered by Bosch[5].

Oswald Riedel

Badische Anilin- und Soda-Fabrik AG.,
Ludwigshafen a. Rh.,
Germany.

[1] Collinson, A. J. L., Demetsopoullos, I. C., Dennis, J. A., and Zarzycki J. M., *Nature*, 185, 369 (1960).
[2] Riedel, O., *Z. Naturforsch.*, 5, a, 331 (1950).
[3] Shore, L. G., *Rev. Sci. Instr.*, 20, 956 (1949)
[4] Kenty, C., Aicher, I. O., Noel, E. B., Poritsky, A., and Paolino, V., *Phys. Rev.*, 69, 36 (1947).
[5] Bosch, C., *Ann. Physik*, 19, 65 (1934).

We feel that the xenon–oxygen phenomenon referred to by Dr. Riedel, although interesting, is only of importance in mixtures where xenon is the main gas. While such an effect is possibly a small contributory factor in the quenching mechanism of the argon–xenon–oxygen–nitrogen mixtures which we have investigated, our results show that the important mechanism is the interaction of xenon with argon metastable states.

It is most unlikely that the behaviour of these mixtures could be accounted for, as Dr. Riedel suggests, by the unintentional introduction of some other gas or vapour. This was shown by the constancy of the starting voltages of the counter even after many hours of continuous discharge. One counter in particular was run steadily for two months, recording 10^9 counts and operated in continuous discharge for about 30 min. each day. At the end of this period the starting voltage was unaltered, although the plateau length was increased.

We consider that Dr. Riedel's lack of success in obtaining Geiger counting regions with the Shore mixture can be attributed to the choice of cathode, namely, aluminium, and to the use of hard rubber in the construction of the counter, which precluded the possibility of baking, etc., during evacuation.

A. J. L. Collinson
I. C. Demetsopoullos
J. A. Dennis
J. M. Zarzycki

The Borough Polytechnic,
London, S.E.1.

MINERALOGY

A Regular Mixed-Layer Chlorite–Vermiculite Mineral

Various mixed-layer clay minerals have been reported in many publications. So far as the structure is concerned, the main interest in this field of investigations has been in examining the way of stacking in the direction along the perpendicular to the layer, and the order–disorder problem involved in these minerals has only been discussed in terms of the variations of X-ray basal reflexions.

The present work has been undertaken for a regular mixed-layer chlorite–vermiculite mineral with two main objectives in view: (1) to examine the change in basal reflexions in the course of dehydration; (2) to clarify the regularity of stacking parallel to the layer, which is shown by the presence of reflexions other than the (00*l*)'s.

A regular mixed-layer mineral was found in the alteration zone of mudstone belonging to a tertiary bed in Noto Peninsula, Japan, and its pure specimen was obtained by elutriating the crude clay. In view of the complexity of X-ray diffraction pattern of the mineral, two different specimens were provided for its X-ray examinations. The basal reflexions of the mineral were examined without ambiguity by using a completely oriented specimen which was obtained by the sedimentation method. The 29·2 Å. reflexion and the presence of the rational sequence of its higher-order reflexions indicate that the mineral is of regular mixed-layer type. A randomly oriented specimen yielded diffraction peaks corresponding to the (020), (20*l*), (13*l*) and (060) reflexions. The chemical composition, differential thermal analysis curve and *d*-spacing of the (060)—1·53 Å.—strongly suggest that the mineral is made up of the chlorite and vermiculite layers rather than the chlorite–montmorillonite.

By means of an X-ray diffractometer with a heating furnace, measurements were made of the changes in the diffraction lines when the specimens were subjected to heat treatment. As has been described by Walker[1], the dehydration process of vermiculite is somewhat complicated. It proceeds from the 14·8 Å. phase (fully hydrated), through the 13·6 Å. and 11·6 Å. phases, finally to the 9·1 Å. phase. Therefore, one may predict that heating of this mineral at 300° C. might result in the formation of a random mixed-layer lattice with the components of 26 Å. (14·4 + 11·6) and 23·5 Å. (14·4 + 9·1) layers. Of this mineral, however, a striking feature is that this is not the case. The close examination of the line profiles at 6–8° and 10–13° in 2θ with copper *Kα* radiation shows that there is a tendency for crystallites to segregate into two parts, namely, the 26 Å. and 23·5 Å. phases respectively. Further heating to 500° C. brings about a monophase again with the layer thickness of about 24 Å.

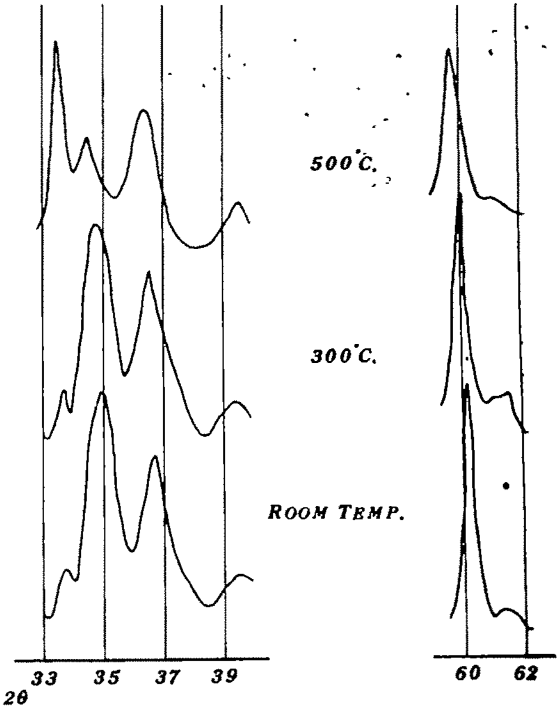


Fig. 1. Diffractometer traces at various temperatures

The evidence for a three-dimensional order in this mineral rests largely on the presence of diffraction peaks ranging from 30° to 40°. These reflexions are not observed in the diffraction pattern of the oriented specimen and are tentatively indexed as (20*l*) and (13*l*). The changes which occurred in the position and intensity of these reflexions on heating are shown in Fig. 1 together with the (060) reflexion. An expansion of the *b*-periodicity upon heating can be seen. It is not certain whether the expansion is merely due to the thermal vibration of atoms or to some structural change within the layer. Judging by the change in intensities of the (20*l*) and (13*l*) reflexions, however, we are inclined to think that the migration of atoms and the decrease in the degree of distortion of the silica-layer on heating would give rise to the lattice expansion of the layer.

The shrinkage in the *c*-periodicity would move the positions of the (20*l*) and (13*l*) reflexions toward the higher-angle side, whereas the expansion of the layer would result in the displacement of these reflexions toward the lower-angle side. In view of the small number of reflexions, little can be said concerning the indices of these reflexions or of the detailed structure of the mineral.

A detailed description of this work will be given in the near future.

M. NAKAHIRA
Department of Mineralogy,
Faculty of Science,
University of Tokyo,
Hongo, Tokyo.

S. SUGIURA
Department of Geology and Mineralogy,
University of Kanazawa,
Kanazawa.

[1] Walker, G. F., "Clays and Clay Minerals", 101 (1956).

RADIATION CHEMISTRY

Use of Nitrous Oxide to discriminate between the Forms of Hydrogen Atoms ($H^{\bullet}$ and H_2^+ ?) produced by γ-Irradiation of Aqueous Solutions

IN 1958 Proskurnin and Chernova[1] reported that $G(Fe^{3+})$ for oxygen-free solutions of ferrous sulphate saturated with nitrous oxide in 0·8 N sulphuric acid irradiated with cobalt-60 γ-rays has a value of between 12 and 13 which depends on the concentration of ferrous ion. This is larger than the value of 8·2 obtained for completely degassed solutions[2,3] and Proskurnin and Chernova suggested that the difference might be due to the occurrence of reactions (1) and (2):

$$NNO + H \rightarrow NNOH \quad (1)$$

$$NNOH + Fe^{2+} \rightarrow N_2 + OH^- + Fe^{3+} \quad (2)$$

However, since every hydrogen atom generated in a completely degassed solution of ferrous sulphate in 0·8 N sulphuric acid always oxidizes a ferrous ion according to reaction (3a) or (3b) or to the reaction sequence (3c):

$$H + Fe^{2+} . H_2O \rightarrow H_2 + Fe^{3+} + CH^- \quad (3a)$$

$$H + H^+ + Fe^{2+} \rightarrow H_2 + Fe^{3+} \quad (3b)$$

$$H + H^+ \rightarrow H_2^+ ;\ H_2^+ + Fe^{2+} \rightarrow H_2 + Fe^{3+} \quad (3c)$$

it is not clear why the presence of nitrous oxide should have any effect on $G(Fe^{3+})$.

In order to clarify the situation and because reaction (1) may in fact be (4):

$$N_2O + H \rightarrow N_2 + OH \quad (4)$$

and thus provide a much-needed ready means of converting hydrogen atoms into hydroxyl radicals, we have undertaken a more detailed investigation of the radiation chemistry of aqueous solutions containing nitrous oxide. Some of the results for ferrous sulphate solutions are shown in Table 1, from which it is evident that: (a) $G(Fe^{3+})$ has the same value in the deaerated nitrous oxide-containing solution as in a nitrous oxide-free solution; (b) the total gas yield is the same in both systems and equal to $G_{H_2} + G_H$; (c) in the nitrous oxide-containing system some nitrogen is always produced and the ratio $G(N_2)/G(H_2)$ increases slightly as the pH is increased to 2 and then rises sharply with further increase of pH.

Table 1. γ-RAY YIELDS IN OXYGEN-FREE, NITROUS OXIDE-CONTAINING ACIDIFIED mM FERROUS SULPHATE SOLUTION

Dose-rate = 1·05 × 10^{18} eV. ml.$^{-1}$ min.$^{-1}$

pH	$[N_2O]$	$G(H_2)$	$G(N_2)$	$G(H_2) + G(N_2)$	$G(Fe^{3+})$
0·45*	0	4·15	0	4·15	8·1
0·45*	~ 0·01 M	3·60	0·52	4·12	8·1
1·36	,,	2·98	0·94	3·92	7·8
1·60	,,	2·80	1·02	3·82	7·7
2·23	,,	1·76	1·83	3·59	7·1
3·30	,,	0·57	2·61	3·18	6·2

* 0·8 N sulphuric acid solution.

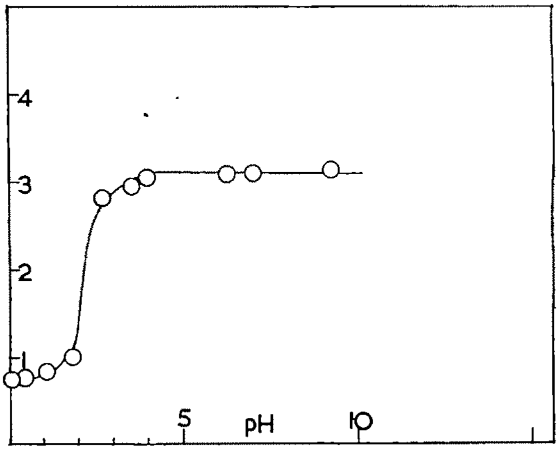


Fig. 1. $G(N_2)$ as a function of pH for cobalt-60 γ-irradiated solutions of nitrous oxide in pure water at room temperature. P_{N_2O} = 395 mm. mercury; dose-rate = 1·05 × 10^{18} eV. ml.$^{-1}$ min.$^{-1}$; pH varied by addition of sulphuric acid or sodium hydroxide

Result (a) indicates that reaction (5) does not occur, a conclusion which we have verified by a study of the effect of N_2O on the stoichiometry of the Fenton reaction:

$$HO + N_2O \rightarrow HO_2 + N_2 \quad (5)$$

All the results require that a large fraction, but by no means all, of those species which in acid solution oxidize ferrous ion according to (3) are incapable of reacting with nitrous oxide at $p\mathrm{H} < 2$, but become able to do so according to reaction (1) or (4) at $p\mathrm{H} >$ 2·3. To test this hypothesis we have measured $G(H_2)$, $G(N_2)$, $G(O_2)$ and $G(H_2O_2)$ for solutions of nitrous oxide in pure water over a wide range of pH. The variation of $G(N_2)$ with pH is shown in Fig. 1.

The value of $G(N_2)$ at $p\mathrm{H} > 2·7$ is that expected on the hypothesis that all the available hydrogen atoms or their stoichiometrical equivalents are scavenged by nitrous oxide in a reaction in which 1 mole of nitrogen appears for every mole of hydrogen atoms so scavenged, for example, by reaction (4). Below this pH, $G(N_2)$ falls sharply because a large proportion of these species reacts with acid and is thereby rendered incapable of reducing nitrous oxide. We consider this fraction to consist of hydrogen atoms which in their protonated form (H_2^+) are incapable of reacting with nitrous oxide and for which $pK_a(H_2^+) \simeq$ 2·3.

The fact that $G(N_2)$ does not become zero in solutions containing nitrous oxide at $p\mathrm{H} < 2$ is especially significant, and we interpret this as evidence for the possible existence of two different species of H atom or H atom precursor, only one of which is capable of reducing nitrous oxide in this low pH range. At present we are unable to say whether the form reactive to nitrous oxide is a solvated electron ($e^-_{aq.}$) or some other entity such as an excited water molecule. The existence of more than one form of hydrogen atom has been postulated by several groups of workers, but nitrous oxide affords perhaps the clearest evidence for this and the related ionic equilibria. A more detailed account of this and related work will be published elsewhere.

We are grateful to the (U.S.) National Science Foundation for the award of a fellowship to one of us (D. B. P.) and to the Rockefeller Foundation for financial aid.

F. S. Dainton
D. B. Peterson
Department of Physical Chemistry,
The University, Leeds 2.

---

[1] Proskurnin and Chernova, quoted by Proskurnin and Kolotyrkin, Proc. Second U.N. Conf. on the Peaceful Uses of Atomic Energy, Geneva, 29, 52 (1958).

[2] Barr and King, *J. Amer. Chem. Soc.*, 78, 303 (1956).

[3] Allen and Rothschild, *Rad. Res.*, 7, 591 (1957).

Use of Nitrous Oxide to discriminate between Various Forms of Hydrogen Atoms existing in Aqueous Solutions of Potassium Iodide irradiated with Ultra-violet Light

Deaerated, acidified, aqueous solutions of potassium iodide decompose to form equimolar amounts of hydrogen and iodine under the influence of light of wave-length less than 2600 Å. which is absorbed by the hydrated iodide ion ($I^-_{aq.}$). The quantum yield is small, but increases with increasing iodide and hydrion concentration. A postulated cause[1] of the effect of *p*H on the quantum yield is that hydrogen atoms found in the primary act can be protonated to form the hydrogen molecule ion, H_2^+, which will oxidize iodide ions in the reaction (1), whereas hydrogen atoms serve only to reduce iodine atoms and molecules. In the preceding communication[2] it was shown that nitrous oxide is inert to H_2^+, but reacts rapidly with hydrogen atoms most probably according to equation (3), and that $pK_a(H_2^+) \simeq 2{\cdot}3$:

$$H_2^+ + I^- \rightarrow H_2 + I \qquad (1)$$

$$H + I \rightarrow HI \qquad (2a)$$

$$H + I_2 \rightarrow HI + I \qquad (2b)$$

$$H + N_2O \rightarrow N_2 + OH \qquad (3)$$

Therefore, if solutions of potassium iodide saturated with nitrous oxide are irradiated with ultra-violet light it would be expected that little or no nitrogen would be produced until the *p*H of the solution exceeded 2, when reaction (3) becomes possible and $\varphi(N_2)$ should increase steeply to a limiting value which would be the true primary quantum yield of the iodide photolysis. The hydroxyl radicals liberated in reaction (3) will oxidize iodide ions very rapidly according to equation (4):

$$OH + I^- \rightarrow OH^- + I \qquad (4)$$

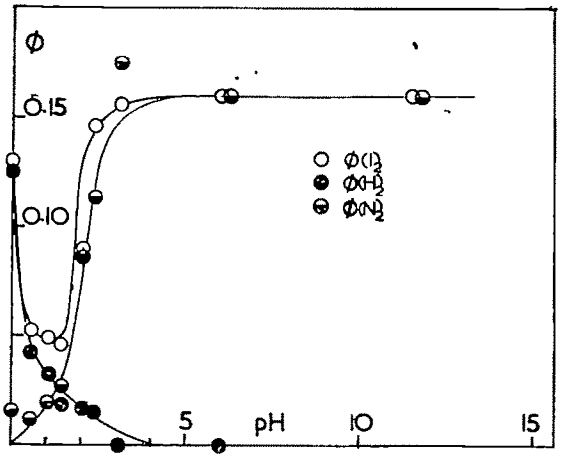


Fig. 1. $\varphi(H_2)$, $\varphi(I_2)$ and $\varphi(N_2)$ of aqueous solutions of potassium iodide containing nitrous oxide. [KI] = 0·276 *M*; P_{N_2O} = 810 mm. mercury; incident light intensity = 7 5 × 10^{14} quanta cm.$^{-2}$ sec.$^{-1}$ in wave-length range 2000–2600 Å. *p*H varied by addition of sulphuric acid or potassium hydroxide

We have recently measured the quantum yields of formation of hydrogen, nitrogen and iodine for this system over a wide range of *p*H, and the results, which are shown in Fig. 1, entirely confirm these predictions. It will be noticed that $\varphi(N_2)$ remains constant at 0·16 over the *p*H range 3–11 and therefore whatever forms hydrogen atoms assume in strong alkali, for example, $e^-_{aq.}$ or H_2O^-, also react rapidly with nitrous oxide in a reaction which is stoichiometrically equivalent to reaction (3).

As the *p*H is decreased below 3, $\varphi(N_2)$ diminishes rapidly and ultimately becomes zero, whereas $\varphi(H_2)$ increases steadily to a value which in $\sim 2\ N$ sulphuric acid approaches the primary quantum yield, and $\varphi(I_2)$ passes through a minimum value but is always equal to $\varphi(H_2) + \varphi(N_2)$. These and related results, in particular the observation that, contrary to the predictions of the Rigg and Weiss mechanism, $\varphi(H_2)$ and $\varphi(I_2)$ for deaerated iodide solutions are independent of the light intensity, have led us to the view that the mechanism of the photolysis of deaerated iodide solutions more nearly approaches the following than any of those hitherto published[1]:

$$I^-_{aq.} \xrightarrow{h\nu} I^-_{aq.}{}^* \text{ (electronically excited aquated iodide ion)} \qquad (4)$$

$$I^-_{aq.}{}^* \rightarrow I^-_{aq.} \text{ (degradation)} \qquad (5)$$

$$I^-_{aq.}{}^* + I^- \rightarrow I_2^- + OH^- + H \qquad (6)$$

$$H + H^+ \rightarrow H_2^+ \qquad (7)$$

$$H_2^+ \rightarrow H + H^+ \qquad (8)$$

$$H_2^+ + I_2^- \rightarrow H_2 + I_2 \qquad (9)$$

$$H + I_2^- \rightarrow H^+ + 2I^- \qquad (10)$$

Further details of these and related experiments will be published elsewhere. One of us (S. A. S.) is indebted to the Distillers Co. for financial help.

F. S. Dainton
S. A. Sills
Department of Physical Chemistry,
The University, Leeds 2.

---

[1] Rigg and Weiss, *J. Chem. Soc.*, 4198 (1952).

[2] Dainton and Peterson, *Nature*, 186, 878 (1960).

CHEMISTRY

A Reversible Nitrate Electrode

Following some earlier work in this Laboratory, a number of electrodes have been constructed which are capable of displaying a more or less reproducible nitrate function. The electrodes are of interest in that they make possible the determination of nitrates by potentiometric methods.

To make the electrodes, a slightly lumpy (½–1 mm.) sample of powdered zinc fluoride was made up to a viscous paste with 'Diakon' plastic (Imperial Chemical Industries, Ltd.) in chloroform, and coated on to a zinc rod (5 mm. diam.), such that several fragments of the salt were in contact both with the zinc core and with the surrounding solution. The electrodes were 'aged' by standing in 0·4 *M* calcium nitrate solution for 1–7 days.

The gelatinous coating of a basic zinc salt produced on the hydrolysis of the fluoride is apparently able to

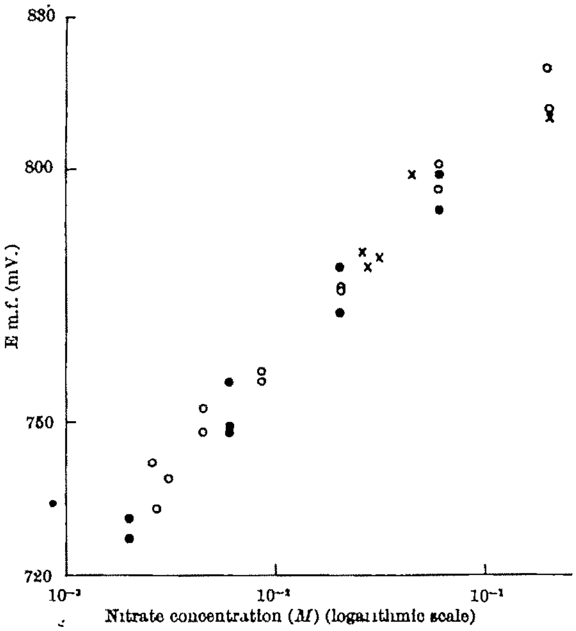


Fig. 1. Electrode potentials, relative to saturated calomel standard, in solutions of calcium and potassium nitrates ●, Calcium nitrate (four series); ○, calcium nitrate + 0 0025 *M* potassium nitrate (two series); ×, calcium nitrate + 0·025 *M* potassium nitrate (one series)

display an electrode function for the anion of the solution in which the electrode has been aged. Fig. 1 shows the electrode potentials in solutions of calcium and potassium nitrate, relative to saturated calomel, of such an electrode after it had been aged for 12 hr. in 0·4 *M* calcium nitrate solution. This particular electrode has been aged first in 0·1 *M* calcium chloride solution, following which it showed a reversible chloride function. Chloride ageing is not necessary for an electrode to show a nitrate function. Stable potentials were achieved after 15 min. provided that the air/solution interface on the electrode surface was protected by a coating of impermeable plastic. No electrode function was shown in nitrate solutions of concentrations less than 0·001 *M*.

This work was carried out during the tenure of an Agricultural Research Council Postgraduate Studentship.

P. H. T. Beckett

Soil Science Laboratory,
Department of Agriculture,
Oxford.

Heats and Entropies of Reaction of Transition Metal Ions with Ethylenediamine

The heats of formation of complexes between ligands and metal ions are very important to further the ligand field-theory and check its implications. Until now, only the heats of hydration of the first transition group ions have been used for this purpose[1] as the thermochemical data on the complexes formed by ligands other than water are very incomplete. The transition metal complexes of ethylenediamine, which have a very nearly octahedral configuration, could also be fruitfully studied in terms of ligand field-theory. Unfortunately only the thermal data on nickel (II), copper (II) and zinc (II) complexes are known[2], and so the formation constants have been used instead of the values of enthalpy changes, with the optimistic assumption that the entropy changes remain constant[1,3].

For this reason we have measured calorimetrically under similar conditions the heats of the stepwise formation of the ethylenediamine complexes of manganese (II), iron (II), cobalt (II), which are easily oxidized, as well as of nickel (II) and zinc (II). Copper was not taken into consideration since, because of the Jahn–Teller effect, the ligand field stabilization energy is difficult to estimate. Moreover, the third molecule of ethylenediamine is probably bound to the metal through only one nitrogen atom[4].

The calorimetric measurements were carried out using a calorimeter similar to that described by Davies, Singer and Staveley[2a]. The systems investigated were $2 \cdot 5 \times 10^{-2}$ *M* in metal sulphate and 1 *M* in potassium chloride. In the case of manganese, iron and cobalt, oxidation was prevented by bubbling nitrogen slowly through the calorimetric liquid during the measurements. The actual ionic composition of the solution was calculated from a knowledge of the stability constants[5]. The values of ΔH_1, ΔH_{1-2} and ΔH_{1-3} were obtained by combining the results of the measurements made at three different $\bar{n}$ values. For the measurements at low $\bar{n}$ values, the solutions were buffered with hydrochloric acid in order to prevent the precipitation of basic salts. Experimental conditions made it necessary for us to correct the heats of reaction for the side reactions:

$$2\,\mathrm{enH^+} \rightleftharpoons \mathrm{en} + \mathrm{enH_2^{++}} \quad \text{and}$$
$$\mathrm{en} + \mathrm{H_2O} \rightleftharpoons \mathrm{enH^+} + \mathrm{OH^-}$$

The heats of reaction have been combined with the known free-energy changes to obtain the entropy changes.

Table 1 gives the values of ΔH, ΔF and ΔS at 25° for the formation of mono-, di- and *tris*-ethylenediamine complexes. The values of ΔH_1, ΔH_{1-2} and ΔH_{1-3} are roughly in the ratio 1 : 2 : 3, that is, $\Delta H_1 \approx \Delta H_2 \approx \Delta H_3$. This confirms Poulsen and Bjerrum's statement[2b] that such a ratio is to be

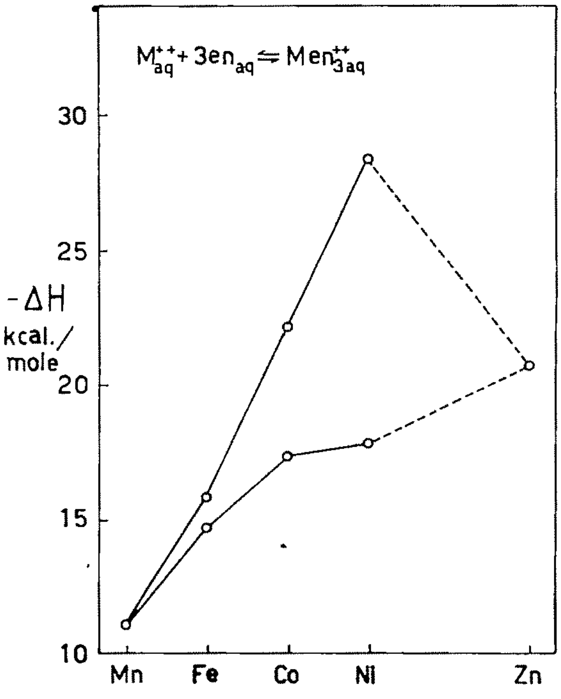


Fig. 1. Heats of formation of metal(II).3en complexes plotted against atomic number

Table 1. THERMODYNAMIC FUNCTIONS FOR SOME METAL(II)-ETHYLENEDIAMINE SYSTEMS IN 1 M POTASSIUM CHLORIDE AT 25°

	Mn^{++}	Fe^{++}	Co^{++}	Ni^{++}	Zn^{++}
$-\Delta H_1$	2·80	5·05	6 90	8·90	6·65
$-\Delta H_{1-2}$	6 00	10 40	13·95	18·35	13 75
$-\Delta H_{1-3}$ (kcal./mole)	11 05	15·85	22·15	28·35	20 70
$-\Delta F_1$	3·75	5·90	8·10	10·50	7·90
$-\Delta F_{1-2}$	6 65	10·45	14 55	19 20	14·40
$-\Delta F_{1-3}$ (kcal./mole)	7 90	13·25	18·65	25·10	16·80
ΔS_1	+3·2	+2 9	+4·0	+5·4	+4·2
ΔS_{1-2}	+2·2	+0 2	+2·0	+2 9	+2·2
ΔS_{1-3} (e.u.)	−10·5	−8 7	−11 8	−10·9	−13·1

expected for all normal complexes, that is, complexes free from steric strains and which undergo no change in multiplicity during stepwise complex formation. Only in the case of manganese is the ΔH_2 value very much higher than either ΔH_1 or ΔH_3. In Fig. 1 the experimental ΔH_{1-3} values (upper line) as well as the corrected values for the ligand-field stabilization energy (lower line) are plotted against the atomic number of the metal. The $\Delta H_{1-3\text{ cryst.}}$ corrections were calculated according to the formula:

$$\Delta H_{1-3\text{ cryst.}} = (4n_{\epsilon} - 6n_{y})\,(Dq_{6\,\text{H}_2\text{O}} - Dq_{3\,\text{en}})$$

The corrected values all lie above the straight line joining manganese to zinc. Therefore the hypothesis according to which the corrected values for the ligand-field stabilization energy vary linearly with atomic number[1] is not verified in this case.

A more detailed account of this work will be published elsewhere.

M. CIAMPOLINI
P. PAOLETTI
L. SACCONI

Institute of General Chemistry,
University of Palermo.

---

[1] Orgel, L. E., *J. Chem. Soc.*, 4756 (1952). Holmes, O. G., and McClure, D. S., *J. Chem. Phys.*, 26, 1686 (1957). Basolo, F., and Pearson, R. G., "Mechanism of Inorganic Reactions" (Wiley, New York, 1958).

[2] (*a*) Davies, T., Singer, S. S., and Staveley, L. A. K., *J. Chem. Soc.*, 2304 (1954). (*b*) Poulsen, I., and Bjerrum, J., *Acta Chem. Scand.*, 9, 1407 (1955). Spike, C. G., and Parry, R. W., *J. Amer. Chem. Soc.*, 75, 2726, 3770 (1953). McIntyre, jun., G. H., Block, B. P., and Fernelius, W. C., *ibid.*, 81, 529 (1959).

[3] Orgel, L. E., Report of the Tenth Solvay Council (Brussels, 1956). 289. Linnett, J. W., *Discuss. Farad. Soc.*, 26, 7 (1958).

[4] Bjerrum, J., and Nielsen, E. J., *Acta Chem. Scand.*, 2, 297 (1948).

[5] Bjerrum, J., Schwarzenbach, G., and Sillén, L. G., "Stability Constants", Part 1, Chem. Soc. Spec. Pub. No. 6 (1957).

Molecular Quadrupole Moment of Nitric Oxide

IT is known that nitric oxide is an interesting case of a three-electron bond. Taking the x-axis along the line of centres, the isolated atoms may be described as:

$$\text{N}\ (1s)^2\,(2s)^2\,(2p_x)\,(2p_y)\,(2p_z)$$
$$\text{O}\ (1s)^2\,(2s)^2\,(2p_x)\,(2p_y)\,(2p_z)^2$$

The molecular orbital description of the molecule is then[1]:

$$\text{NO}\ KK(2s_N)^2\,(2s_O)^2\,(\sigma 2p_x)^2\,(\pi 2p_y)^2\,(\pi 2p_z)^2\,(\pi^* 2p_z)$$

The two electrons in the MO $(\sigma 2p_x)$ form a σ bond, the four in $(\pi 2p_y)$, $(\pi 2p_z)$—degenerate orbitals—form π bonds, whereas the remaining single electron in $(\pi^* 2p_z)$ is antibonding.

The quadrupole moment $Q_{\overline{\text{mol.}}}$ due to the charge distribution of the nuclei and electrons may be defined[2] as:

$$Q_{\text{mol.}} = \tfrac{1}{2}\iiint \nu_i \rho_i 2(3\cos^2\theta_i - 1)\,d\tau \qquad (1)$$

where ν_i is an element of charge (electron or nucleus), ρ_i is the distance of the charge from the mass centre and θ_i is the angle between the internuclear axis and ρ_i. $Q_{\text{mol.}}$ may be treated as a sum of contributions due to the charge distribution of the nuclei N, O ($= Q_n$) and the electrons ($= Q_e$).

The following assumptions are made in the calculations: (1) The mass centre of the system is located at the midpoint of the internuclear line nitric oxide. (2) The bond N—O is of a pure covalent type with no hybridization on N or O atoms. (3) The molecular orbitals are represented by combinations of Slater type atomic orbitals with suitable screening constants for N and O. The contribution of the slight non-orthogonality of the molecular orbitals is negligible[3]. (4) The exchange quadrupole contributions are negligible[3].

Since the four electrons in spherical s shells cancel four units of the nuclear contribution in both N and O, we have:

$$Q_n = 3e\left(\frac{R}{2}\right)^2 + 4e\left(\frac{R}{2}\right)^2 \qquad (2)$$

R being the internuclear distance and e the protonic charge. For evaluating the electronic contribution we may use the equation:

$$Q_e = -\frac{e}{2}\,\Sigma_{MO} < \psi_{MO}\rho_e{}^2\,(3\cos^2\theta_e - 1)\psi^*{}_{MO} > \qquad (3)$$

The calculations are essentially similar to those of Greenhow and Smith[3]. The necessary overlap integrals are read from Mulliken's[4] master tables. The quadrupole integrals of the form:

$$Q(2p_\sigma) = -\frac{e}{2}\int \psi_A(2p_\sigma)x\ \rho_e{}^2(3\cos^2\theta_e - 1)\ \psi_A(2p_\sigma)d\tau$$

are read from Greenhow and Smith[3] as they were conveniently tabulated in units of eR^2.

The final value of $Q_{\text{mol.}}$ comes out as $+\,1{\cdot}57\ ea_H{}^2$ as against the experimental value[5] of $0{\cdot}28 \times 10^{-16}$ E.S.U. or $1{\cdot}01\ ea_H{}^2$, from observation of microwave collision diameters. It may, however, be mentioned that the sign of Q is not given by experiment, and the magnitude may be in error by as much as 50 per cent as a result of some theoretical approximations in deriving Q from microwave line-widths.

It is rather simple to calculate the nuclear contribution Q_n with reference to the exact mass centre of the molecule, which is located at a distance of 8/15 R from the N atom. In this case $Q_{\text{mol.}}$ turns out to be $1{\cdot}45\ ea_H{}^2$. The error introduced in Q_n due to the approximation (1) is estimated as only ~ 1 per cent though it is ~ 8 per cent in the over-all moment. But in evaluating Q_e this makes the integrals complicated.

I am indebted to Prof. Walter Gordy for his kind interest and encouragement. My grateful thanks are due to the United States Educational Foundation in India for awarding me a Fulbright travel grant.

This research was supported by the United States Air Force through the Air Force Office of Scientific Research of the Air Research and Development

Command. Reproduction in whole or in part is permitted for any purpose of the United States Government.

D. V. G. L. NARASIMHA RAO*

Department of Physics,
Duke University,
Durham, North Carolina.

---

* On leave from the Physics Department, Andhra University, Waltair, India.

[1] Coulson, C. A., "Valence", 152 (Clarendon Press, Oxford, 1952).

[2] Gordy, W., "Microwave Spectroscopy", 295 (John Wiley and Sons, Inc., New York, 1953).

[3] Greenhow, C., and Smith, W. V., *J. Chem. Phys.*, **19**, 1298 (1951).

[4] Mulliken, R. S., *et al.*, *J. Chem. Phys.*, **17**, 1248 (1959).

[5] Hill, R. M., and Smith, W. V., *Phys. Rev.*, **82**, 451 (1951).

Concentration-Dependent Sedimentation of Aggregating Proteins in the Ultracentrifuge

PROTEINS are by nature sticky substances, and it is not surprising that many of them form molecular aggregates in solution at well below the concentration needed for the appearance of a stable solid phase. Ultracentrifuge measurements provide a direct method of detecting and estimating such aggregation, and this communication is concerned with the interpretation of these measurements when aggregation is rapidly reversible, and the velocity of each sedimenting species is a function of the total concentration of protein.

The detailed experiments of Schwert[1] with α-chymotrypsin illustrate one of the most noticeable effects of strong aggregation on sedimentation. The sedimentation velocity of α-chymotrypsin was shown to increase sharply with concentration at low concentrations of protein, to reach a maximum value, and then to decrease steadily with further increase of concentration[1]. The effect was sensitive to changes in *p*H and ionic strength.

As is now well understood, this behaviour is due to the opposition of two factors: the increase in relative sedimentation velocity of the protein as a whole, as the average particle size increases with concentration, and the normal decrease in velocity caused by changes in the viscosity and density of the solution and in the back-flow of solvent[2,3]. This can be expressed theoretically by two methods. The first, suggested by Tiselius[4] (see also ref. 2, and Goldberg[5]), calculates the velocity of the boundary as if this remained sharp, and gives the weight-average velocity of the protein molecules. The second method[6,7] takes account of the spreading of the boundary by differential transport, although making no allowance for spreading by diffusion, and calculates the velocity of the median of the boundary.

These two methods are illustrated by curves in Fig. 1, calculated for the simplest case of aggregation, reversible dimerization. It will be found that they resemble closely the types of curve obtained by Schwert in the reference quoted above. More general cases will be considered in a later paper. In the present case, the equilibrium between monomer and dimer has been assumed to be governed by the equation $a_2 = ka^2$, where k is a constant, and a and a_2 are the respective molecular concentrations of monomer and dimer. The velocities of the species have been regarded as decreasing linearly with concentration, as for non-aggregating proteins[8].

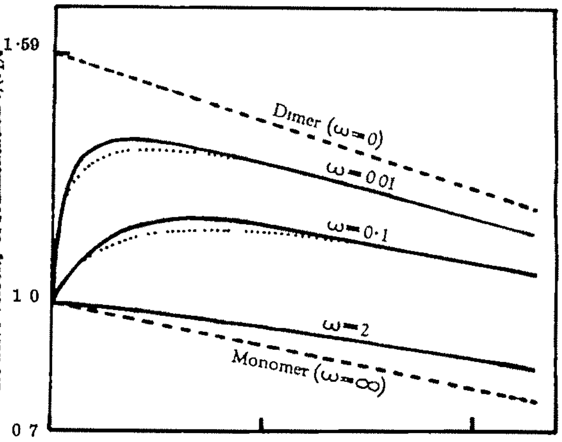


Fig. 1. Velocity of sedimentation in the ultracentrifuge as a function of concentration for monomer–dimer systems in reversible equilibrium. .. .. .., Weight–average velocity; ———, velocity of median of boundary; ----, limiting velocities

Thus:

$$v_1 = (v_1)_0(1 - gc)$$

and

$$v_2 = (v_2)_0(1 - gc)$$

respectively, where $c(= a + 2a_2)$ is the total concentration of protein expressed in base-molecules per unit volume, and g is a constant. Also the monomer and dimer particles have been treated as spheres[8], so that $v_2 = 1{\cdot}59\ v_1$. In the calculations by the second method, the hyper-sharp edge to the boundary on the higher concentration side of the maximum of the curves has been taken into account.

By plotting relative velocity, $v/(v_1)_0$, against relative concentration, gc, as in Fig. 1, it is possible to represent the whole family of curves on one diagram. The determining parameter is the quotient g/k ($= \omega$ say). It can be shown that for any system for which $\omega \gtrsim 1{\cdot}18$ the curve has no maximum, and the velocity falls steadily with increase of concentration. In this region $\omega \gtrsim 1{\cdot}18$, the two methods of calculation are equivalent.

Two practical conclusions can be drawn from the curves in Fig. 1. First, extrapolation backwards of the downward-sloping part of the curves leads to an intercept somewhere between the limiting sedimentation velocities of the monomer and the dimer. Identification of this intercept with the velocity of the dimer will suggest a false, and anomalously high, value for the frictional coefficient of the dimer[8].

Second, it appears that even a slight tendency to aggregate, far too slight for any tell-tale maximum in the curve, will be sufficient to reduce the downward slope measurably. In cases, therefore, where a change of *p*H, ionic strength or electrolyte causes a change in slope greater than would be expected from sedimentation potential effects[9], aggregation should be looked for. Fibrinogen[10] seems to be a case in point. Also, if appreciable differences in slope are found between the curves for rather similar proteins, as, for example, for myeloma globulins[11], for which the values of g could not be expected to differ very much, the cause is again likely to lie in differences in aggregation. The many unpublished records of sedimentation velocity-concentration curves could well repay a search for this effect.

G. A. GILBERT

Department of Chemistry, The University,
Edgbaston, Birmingham, 15.

[1] Schwert, G. W., *J. Biol. Chem.*, 179, 655 (1949).

[2] Svedberg, T., and Pedersen, K. O., "The Ultracentrifuge" (Oxford University Press, London, 1940).

[3] Schachman, H. K., "Ultracentrifugation in Biochemistry" (Academic Press, New York and London, 1959).

[4] Tiselius, A., *Nova Acta Regiae Soc. Sci. Upsal.*, IV, 7, No. 4, 1 (1930).

[5] Goldberg, R. J., *J. Phys. Chem.*, 57, 194 (1953).

[6] Gilbert, G. A., *Discuss. Farad. Soc.*, 20, 68 (1955).

[7] Gilbert, G. A., *Proc. Roy. Soc.*, A, 250, 377 (1959).

[8] Massey, V., Harrington, W. F., and Hartley, B. S., *Discuss. Farad. Soc.*, 20, 24 (1955).

[9] Pedersen, K. O., *J. Phys. Chem.*, 62, 1282 (1958).

[10] Sowinski, R., Oharenko, L., and Koenig, V. L., *J. Amer. Chem. Soc.*, 81, 6193 (1959).

[11] McConnel, R. J., and Martin, N. H , *Brit. J. Cancer*, 12, 264 (1958).

Application of Pyramidone to Detection of Nitrous Acid

PYRAMIDONE (1-phenyl-2,3-dimethyl-4-dimethylaminopyrazolone-5) or antipyrine (1-phenyl-2,3-dimethylpyrazolone-5) have been used in analytical chemistry to detect copper, cobalt, and iron. But there are a few references to the application of pyramidone as a cation and anion reducer[1,2]. I have used a freshly prepared 5 per cent solution of pyramidone (Merck), to detect nitrous acid ions in the presence of other anions and cations.

Method 1. 3–4 drops of pyramidone solution and 1–2 drops of diluted (10 per cent) acetic acid were added to about 1 ml. of, for example, a solution of sodium nitrite or potassium nitrite (Schering–Kahlbaum). A violet coloration, not spreading in ether, chloroform, amyl alcohol, or carbon tetrachloride, appeared immediately or after a few seconds according to the amount of sodium or potassium nitrite present. If the quantity of nitrite ions is small, the reaction may be accelerated by heating. By means of this reaction it is possible to detect 0·0140 gm. of sodium nitrite in 1 litre of water, or 0·009 mgm. of nitrite/ml.

The presence of sulphuric, nitric, iodic, hydrochloric, phosphoric, boric, oxalic, citric, tartaric or hydrobromic acid ions does not impair the reaction. Hydroiodic acid ions give in such a case a brown sediment, which disappears after heating, and the solution turns violet. The appearance of the sediment is at the same time a proof of the presence of nitrites, since there is no sediment in their absence. The reaction is not retarded by the presence of a number of bi- and tri-valent metal ions. Silver ions and pyramidone give a blue-violet colouring. The detection of small quantities of nitrite in the presence of silver is accomplished by the addition of sodium chloride and then of pyramidone and acetic acid to the solution under examination. Ferric iron also interferes. But if the reaction proceeds in the presence of potassium fluoride (and tartaric acid as well), then the test with nitrites is positive. Mercuric salts and pyramidone give a white sediment not interfering with the detection of nitrite; mercurous salts are reduced to metallic mercury. If acetic acid is present in excess, the sediment is dissolved, and in the presence of nitrite ions the solution turns violet.

Method 2. In view of the fact that aqueous solutions of pyramidone decompose rapidly, a dry reagent was also used for the detection of nitrite. The reagent was prepared as follows: 1 gm. of pyramidone and 1·5 gm. of tartaric acid or citric acid are thoroughly mixed in a mortar and then kept in the dark, in tightly closed gallipots. A pinch of the reagent is added to the solution under examination and mixed with it. If nitrites are present, the solution turns violet.

Method 3. A 'wet' reagent in chloroform or alcohol can also be used. (*a*) A drop of the saturated, chloroform solution of pyramidone is added to the acidified solution under investigation and shaken. If nitrites are present in small quantities, the mixture must be slightly heated. The solution turns violet. (*b*) A few drops of a mixture composed of equal parts of saturated, alcoholic (anhydrous) solution of tartaric acid and the same solution of pyramidone are added to about 1 litre of the solution under examination. In the presence of nitrite, the solution turns violet.

WIKTOR WAWRZYCZEK

General Chemistry Department,
School of Agriculture, Olsztyn, Poland.

[1] Wachsmuth, F , *Quart. J. Pharm. Pharmacol.*, 10, 734 (1937).

[2] Broeksmit, J., *Z. Anal. Chem.*, 57, 584 (1918).

Polyvinyl Benzoate Monolayers

MONOLAYERS of polyvinyl benzoate show strong film properties strikingly similar to those of vertically oriented fatty acids and unlike those of horizontally oriented polyvinyl acetate. The polymer was prepared by free-radical bulk polymerization at 82° C. Monolayers were studied at 25° C. on the film balance[1–3]. The spreading solvent was twice-distilled benzene.

Fig. 1 shows duplicate pressure-area isotherms for polyvinyl benzoate and a representative isotherm for polyvinyl acetate[4]. Polyvinyl benzoate gives a surprisingly small extrapolated area—0·38 m.^{2} per mgm., or about 9 Å.^{2} per monomer unit. Film thickness corresponding to this area averages 20 Å. As shown in Table 1, compressibility is not much greater than that for octadecylphosphonic acid[2]. Most unexpected, however, is the high collapse pressure of 53 dynes per cm.; it is much greater than those for many other polymers, somewhat greater than that for stearic acid, and the same as that for octadecylphosphonic acid. Surface pressures are unusually stable throughout the compression, and the film is rigid.

Polyvinyl acetate is typical of many horizontally oriented polar polymers; the isotherm gives a large extrapolated area that corresponds to a film thickness of only 5 Å. The film is highly compressible, and collapse takes place gradually at about 25 dynes per cm.—a pressure hitherto considered high for a film of horizontally oriented molecules.

The strong film properties of polyvinyl benzoate and the marked difference between the benzoate and acetate films are difficult to explain. One might

Table 1. MONOLAYER PROPERTIES

	Area		Collapse pressure (dynes/cm.)	Compressibility (cm./dyne)
	m.^{2}/mgm.	Å.^{2}/mol.		
Polyvinyl benzoate	0 38	9*	53	0 0056
Polyvinyl acetate	1·90	27*	25	0·0252
Stearic acid	0 43	20	42	0 0019
Octadecylphosphonic acid	0 40	22	53	0 0035

* Per monomer unit.

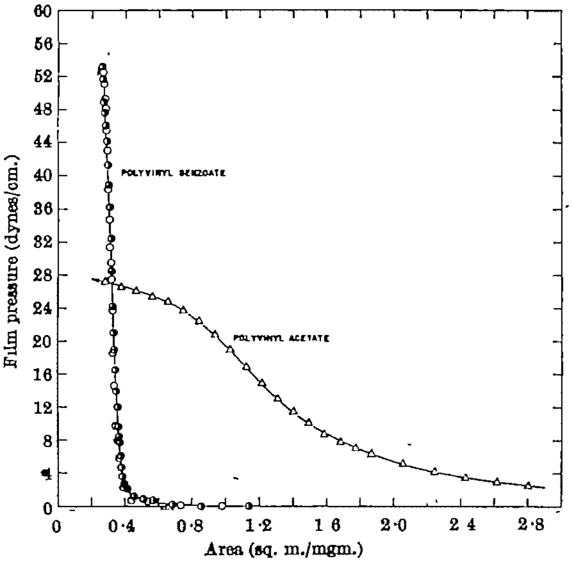


Fig. 1. Pressure-area isotherms for polyvinyl benzoate and polyvinyl acetate

expect aromatic rings to interfere with formation of a strong film, as they do in tri-*p*-cresyl phosphate and related compounds[2]. Molecular models of the polymer indicate that close packing of rings is possible; cohesive forces could be great between coplanar rings in contiguous parallel alignment. Another possibility is that rigid coils or folds rise from the surface and pack tightly. The small area per monomer unit would favour the coiling or folding picture.

Any branching in the polyvinyl benzoate probably could not account for the high collapse pressure. Polar branches would tend to orient horizontally as does the backbone chain. Moreover, a copolymer of vinyl benzoate and vinyl acetate, which presumably has less branching than the homopolymer of vinyl benzoate, gives films that collapse at similar high pressures.

Studies of mixed films may help explain the unusual properties of the monolayer of polyvinyl benzoate. An equiweight mixture with stearic acid gives reproducible monolayers that collapse at 36 dynes per cm.—well below the collapse pressures of the components alone—whereas a corresponding mixture of polyvinyl acetate and stearic acid collapses at a far greater pressure than do the components[4]. Evidently the vertically oriented fatty acid interferes with the packing of the benzoate polymer, in contrast to the marked strengthening produced by the interaction of the acid and the acetate polymer. An equiweight mixture of polyvinyl benzoate and polyvinyl acetate collapses at a pressure close to the average for the two components.

Further monolayer studies of polar polymers and mixtures should shed light on many complex problems of polymer structure and behaviour.

HERMAN E. RIES, JUN.
NICKY BEREDJICK
JOSEPH GABOR

Research and Development Department,
Standard Oil Company (Indiana),
Whiting, Indiana.

---

[1] Adam, N. K., "The Physics and Chemistry of Surfaces", third ed. (Oxford University Press, Oxford, 1941).

[2] Ries, jun., H. E., and Cook, H. D., *J. Colloid Sci.*, **9**, 535 (1954).

[3] Cook, H. D., and Ries, jun., H. E., *J. Phys. Chem.*, **60**, 1533 (1956).

[4] Ries, jun., H. E., Ahlbeck, R. A., and Gabor, J., *J. Colloid Sci.*, **14**, 354 (1959).

BIOCHEMISTRY

Vanadium Catalysis of the Oxidation of Catechol Amines, Dihydroxyphenylalanine and 5-Hydroxyindoles

IN the course of an investigation of the mechanism of enzymatic oxidation of serotonin (5-hydroxytryptamine) by human serum[1], we found that apparently identical chromatographic reaction products[2] resulted when this oxidation was catalysed non-enzymatically by cupric ion. We became curious as to what extent transitional metals other than copper catalysed this reaction, and expanded our investigation to include a study of the relative catalytic effectiveness of 18 transitional elements in the oxidations of related compounds of biological interest.

Glassware which had been washed in sulphuric acid – dichromate solution was treated with warm nitric acid, 0·01 *M* versene and 12–15 rinses of de-ionized water having a specific resistance $>10^6$ ohms at 25° C. All reagents were made up with de-ionized water. To 0·01 *M* concentrations of substrates in a 0·1 *M* acetate buffer at *p*H 6·0, catalytic amounts of transitional metals were added so that the final concentration of metal was 0·04 m*M*, or about 2γ of metal per ml. of reaction volume. Test-tubes were incubated at 37° C. and the development of colour was followed by measuring the light absorbance at 500 mμ in a Coleman Jr. spectrophotometer. The following metals were tested: copper (I and II), silver (I), zinc (II), lanthanum (III), vanadium (V), chromium (II), manganese (II), iron (III), cobalt (II), nickel (II), gold (III), cadmium (II), mercury (II), yttrium (III), zirconium (II) and palladium (II). The substrates employed were L-tryptophan, tryptamine, 5-hydroxytryptamine, D,L-5-hydroxytryptophan, 5-hydroxyindole-3-acetic acid, L-tyrosine (saturated solution), tyramine, L-3,4-dihydroxyphenylalanine, 3-hydroxytyramine, L-adrenalin and L-noradrenalin. In terms of the rapidity and intensity of colour development, the results were striking: vanadium was by far the most active catalyst of the oxidations of L-3,4-dihydroxyphenylalanine, 3-hydroxytyramine, noradrenalin and D,L-5-hydroxytryptophan. It was also the most active catalyst of the oxidation of adrenalin, although copper (I and II) were nearly as effective in catalysing this reaction. Colour also developed in the vanadium (V)–5-hydroxytryptamine and vanadium (V)–5-hydroxyindole-3-acetic acid systems, but in neither case was it nearly so intense or rapid as in the corresponding systems with cupric or cuprous ions. It was of considerable interest that colour did not develop in any of the systems containing tyrosine, tyramine, tryptamine and tryptophan, even after standing for a week.

Our interest naturally focused on vanadium, and we next tried a series of vanadium compounds including pentavalent V_2O_5 and $NaVO_3$ and the tetravalent $VOSO_4$ and $VOCl_2$. All were quite active in catalysing the oxidations of 5-hydroxytryptamine, 5-hydroxytryptophan, dihydroxyphenylalanine, 3-hydroxytyramine, adrenalin and noradrenalin. There was also slight activity in the vanadium–5-hydroxyindole-3-acetic acid systems. (After 72 hr., a light pink colour developed in test-tubes containing 5-hydroxyindole-3-acetic acid and vanadium salts, while duplicate controls remained colourless.) Niobium (V) and tantalum (V) (Na_2NbF_7 and K_2TaF_7 were obtained from the Kawecki Chemical Company,

Table 1. OXIDATION OF SOME TYROSINE AND TRYPTOPHAN DERIVATIVES IN THE PRESENCE OF VANADIUM AND COPPER

Manometric incubation of 8 m*M* substrates with 0·02 m*M* metals at *p*H 6 0 in 0 1 *M* acetate buffer at 40 0° C. Total flask volume = 2·6 ml. + 0·2 ml. 10 per cent potassium hydroxide in centre well. Shaking rate = 112 oscillations/min. μl. O = total oxygen consumed during incubation period. *T*, percentage transmission of light at 500 mμ at end of incubation period

	Incubation (hr.)	Control		$NaVO_3$		$CuSO_4.5H_2O$	
		μl. O	*T*	μl. O	*T*	μl. O	*T*
Tryptamine	72	8	100	14	100	6	100
5-Hydroxytryptamine	24	10	100	7	42	138	21
D,L-5-Hydroxytryptophan	54	24	89	111	8	6	91
5-Hydroxyindole-3-acetic-acid	72	18	94	16	81	87	83
L-3,4-Dihydroxyphenylalanine	5	8	98	70	4	22	68
3-Hydroxytyramine	5	3	90	70	44	22	67
L-Adrenalin	5	58	23	135	2	146	5
L-Noradrenalin	5	7	91	50	51	27	78

New York), the two other group V*a* elements, were also tested with the different substrates. Results were negative except that there was definite colour (first pink, then gun-metal grey and finally black) in the niobium–5-hydroxytryptophan system. This reaction was slow compared to that obtained when 5-hydroxytryptophan was oxidized in the presence of vanadium. The resulting colours were identical, and a black precipitate finally developed in each case.

We next measured consumption of oxygen in a Warburg apparatus; 8 m*M* substrates were incubated with 0·02 m*M* metals at *p*H 6·0 in an acetate buffer at 40·0° C. Most of the metals listed above were tested in this system. Table 1 represents typical results of many such experiments. Neither oxygen consumption nor colour occurred in any system containing tryptamine. There was considerable oxygen consumption and development of a yellow-brown colour in the copper (I and II) – 5-hydroxytryptamine systems. After 24 hr., although no oxygen was consumed, the vanadium (IV)– and vanadium (V) – 5-hydroxytryptamine systems also developed a yellow-brown colour. With incubation times longer than 24 hr., oxygen consumption was observed following the initial development of colour. In the case of 5-hydroxytryptophan, considerable oxygen uptake occurred in the presence of vanadium (IV and V), but in no other systems with the exception of niobium (V), in which there was a minimal oxygen uptake and a definite pink colour. Vanadium (IV and V) produced marked catalysis of the oxidations of the catechol amines. However, all these oxidations were also catalysed by copper. The only other findings of note were a considerable catalysis by manganese (II) and a slight catalysis by iron (III) of the oxidation of adrenalin.

None of these reactions occurred when the systems were incubated in an atmosphere of nitrogen for periods of up to 24 hr.; when incubated in an atmosphere of oxygen, the rate of development of colour and of consumption of oxygen increased in all cases.

Descending paper chromatography of the vanadium (V) – 5-hydroxytryptophan systems was performed in *n*-butanol/acetic acid/water (125 : 30 : 125, upper layer), but no indolic products could be found other than 5-hydroxytryptophan. Black pigment was noted at the origin.

Because of the relative specificity of the vanadium – 5-hydroxytryptophan reaction, we attempted to develop this reaction as an assay for small amounts of vanadium. While it has been possible to detect as little as 0·02γ of vanadium per ml. of buffered substrate solution, equimolar amounts of copper (II), iron (III) and cobalt (II) have been found to interfere with colour development. The oxidation of dihydroxyphenylalanine is even more sensitive to trace amounts of vanadium, but copper (II), iron (III), chromium (II) and cobalt (II) also catalyse this reaction, in decreasing order of effectiveness. If interfering ions could be removed chromatographically, these reactions might prove useful for the colorimetric determination of trace amounts of vanadium. The hydroxyl ion is a powerful catalyst of all these oxidations, so that *p*H control must be rigorous.

The chief actions of vanadium when administered intravenously to dogs are said[3] to involve the vascular system, with the production of intense peripheral vasoconstriction in the spleen, kidneys and intestines. 'Some time' after an intravenous injection is given, the kidney is said to show an irregular alternating constriction and dilatation of its volume. There is also a marked increase in peristalsis which is 'at once allayed' by injection of adrenalin. It is possible that one or more of the various vanadium-catalysed oxidations described in this communication play a part in the mediation of these important pharmacological actions.

This investigation was supported in part by Research Grant *H*-3174 from the National Heart Institute of the U.S. Public Health Service and by a grant from the State of Washington Fund for Biology and Medicine; a preliminary report has been made[4]. The technical assistance of Mrs. Grace Warren is gratefully acknowledged.

G. M. MARTIN
E. P. BENDITT
N. ERIKSEN

Department of Pathology,
University of Washington School of Medicine,
Seattle, Washington.

[1] Martin, G., Benditt, E. P., and Eriksen, N., *Fed. Proc.*, 17, 447 (1958).

[2] Eriksen, N., Martin, G. M., and Benditt, E. P., *J. Biol. Chem.* (in the press).

[3] Jackson, D. E., *J. Pharmacol. and Exp. Therap.*, 3, 477 (1912).

[4] Martin, G. M., Benditt, E. P., and Eriksen, N., *Fed. Proc.*, 18, 492 (1959).

Diffusion of Proteins through Lipophilic Agar Gels

IF agar is used as a gelling agent, the aqueous phase of the gel should not be reduced below 38 per cent, otherwise the gel loses quickly its homogeneity and the necessary rigidity for handling it experimentally. Thus the intermediate gels, through which the diffusion occurs, contain 2 per cent agar ('Bacto-Agar', Difco Laboratories), 38 per cent aqueous buffer solution and 60 per cent of a lipophilic component. In gels Nos. V, VI and VII the latter consists of 48 per cent 1,2-propandiol and 12 per cent (by weight) of a further lipophilic component as indicated in Table 1. These additions raised the lipophilic properties considerably. The gel is formed by pouring 11 ml. of the hot, thoroughly mixed solution on a hot glass plate, such as are used in the 'Elphor' paper strip scanner. After setting, the gel is detached from the glass plate and laid upon the basis gel of 1 per cent agar in buffer. Drops of 2 per cent solutions of pure serum protein fractions, containing 200 μgm. of protein, are now placed, using

Table 1

No.	Composition of intermediate gel 2 per cent agar in veronal-acetate buffer of pH 8·6 + the following lipophilic components.	Specific viscosity sp. $\eta_{20°}$	Uptake of aniline blue (mgm. in 100 ml.)	Relative turbidity Sol (per cent)	Relative turbidity Gel (per cent)	Percentage of diffusion Albumin (per cent)	Percentage of diffusion α_1-lipoprotein (per cent)	Percentage of diffusion α_2-macroglobulin (per cent)
I	2 per cent agar	—	—	65	540	12	8	9
II	2 per cent agar + ethyleneglycol	4·10	0·01	60	263	13	10	14
III	2 per cent agar + dimethylformamid	1·90	5·18	112	454	22	10*	—
IV	2 per cent agar + 1,2-propandiol	7·44	0·15	67	322	8*	18	12*
V	2 per cent agar + 1,2-propandiol + propanamid	5·76	2·43	137	370	—	16	—
VI	2 per cent agar + 1,2-propandiol + hexane-1,6-diol	7·76	1·61	156	358	11	30	—
VII	2 per cent agar + 1,2-propandiol + glycerol triacetate	5·64	1·12	125	355	13	37	—

* Approximate values.

an 'Agla' pipette, at regular intervals on the surface of the intermediate gel. After 48 hr. in a wet chamber the proteins having diffused into the basis gel are measured by a technique which I have already described[1,2] (Fig. 1). The following protein-fractions were used: serum albumin (mol. wt. 69,000); α_1-lipoprotein (mol. wt. approx. 250,000, ref. 3, 45 per cent lipoid-component, ref. 4; Behringwerke, Marburg/Lahn) and α_2-macroglobulin (mol. wt. 846,000, ref. 5; Behringwerke, Marburg/Lahn). Fig. 1 shows results of the standardized technique, allowing 7 diffusion tests per glass plate. If the intermediate gel contains only agar, average values should not differ by more than 5 per cent; with a lipophilic component in the gel the limit is rather 8 per cent. Microphotograms have shown that the latter gels are less homogeneous.

The values given for diffusion in Table 1 are in percentages of those obtained without diffusion (compare *a* in Fig. 1). Differences in dye-uptake of the various fractions are thus avoided. Viscosity of the buffered solutions (without agar) was measured in an Ostwald capillary viscosimeter immersed in a 20° C. constant-temperature glass water-bath. In order to obtain a measure of the lipophilic property, these solutions were shaken with ethanol-soluble aniline blue (Geigy, Basle). Optical density of the filtrate was measured in the Beckman *DU* on wavelength 600 mμ. Values for relative turbidity were measured by the Zeiss Stufenphotometer with a special attachment for the measurement of the stray light.

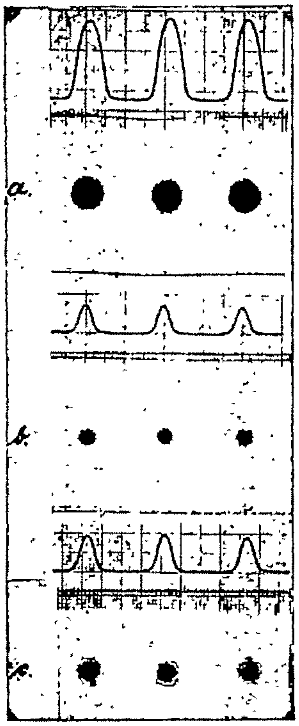


Fig. 1. *a*, Spots of α_1-lipoprotein, placed on a 1 per cent agar gel and stained with naphthalene black. Above each spot is the scanning as delivered by the Zeiss Extinktionsschreiber II; *b*, spots of α_1-lipoprotein after diffusion through a lipophilic agar-gel containing 1,2-propandiol and propanamid (see Table 1, gel No. V); *c*, spots of α_1-lipoprotein after diffusion through an agar gel containing 1,2-propandiol and hexane-1,6-diol (see Table 1, gel No. VI)

It follows that in gels with a lipophilic component (II, III, VI, VII), the diffusion of albumin remains stationary, whereas the diffusion of α_1-lipoprotein increases up to 450 per cent (comparison of gels I and VII). The chemical composition of this lipoprotein seems to be more important than particle-size. The latter interferes with the diffusion of α_2-macroglobulin in gels III, V, VI and VII; no measurable amount passes the intermediate gel within 48 hr. Work on the electrophoretic behaviour in analogous agar-gels is in progress.

Ch. Wunderly

Medical University Clinic,
Zurich.

Jan. 16.

---

[1] Wunderly, Ch., *Nature*, 182, 1087 (1958).
[2] Wunderly, Ch., *Clin. Chim. Acta*, 4, 754 (1959).
[3] Lindgren, F. T., Elliot, H. A., and Gofman, J. W., *J. Phys. Coll. Chem.*, 55, 80 (1951).
[4] Heide, K., Schmidthberger, R., and Schwick, G., *Behringwerk-Mitt.*, 33, 1 (1957).
[5] Schultze, H. E., *Clin. Chim. Acta*, 3, 24 (1958).

Antioxidative Effect of Amino-Acids

Amino-acids are often mentioned as synergistic antioxidants. Their mechanism of enhancing the effect of primary antioxidants can be explained in different ways: by chelation of pro-oxidative metal traces[1] and by regeneration of oxidized primary antioxidants[2-4]. It has also been shown that amino-acids may play the part of synergistic antioxidants as natural constituents of food material[5]. On the other hand, there is a lack of systematic survey on a more general basis of this effect of amino-acids. Certain results have been published, which, however, refer to special conditions[6,7]. No data are available on the effect of amino-acids in absence of other antioxidative substances.

Experiments have been carried out to compare the antioxidative effect of several amino-acids and to study the dependence of this effect on certain factors, both in herring oil emulsions and in model systems with linoleic acid. Originally this work referred to oxidation in fatty fish. Variation of oxidizability in this material made it necessary to pass to the model

Table 1. RATE OF OXIDATION IN HERRING OIL EMULSIONS, WITH ADDED AMINO-ACIDS, RELATIVE TO THE RATE WITHOUT AMINO-ACID

Amino-acid	Molar 0·001	0·01
Glutamic acid	0·92	0·74
Methionine	0·88	0·72
Alanine	0·93	0·68
Asparagine	0·88	0·66
Valine	0·87	0·57
Aspartic acid	0·86	0·56
Serine	0·81	0·47
Lysine	0·69	0·87
Tryptophan	0·45	0·31
Histidine	0·41	0·17

4 ml. emulsion with 33 per cent oil, 1 per cent 'Tween' 20 and 1/150 mol. phosphate buffer, *p*H 5·6, 35° C.

systems. Oxidation has been followed by measurement of oxygen consumption by means of a manometric Warburg apparatus. In the case of herring oil and linoleic acid autoxidation, the course of oxygen consumption did not show any distinct induction period. Oxygen consumed per hour based upon consumption during several hours was taken as a measure of oxidation rate and the relation between oxidation rate with and without addition of the substances examined as a measure of their effect on oxidation.

In the case of herring oil, 10 of 11 amino-acids examined had antioxidative effects of varying degree. The effect was strongest with histidine (Table 1). It was pro-oxidative with cysteine. The tocopherol content of herring oil was determined to be about 0·01 molar.

The results obtained for autoxidation of linoleic acid show that amino-acids may have an antioxidative effect in the absence of tocopherol or other primary antioxidants. Amino-acids are consequently able to act as primary antioxidants themselves. Several amino-acids were examined and showed different effects. The effect is considerably dependent on *p*H : it was, in the case of alanine and histidine, relatively small at *p*H 7·5 and strong at *p*H 9·5 (Fig. 1).

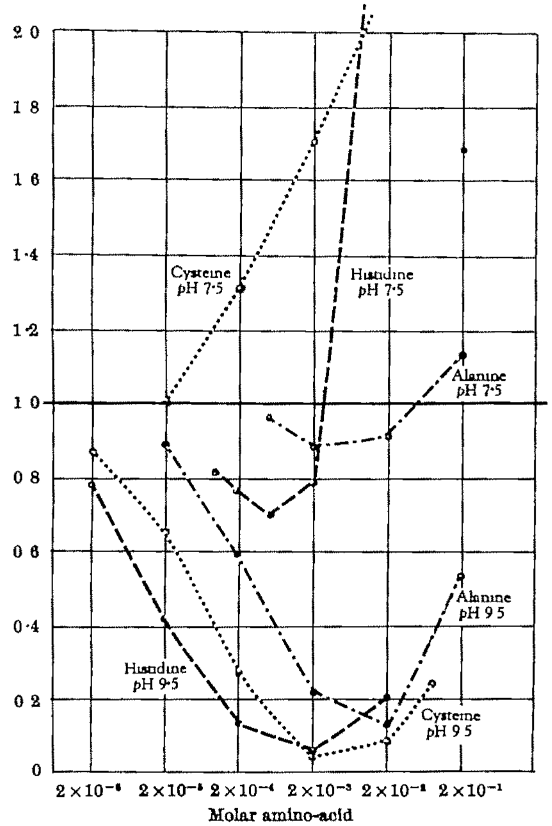


Fig. 1. Rate of oxidation of linoleic acid with amino-acid added, relative to the rate without amino-acid. 1 ml. 0 2 molar linoleate at 30° C.

With increasing concentration of amino-acid, the effect—after having passed a maximum (that is, a minimum oxidation-rate)—decreases and may, at *p*H 7·5, change from antioxidative to pro-oxidative. This phenomenon is well known from other primary antioxidants, for example, tocopherol. The threshold concentration for this inversion was different for the specific amino-acids examined. The effect of cysteine was at *p*H 7·5 pro-oxidative within the whole range. At *p*H 9·5 cysteine was strongly antioxidative like the other amino-acids examined. The results at *p*H 7·5 were in certain respects in agreement with the results of experiments with herring oil emulsions.

The amino-acids could also be shown to have a synergistic effect together with α-tocopherol. When α-tocopherol was added in a concentration which without amino-acids only slightly decreased the rate of oxidation, the relative effect of amino-acid addition was considerably greater than in the absence of tocopherol, at least at *p*H 7·5. At *p*H 9·5 the strong effect of amino-acid addition was only slightly re-inforced by tocopherol.

Work is going on regarding the effect of amino-acids in the hæmin-catalysed oxidation of linoleic acid. In this case quite a different type of curve for oxygen consumption, with a distinctly marked induction period, is obtained. The influence of amino-acid addition on the length of the induction period seems not to be correlated with the effects described above. A final account will be published later.

REINHARD MARCUSE

Swedish Institute for Food Preservation Research,
Gothenburg.

[1] Desnuelle, P., "The Proteins", 116 (1953).
[2] Golumbic, C., "Biological Antioxidants", 46 (1946).
[3] Isidorides, A., *J. Amer. Chem. Soc.*, 5146 (1951).
[4] Heimann, W., *et al.*, *Z. Lebensmittelunters.*, 102, 1 (1955).
[5] Jannesson, E., and Marcuse, R., *Olii Minerali Grassi*, 1 (1957).
[6] Janicki, J., and Gogolewski, M., *Przemysl Spozywczy*, 417 (1958).
[7] Olcott, H. S., and Kuta, E. J., *Nature*, 183, 1812 (1959).

Mycosides: a New Class of Type-Specific Glycolipids of *Mycobacteria*

STUDIES by the combined techniques of chromatography and infra-red spectroscopy of the lipid content of 85 strains of *Mycobacteria* including human, bovine and avian species and representatives of the atypical acid-fast group[1], have led to the recognition that some of the compounds are limited in distribution to a single species of organism and may in fact serve to distinguish between the various species of *Mycobacteria*. The distribution of these substances in the various species of *Mycobacteria* studied is as follows: phthiocerol dimycocerosate present in the lipids of 28 out of 30 human strains studied; a compound called G_B [2,3] present in the lipids of 7 out of 7 bovine strains studied (G_B is accompanied by phthiocerol dimycocerosate in virulent bovine strains); a compound called G_A [4]

present in the lipids of 17/17 photochromogenic[1] strains; a compound called J_{av}[4] present in the lipids of 11/13 avian strains and also in the lipids of 3/6 non-photochromogenic strains. The purpose of this communication is to propose a more rational nomenclature for these substances.

Chemical investigation has shown that the three categories of substances provisionally named G_A, G_B and J_{av} are glycolipids, containing characteristic *O*-methylated 6-deoxyhexoses in glycosidic linkage.

We wish to propose the general name 'mycoside' for these compounds; a mycoside could be defined as 'a type specific glycolipid of Mycobacterial origin'. —G_A, characteristic of photochromogenic strains, should be called mycoside *A*. —G_B, characteristic of bovine strains, should be called mycoside *B*. —J_{av}, characteristic of avian strains, should be called mycoside *C*. The following preliminary data can be given concerning the chemical structure of these compounds:

(1) Mycoside *A* has been obtained as a nearly colourless solid melting at 105°, $[\alpha]_D^{20}$ − 37° ($CHCl_3$); C, 72·2; H, 11·3; OCH_3, 8·6; N, 0; P, 0 per cent. The ultra-violet absorption spectrum shows maxima at 222, 274 and 278 mμ (in hexane). Mycoside *A* contains three different *O*-methylated-6-deoxyhexoses, which have been identified as 2-*O*-methyl-fucose, 2-*O*-methyl-rhamnose and 2,4-di-*O*-methyl-rhamnose[5]. The lipid moiety of mycoside *A* is a mycocerosate of an aromatic alcohol.

(2) Mycoside *B* is a colourless wax, melting at 25° $[\alpha]_D^{20}$ − 22° ($CHCl_3$); C, 76·6; H, 12·0; OCH_3 4·3; N, 0; P, 0 per cent. Mycoside *B* has about the same ultra-violet absorption maxima as mycoside *A* (222, 274, 281 mμ). Mycoside *B* contains only one sugar, identified as 2-*O*-methyl-rhamnose[5]. The lipid moiety of mycoside *B* is a diester of two molecules of a branched chain acid fraction of mean molecular weight corresponding to $C_{22}H_{44}O_2$ with a phenolic alcohol (Demarteau-Ginsburg, H., and Lederer, E., unpublished experiments). In previous experiments[4] mycocerosic acid was found in mycoside *B*; it is possible that the nature of the acid varies in dependence of strain and culture medium.

(3) Mycoside *C* is a peptide–glycolipid[4] and can be separated by chromatography on silicic acid into several closely related compounds. One of these, melting at 200°, $[\alpha]_D^{20}$ − 31° ($CHCl_3$), has an approximate molecular formula $C_{72}H_{133}N_5O_{24}$; calculated for $C_{72}H_{133}N_5O_{24}$: C, 59·8; H, 9·1; N, 4·8; for 3 OCH_3 6·3 per cent; found: C, 60·1; H, 8·7; N, 5·1; OCH_3, 6·0 per cent.

This particular mycoside *C* preparation contains three different deoxyhexoses, of which two have been tentatively identified as 6-deoxytalose and 3,4-di-*O*-methyl-rhamnose; the third sugar is possibly a monomethyl ether of 6-deoxy-talose (MacLennan, A. P., unpublished experiments).

The peptide portion of mycoside *C* contains three different amino-acids linked in a pentapeptide; one molecule of D-phenyl-alanine, two molecules of *allo*-threonine and two molecules of D-alanine. The lipid moiety of mycoside *C* has not yet been obtained in a pure state, but seems to be a hydroxyacid of approximate molecular formula $C_{24}H_{48}O_3$. Two *O*-acetyl groups are also present in mycoside *C* and can be readily recognized in the infra-red spectrum by a band at 8·1μ.

A more detailed report on the chemical structure of mycoside *C* will be published soon[6].

We are indebted to Drs. M. Ikawa and E. E. Snell (Berkeley) for the determination of the configuration of the amino-acids obtained from mycoside *C*.

DONALD W. SMITH
Department of Medical Microbiology,
University of Wisconsin.
H. M. RANDALL
Department of Physics,
University of Michigan.
A. P. MACLENNAN
Microbiological Research Establishment,
Porton.
E. LEDERER
Institut de Biologie Physico-Chimique,
Paris.

---

[1] Runyon, E. H., *Medical Clinics of North America*, **43**, 273 (1959).

[2] Smith, D. W., Harrell, W. K., and Randall, H. M., *Amer. Rev. Tub.*, **69**, 505 (1954).

[3] Noll, H., *J. Biol. Chem.*, **224**, 149 (1957).

[4] Smith, D. W., Randall, H. M., MacLennan, A. P., Putney, R. K., and Rao, S. V., *J. Bact.*, **79** (1960).

[5] MacLennan, A. P., Smith, D. W., and Randall, H. M., *Biochem. J.*, **74**, 3*P* (1960).

[6] Bigler, E., Gendre, T., Jolles, P., and Lederer, E., *Bull. Soc. Chim. Biol.* (in the press).

Hæmorrhagic Lipæmia in the Rat

Coleman and Beveridge[1] have recently directed attention to the influence of blood sampling on the level of plasma cholesterol in the rat. They observed that a diet containing merely corn oil did not increase the plasma cholesterol-level; but when it was combined with frequent blood sampling a significant increase followed. Further, blood sampling on alternate days even in the absence of fat in the diet was sufficient to cause an increase in the plasma

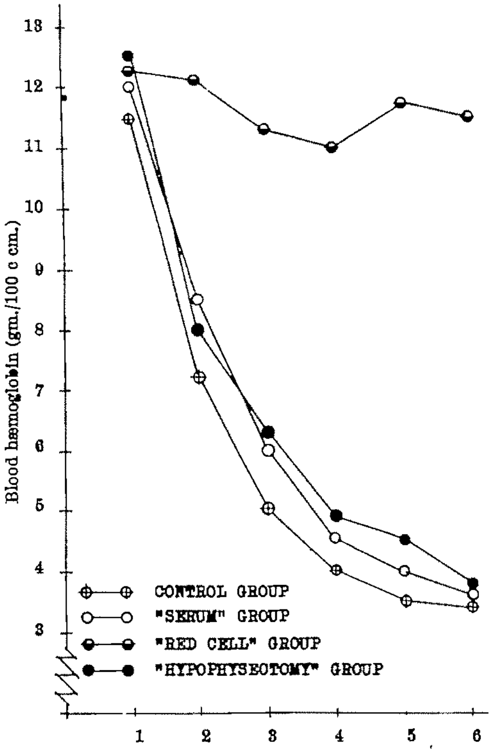


Fig. 1. Mean group values for blood hæmoglobin during the experiment

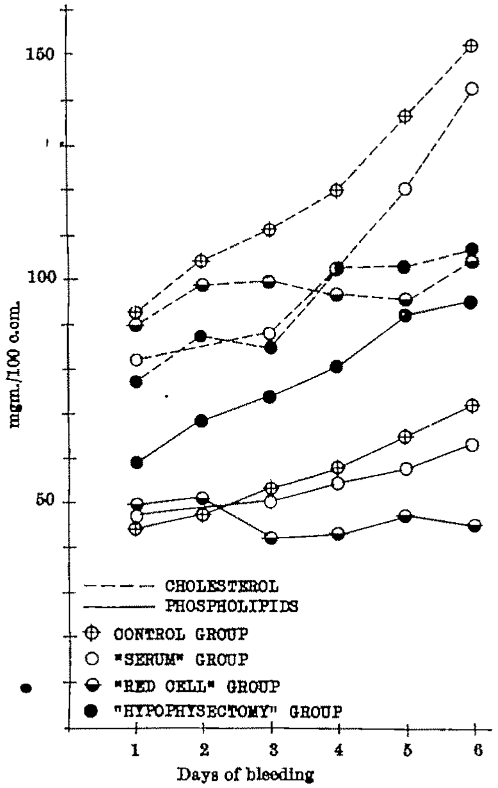


Fig. 2. Mean group values for serum total cholesterol and phospholipids during the experiment

cholesterol. Since some important earlier studies on hæmorrhagic lipæmia in experimental animals are not mentioned, we wish to give the following brief references and to present some additional data of our own.

Miettinen[2] has shown that in the rat bleeding causes a lipæmic turbidity of the serum and that relatively the greatest rise occurs in the total lipids. The phospholipids increase significantly more than the cholesterol. He further showed that the increase in cholesterol and phospholipids occurs chiefly in the α-2 lipoprotein fraction separated by paper electrophoresis. The administration of heparin to such lipæmic rats caused changes which were opposite to those resulting from bleeding[3]. In these experiments the bleeding was heavy enough to make the rats markedly anæmic.

In an extensive and thorough work Starup[4] showed that the development of hæmorrhagic lipæmia in the rabbit correlated best to the changes in the blood hæmoglobin-level. A similar lipæmia resulted from exposure of the animals to low atmospheric pressures. Starup regarded hypoxæmia as the cause of the lipæmia.

We have recently investigated some of the factors connected with the development of hæmorrhagic lipæmia in the rat[6]. Three groups of rats, each consisting of eight intact male animals on a standard low-fat diet, were subjected to a daily withdrawal of an amount of blood corresponding to 2 per cent of body-weight. The first group served as a control group and developed a marked anæmia, together with a definite increase in the serum cholesterol and phospholipid concentrations and visible lipæmia. The animals of the second group received after each bleeding an amount of rat serum approximately corresponding to the amount withdrawn. In this group anæmia and lipæmia developed similarly to the control group. The rats of the third group received after each bleeding an amount of washed red cells sufficient to prevent the development of anæmia. In this group no lipæmia occurred. These results are in accordance with those obtained on rabbits by Starup[4,5].

A fourth group of rats consisted of seven hypophysectomized animals which were bled sufficiently to produce an anæmia of the same degree as that of the control rats. Also in hypophysectomized rats the bleeding caused an increase in the serum cholesterol- and phospholipid-levels, but in the sera of these animals there occurred no visible turbidity.

It thus seems probable that the anæmic anoxia is the cause of the hæmorrhagic lipæmia. As to the mechanism of development of the hæmorrhagic lipæmia, it cannot be considered to be due solely to a reaction dependent on the hypophysis, such as stress, since the serum cholesterol- and phospholipid-levels rose also in the hypophysectomized rats. The lack of an apparent increase of serum neutral fats in these rats can be explained in several ways, for example, by an acceleration in 'the lipæmia clearing activity' in hypophysectomized rats[7], or by an impaired neutral fat mobilization from the depots. There remains the possibility, however, that in bleeding anæmia the elevation of neutral fats, on one hand, and that of cholesterol and phospholipids, on the other hand, are mediated by different mechanisms, the former possibly through the hypophysis.

Sven Punsar
Gottfried Härtel
Antti Louhija
Olli P. Heinonen

Wihuri Research Institute,
Helsinki, Finland.

[1] Coleman, I., and Beveridge, J. M. R., *Nature*, 184, 1041 (1959).

[2] Miettinen, M., *Ann. Med. Exp. Biol. Fenn.*, 35, 155 (1957).

[3] Miettinen, M., *Ann. Med. Exp. Biol. Fenn.*, 35, 258 (1957).

[4] Starup, U., "Undersøgelser over experimental hyperlipaemi" (Levin and Munksgaard–Ejnar Munksgaard, Copenhagen, 1937).

[5] Starup, U., *Biochem. Z.*, 270, 74 (1934).

[6] Punsar, S., Härtel, G., Louhija, A., and Heinonen, O. P., *Acta Endocrinol.* (in the press).

[7] Constantinides, P., Cairns, A., and So, Y., *Can. J. Biochem. Physiol.*, 35, 503 (1957).

PHYSIOLOGY

Action Potentials in Active Tissue with Delayed Potassium Permeability

In 1952, Hodgkin and Huxley[1] published a model which describes with considerable accuracy the electrical activity of nerve axons. The action potential in this tissue is accounted for by a large temporary increase in the permeability of the cell membrane, first to sodium ions, and then a millisecond or so later to potassium ions.

In the course of an investigation into the applicability of this model to the action potential in cardiac muscle tissue, I was led to explore the solution to the Hodgkin–Huxley equations when the increase in potassium permeability is suppressed. Under this condition active tissue was found to have two stable states which may be understood by reference to Fig. 1.

The equation to be solved[1] is:

$$C\frac{\mathrm{d}V}{\mathrm{d}t} + G_{\mathrm{K}}(V - V_{\mathrm{K}}) + g_{\mathrm{Na}}\, m^3 h\,(V - V_{\mathrm{Na}}) + g_l\,(V - V_l) = 0 \qquad (1)$$

The first term is the capacity current, the remaining terms give the potassium, sodium and leakage currents respectively.

For a steady state the first term is zero, and for simplicity I put the leakage current equal to zero also as it is in any event quite a small term. V_{K} and V_{Na} are reference potentials depending on the internal and external ionic concentrations, which in squid axon are $V_{\mathrm{K}} = +12$ mV., $V_{\mathrm{Na}} = -115$ mV.

If the potassium permeability G_{K} is constant, then the curve representing the second term in the above equation is a straight line, which has been drawn with sign reversed in Fig. 1 (*AB*). In the term giving the sodium permeability, g_{Na} is a constant and *m* and *h* are functions of *V* and *t* given by Hodgkin and Huxley. The steady-state values of these variables have been taken from ref. 1 and the resulting current is plotted on Fig. 1.

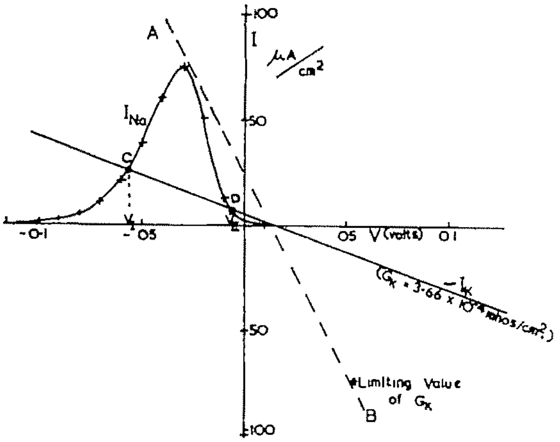


Fig. 1. Equilibrium values of sodium and potassium currents for various voltage displacements from the resting value and for constant potassium conductivity. The potassium current is plotted with sign reversed, and the intersections of these two curves give possible equilibrium values of V, V_{I} and V_{II}

The voltage corresponding to the steady state will then be given by the intersection of these two lines. It is immediately obvious that provided G_{K} is less than a certain limiting value, there are two points of intersection *C* and *D* corresponding to two stable potentials V_{I} and V_{II}. Fig. 1 has been drawn with the value $G_{\mathrm{K}} = 3{\cdot}66 \times 10^{-4}$ mhos/cm.^{2}, the resting value measured by Hodgkin and Huxley, when the values of V_{I} and V_{II} are found to be $V_{\mathrm{I}} = -56$ mV., $V_{\mathrm{II}} = -6$ mV. The limiting value of G_{K} corresponding to the dotted line in Fig. 1 is found to be $G_0 = 1{\cdot}9 \times 10^{-3}$ mhos/cm.^{2}.

The general solution to equation 1 for G_{K} = constant $= 3{\cdot}66 \times 10^{-4}$ mhos/cm.^{2} has been integrated using the fast digital computer *Silliac* in the School of Physics, University of Sydney. The result is shown in Fig. 2 and bears a striking resemblance to the early part of the action potential of Purkinje fibres[2].

Tasaki and collaborators[3-5] have presented evidence demonstrating the existence of a bistable state of the nerve membrane under certain conditions. For example, Tasaki and Hagiwara[3] showed that the effect of tetraethylammonium is to prolong the action potential in the squid axon and abolish the delayed rise in potassium conductivity. These authors were unable to explain their results in terms of the Hodgkin–Huxley model, but it appears that they can be so explained along the lines indicated above. Similarly, the other conditions for producing bistable states[4,5] may be understood in terms of Fig. 1.

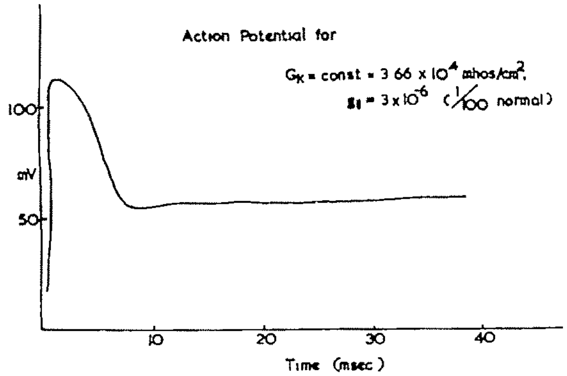


Fig. 2. Form of action potential calculated for G_{K} = constant = 3·66 × 10^{-4} mhos/cm.^{2}. Following the initial spike due to the sodium current, the potential settles down at the alternative steady level (V_{I} of Fig. 1)

A fuller description of these results is in the course of publication.

E. P. GEORGE

Physics Department,
St. Vincent's Hospital,
Sydney, N.S.W.

[1] Hodgkin, A. L., and Huxley, A. F., *J. Physiol.*, **117**, 500 (1952).

[2] Weidmann, S., "Elecktrophysiologie der Herzmuskelfaser" (Huber, Bern, 1956).

[3] Tasaki, I., and Hagiwara, S., *J. Gen. Physiol.*, **40**, 859 (1957).

[4] Tasaki, I., *J. Physiol.*, **148**, 306 (1959).

[5] Tasaki, I., and Spyropoulos, C. S., *Amer. J. Physiol.*, **193**, 318 (1958).

Thyroid-Powder Feeding and Liver Nitrogen in Mice

IT is known that thyroid hormone increases liver-weight in animals[1], accelerates the regeneration of liver in partially hepatectomized animals[2] and induces changes in liver cells representing typical growth[3]. The effect of thyroid hormone on liver nitrogen appears to have been less well studied. We have therefore investigated the effect on liver protein and glutamine in mice of feeding thyroid powder. Glutamine is found in relatively large quantities in various tissues, and the ability of these tissues both to synthesize and to break down proteins suggests that glutamine may serve as an important reservoir of ammonia nitrogen[4].

The experiments were carried out in male mice of Swiss strain weighing 23–25 gm. The animals were fed a standard stock food *ad libitum*. To produce hyperthyroidism, 0·5 per cent desiccated thyroid powder was added to the standard food for 10 days. On the eleventh day the animals were autopsied and liver-weight, protein and glutamine were measured. Liver protein for homogenized tissues was determined by the Kjeldahl–Pregl method. For determination of glutamine, the homogenates were deproteinized by the Folin–Wu method, and glutamine in the filtrate was determined by Whitehead and Whittaker's method[5]. The results are shown in Table 1. Increased weight of liver was observed in thyroid-fed animals. This increase is not related to a change

Table 1. EFFECT OF FEEDING THYROID POWDER ON LIVER-WEIGHT, PROTEIN AND GLUTAMINE

Treatment and No. of animals	Body-weight (gm.)		Liver: Weight		Liver: Protein†		Liver: Glutamine‡	
	Before	After	Actual (gm.)	Relative*	(mgm./100 gm.)	Total (gm.)	(mgm./100 gm.)	Total (mgm.)
Control (33)	24	23·9	1·187±0·090	4·98±0·01	23·50±0·30	0·278±0·030	106·3±5·1	1·250±0·071
Experimental (36)	24	23·7	1·346±0·080	5·85±0·03	23·43±0·22	0·321±0·020	126·4±8·1	1·620±0·084

* Relative liver-weight is the actual weight of liver per 100 gm. body-weight.
† Liver protein is calculated in gm. per 100 gm. Total protein is that in the whole liver in gm.
‡ Glutamine is calculated in mgm./100 gm. Total glutamine is the estimated value in mgm. in the whole liver.

in body-weight, since the relative liver-weight is also increased. The gain in liver-weight is also accompanied by a significant increase in total protein ($P < 0·02$), but there is no change in the percentage of liver protein. The increase in liver glutamine was more pronounced; there is a significant increase in percentage ($P = 0·02$) as well as in the total liver glutamine ($P = 0·001$).

These findings are in conformity with the fact that hypophysectomy reduced kidney glutamine in dogs, but the administration of growth hormone produced increased glutamine in kidneys and plasma along with nitrogen storage and gain in weight[4].

If glutamine is taken as a measure of the metabolic nitrogen pool, the action of thyroid hormone in promoting protein anabolism may be associated with the rise in the amount of glutamine.

This work was supported by a grant from the Royal Hellenic Foundation for Research.

A. N. GRANITSAS
M. KUKKU
M. KONSTANTINIDU

Institute of Physiology,
University, Athens 6.

[1] Myers, J. B., Brannon, E. S., and Holland, B. C., *J. Clin. Invest.*, **29**, 1069 (1950). Belasco, I. J., *Endocrinol.*, **28**, 153 (1941).
[2] Higgins, G. M., *Arch. Path.* (Chicago), **16**, 226 (1933).
[3] Sternheimer, R., *Endocrinol.*, **25**, 899 (1939).
[4] Meister, A., *Physiol. Rev.*, **36**, No. 1, 103 (1956).
[5] Whitehead, T. P., and Whittaker, S. R. F., *J. Clin. Path.*, **8**, 81 (1955).
[6] Bartlett, P. D., *Fed. Proc.*, **8**, 182 (1949).

Effect of Curare on Conduction in Myelinated, Isolated Nerve Fibres of the Frog

THE inhibitory effect of curare on the transmission of nerve impulses across myoneural junctions is generally attributed to its binding with the specific acetylcholine receptors in the motor end-plate membranes in competition with the acetylcholine, thereby preventing the ester from exerting its depolarizing action. Since the work of Claude Bernard, it has been known that curare acts specifically on the motor end-plates without any effect on axonal conduction. The failure of externally applied acetylcholine to affect conduction of nerve fibres was explained by Nachmansohn[1] as being due to permeability barriers surrounding the axon which are impermeable to lipid-insoluble compounds, such as methylated quaternary nitrogen derivatives, and cannot reach, therefore, the interior of the axon. These permeability barriers also explain the absence of any action of curare on axonal conduction: if monoquaternary ammonium salts are unable to penetrate these barriers, it is certainly to be expected that diquaternary salts will not enter. This does not indicate that the acetylcholine receptor upon which curare is supposed to act at the myoneural junction is not present and functional in the axon, only that it cannot be reached. If this viewpoint is correct, then diquaternary compounds which have two cationic nitrogens at the proper distance but are in addition soluble in lipid, such as stilbamidine, should have curare-like action. Block of conduction by stilbamidine was obtained by Bergmann, Wilson and Nachmansohn[2] on the axon, and by Schoffeniels and Nachmansohn[3] on the conducting membrane of the electroplax of *Electrophorus electricus*.

Another possibility to test this point of view is the use of a preparation where there is reason to believe that the structural barrier around the conducting membrane is relatively weak. Electron-microscope studies have revealed that at the nodes of Ranvier the conducting membrane is covered by a very thin structure. *d*-Tubocurarine chloride was applied to a single nerve fibre preparation as described by Stämpfli[4]. Conduction was blocked reversibly in a concentration of 10^{-3} *M*. The time necessary for this effect across the Ranvier node varied between 1 and 15 min. In cases where the blocking time was longer than 7 min., the reversibility was poor. Fig. 1*a* shows the effect of 10^{-3} *M* curare after 40 sec. The duration of the spike is significantly increased. After 100 sec. conduction was completely blocked (*b*). Partial recovery was obtained after rinsing the node with Ringer's solution for 60 sec.; 4 min. later, the height of the spike was restored to its original value, but the duration was still prolonged.

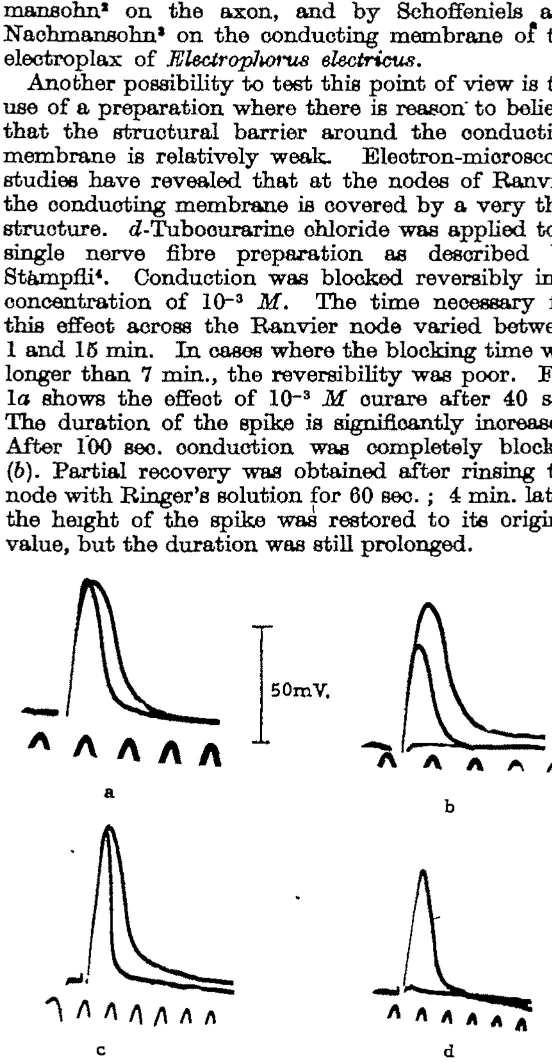


Fig. 1. Electrical activity at the node of Ranvier of a single nerve-fibre preparation of *Rana pipiens* exposed to *d*-tubocurarine chloride.
(*a*) and (*b*), 10^{-3} *M*, (*c*) and (*d*), 5×10^{-3} *M*. (*a*) 40 sec. after exposure, increased duration of spike; (*b*) after 100 sec., complete block of conduction. Return to Ringer's solution brings spike partially back; after 4 min. height of spike has returned to normal although the duration is still increased; (*c*) 5 sec. after curare the height of spike is increased and the duration prolonged. (*d*) after 40 sec., complete block of conduction. After 60 sec. in Ringer's solution, height of spike returns to normal. $t = 24°$ C., time, 1,000 cycles/sec.

In some cases 10^{-3} *M* curare had only a small effect on the duration of the spike and did not cause a block even after exposure for 15 min. In these cases curare in a concentration of 5×10^{-3} *M* had a strong and rapid effect. In Fig. 1*c* the duration of the action potential is prolonged after 5 sec. Block of conduction occurred after 40 sec. (Fig. 1*d*). After 60 sec. in Ringer's solution the spike has returned, although not yet to its original height. Repeated exposure of the same fibre to the same concentration of curare brought the blocking time down to 5 sec. Fibres which did not respond to 1×10^{-3} *M* curare but did to 5×10^{-3} *M* showed block after 1–2 min. when exposed again to 1×10^{-3} *M*.

d-Dimethyltubocurarine chloride, which is slightly more soluble in lipid than is *d*-tubocurarine, was also used, but no significant difference was found. Eserine blocks conduction of the node of Ranvier in low concentrations (30–40 µgm./ml.)[5]. This tertiary nitrogen derivative penetrates readily into the interior of the axon. Prostigmine also causes a block, but the concentration required for the effect is about tenfold higher (about $1{\cdot}7 \times 10^{-3}$ *M*, equivalent to ~ 500 µgm./ml.) and longer periods of exposure are needed[6]. Prostigmine, being a methylated quaternary nitrogen, does not penetrate into the interior of the nerve fibre[1]. Both compounds are *in vitro* almost equally strong inhibitors of acetylcholinesterase. The quantitative differences observed on the Ranvier node as to time and concentration may be attributed to differences in the rate of penetration. It is therefore not surprising that curare, too, requires relatively high concentrations. But the fact that it blocks reversibly electrical activity at the node of Ranvier supports the view of Nachmansohn that the role of the acetylcholine system is basically similar in axonal conduction and in synaptic transmission.

This work was supported by the Division of Research Grants and Fellowships of the National Institutes of Health, U.S. Public Health Service, Grant No. *B*-400, by the National Science Foundation, Grant No. *G*-4331, and by the Atomic Energy Commission, Contract No. *AT*(30-1)-1503.

WOLF D. DETTBARN

Department of Neurology,
College of Physicians and Surgeons,
Columbia University,
New York, N.Y.

[1] Nachmansohn, D., "Chemical and Molecular Basis of Nerve Activity" (Acad. Press, New York, 1959).

[2] Bergmann, F., Wilson, I. B., and Nachmansohn, D., *Biochim. Biophys. Acta*, **6**, 217 (1950).

[3] Schoffeniels, E., and Nachmansohn, D., *Biochim. Biophys. Acta*, **6**, 1 (1957).

[4] Stämpfli, R., *J. Physiol.* (Paris), **48**, 710 (1956).

[5] Dettbarn, W. D., *Biochim. Biophys. Acta* (in the press).

[6] Dettbarn, W. D., in Proc. Symp. Origin of Bioelectrogenesis, Rio de Janeiro (Elsevier Pub. Co., Amsterdam, 1959).

Level of Sulphydryl Compounds in Rat Liver following Feeding with Goitrogenous and Non-goitrogenous Cabbage

IN work on the relationship between the goitrogenous activity of cabbage and sulphate utilization from nutrient media[1,2], we have now followed, among other factors, the total sulphydryl compounds in the liver of experimental rats, by means of polarographic estimation[3]. The rats were given a goitrogenous and a non-goitrogenous variant of cabbage (*Brassica oleracea* var. *capitata*), grown in sand culture with nutrient solutions. The nutrient solution for the non-goitrogenous variant of cabbage contained 1 mgm. equivalent of sulphate and that used for the goitrogenous variant 25 mgm. equivalent of sulphate per 1 l. of solution. The other nutrient substances, both macro- and micro-elements, were present in equal amounts in both solutions.

Goitrogenicity of the cabbage thus cultivated was tested experimentally on white female rats of the Wistar strain, average weight 120 gm. One group of 20 rats received a daily ration of non-goitrogenous, another group of 20 rats had the goitrogenous variant of cabbage. In addition, both groups received Larsen's diet without any water. The controls, a group of 10 rats, were fed on Larsen's diet and had water to drink. The experiment lasted 33 days. 24 hr. before being killed the animals were given 20 µc. of iodine-131 intraperitoneally in 0·5 ml. of physiological solution; during these 24 hr. the animals were kept fasting, but all had water to drink. Beside the sulphydryl compounds, a series of determinations were made from which the goitrogenous activity of the particular variants of cabbage could be inferred (Table 1).

Table 1

Type of estimation	Controls* ($n = 10$)	Rats fed on non-goitrogenous variant of cabbage ($n = 20$)	Rats fed on goitrogenous variant of cabbage ($n = 20$)
Total sulphydryl compounds in liver expressed in mgm. of SH-glutathione/100 gm. of fresh liver	322·7 ± 62·4†	258·2 ± 14·5	625·9 ± 73·4
Percentage of epithelial cells in histological preparation of the thyroid	43·7 ± 4·9	41·5 ± 2·8	51·9 ± 5·8
Percentage of colloid in cells of histological thyroid preparation	44·1 ± 5·7	44·2 ± 8·4	34·5 ± 6·9
Iodine-131 uptake by thyroid as percentage of dose administered	44·2 ± 10·0	48·1 ± 11·2	70·4 ± 16·1‡
PBI-131 content in 1 ml. of serum as percentage of dose administered	0·034 ± 0·01	0·0258 ± 0·003	0·108 ± 0·059‡
Thyroid weight in mgm./100 gm. body-weight	9·8 ± 1·1	10·1 ± 1·9	10·6 ± 1·7

* *n*, number of rats in the experiment.

† Average + standard deviation.

‡ Increased uptake of iodine-131 by the thyroid and PBI-131 in 1 ml. of serum is accounted for by the unblocking effect of goitrogens on the thyroid as a result of a 24-hr. exclusion of cabbage from the diet.

Total sulphydryl compounds in the liver were measured immediately following the death of the animals. 4–5 gm. of liver were homogenized with 40–50 ml. of 1 per cent acetic acid and the anode wave of sulphydryl compounds was registered polarographically in 10 ml. of filtrate on a Heyrovský polarograph, type *V* 301. The quantitative evaluation of the waves of sulphydryl compounds was carried out by adding standard solutions of SH—glutathione.

The results in Table 1 and Fig. 1 show that rats fed with the goitrogenous variant of cabbage store

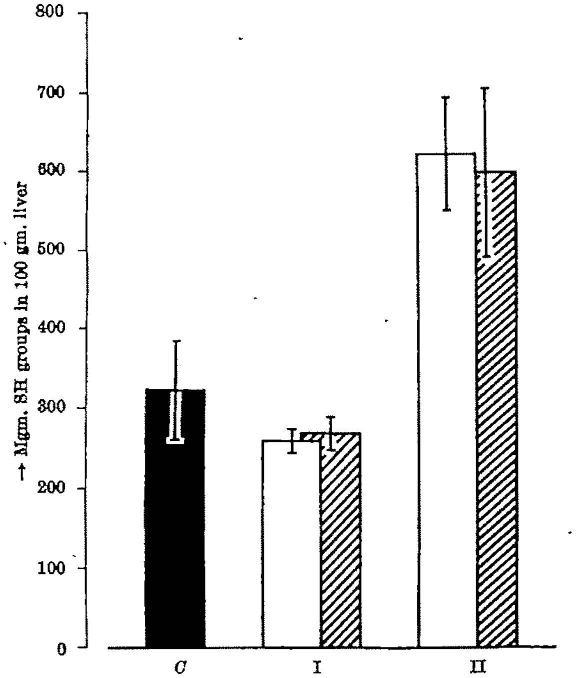


Fig. 1. Total sulphydryl compounds in experimental rat livers. *C*, Control group; I, groups of rats fed with non-goitrogenous variant of cabbage; II, groups of rats fed with goitrogenous variant of cabbage. Individual columns indicate average value with standard deviation. Blank columns indicate values obtained for rats consuming cabbage heads; shaded columns for those consuming green cabbage leaves

in the liver twice as much ($P \leqq 0{\cdot}0001$) total sulphydryl compounds, expressed in terms of glutathione, as do those fed on non-goitrogenous cabbage, or on Larsen's diet.

One of the principal effects of goitrogens on entering the organism is a lowered production of thyroid hormone, bringing about a 'hypothyroid' condition in the whole organism, a lowered over-all metabolic rate and lowered oxygen utilization by the tissues. The inhibiting effect of goitrogens on oxygen uptake by tissues *in vitro* is likewise known[4]. This inhibitory influence of goitrogens may be a causative factor in the increased level of total sulphydryl compounds, that is, of the protein and non-protein sulphydryl compounds in the liver of rats fed with a goitrogenous variant of cabbage. There probably ensues inhibition of the oxidases of SH-glutathione and other sulphydryl compounds in the liver of rats fed with a goitrogenous variant of cabbage.

Since a marked increase in the total sulphydryl compounds occurred after consumption of the goitrogenous variant of cabbage only, it may be possible to use the estimation of total sulphydryl compounds in the liver of experimental animals as a test of the goitrogenicity of vegetable foodstuffs, provided, of course, that account is taken of the specificity of the test. Besides a marked increase in sulphydryl compounds in the liver after consumption of the goitrogenous variant of cabbage, there is probably also an increase in total sulphydryl compounds in the blood and other organs, too, as found by Houssay, Martinez and Caputto[5] following administration of thiouracil, and by Capra[6] after methylthiouracil; therefore a diet of goitrogenous cabbage may give protection from the effects of ionizing radiation.

We are grateful to Mr. Š. Kaločai and Miss J. Horváthová for their technical assistance.

JOZEF SEDLÁK

Endocrinological Institute,
Slovak Academy of Sciences,
Bratislava, ul. Obráncov mieru 1/a,
Czechoslovakia.

[1] Sedlák, J., Michajlovskij, N., and Kaločai, Š., *Biológia*, **14**, 3 (1959).

[2] Sedlák, J., Langer, P., and Ličko, V., *Biológia*, **15**, 183 (1960).

[3] Zuman, P., *Chem. Listy*, **46**, 73 (1952).

[4] Reid, C., and Kissa, J., *Arch. Biochem. Biophys.*, **53**, 321 (1954).

[5] Houssay, B. A., Martinez, C., and Caputto, R., *Rev. Soc. Argentina Biol.*, **23**, 248 (1947).

[6] Capra, P., *Boll. Soc. Med. Chir., Pavia*, **61**, 7 (1947).

Synergetic Action of 2(*o*-Methoxyphenoxymethyl)-5-Oxazolidone on Morphine, Dihydrocodeine and Aminopyrine Analgesia

2(*o* - Methoxyphenoxymethyl) - 5 - oxazolidone (metoxadone), a substance synthesized by us[1] (cf. Argentine Patent No. 118.613, April 21, 1957—Oct. 29, 1959), produced prolonged muscle relaxation and anticonvulsive effects[2,3]. Gray *et al.*[4] found that this substance reduced the spontaneous motor activity and caffeine hyperactivity of mice and specifically blocked their conditioned avoidance reaction. According to its behaviour in the avoidance conditioning test, metoxadone belongs to the group formed by chlorpromazine and its congeners, reserpinoid *Rauwolfia* alkaloids and morphine[5].

We therefore studied the synergetic effect of metoxadone on central analgesic actions of drugs such as morphine, dihydrocodeine and aminopyrine, because a similar effect is characteristic for chlorpromazine and its congeners[6,7], but not for reserpinoid alkaloids which antagonize morphine analgesia[8].

In our experiments we employed the hot-plate test of Woolfe and Macdonald[9], modified by Eddy *et al.*[10,11]. The plate was heated to a constant temperature of 59·5° C. and the time until the mice lifted their hind legs twice was recorded as 'permanence'. The results are shown in Tables 1, 2 and 3.

Table 1. PROLONGATION OF THE PERMANENCE OF MICE ON THE HOT PLATE 30 MIN. AFTER A SUBCUTANEOUS INJECTION OF METOXADONE (MET), DIHYDROCODEINE TARTRATE (DHC) AND THEIR COMBINATION

Doses of the drugs in mgm./kgm., permanence prolongation in sec.

MET alone 12·5	no effect		
MET alone 25·0	no effect		
MET alone 50·5	2·6 ± 1·3	not significant,	*P* = 0·05
DHC alone, 12·5	2·6 ± 0·7	significant,	*P* = 0·05
DHC, 12·5 + MET, 12·5	3·3 ± 0·9	significant,	*P* = 0·05
DHC, 12·5 + MET, 25·0	5·5 ± 0·9	significant,	*P* = 0·01
DHC alone, 25·0	5·6 ± 0·6	significant,	*P* = 0·01
DHC alone, 50·0	7·7 ± 0·8	significant,	*P* = 0·01
DHC, 12·5 + MET, 50·0	13·0 ± 1·7	significant,	*P* = 0·01

Table 2. PROLONGATION OF THE PERMANENCE OF MICE ON THE HOT PLATE 30 MIN. AFTER SUBCUTANEOUS INJECTIONS OF MORPHINE HYDROCHLORIDE (MOR) ALONE AND COMBINED WITH METOXADONE (MET)

Doses in mgm./kgm., permanence prolongation in sec.

MOR alone, 1·25	1·4 ± 0·8	not significant,	*P* = 0·05
MOR alone, 2·5	2·7 ± 1·0	not significant,	*P* = 0·05
MOR, 1·25 + MET, 5·0	3·4 ± 1·1	not significant,	*P* = 0·05
MOR alone, 5·0	4·0 ± 0·8	significant,	*P* = 0·01
MOR, 1·25 + MET, 10·0	9·6 ± 0·9	significant,	*P* = 0·01
MOR, 1·25 + MET, 20·0	10·7 ± 2·4	significant,	*P* = 0·01

Table 3. PROLONGATION OF THE PERMANENCE OF MICE ON THE HOT PLATE 30 MIN. AFTER SUBCUTANEOUS INJECTIONS OF AMINOPYRINE ALONE (AP) AND COMBINED WITH METOXADONE (MET)

Doses in mgm./kgm., permanence prolongation in sec.

AP alone, 50·0	no effect		
AP alone, 100·0	no effect		
AP alone, 200·0	3·9 ± 0·8	significant,	*P* = 0·01
AP, 50·0 + MET, 10·0	3·5 ± 1·6	not significant,	*P* = 0·05

Table 1 shows that metoxadone has a marked synergetic effect on dihydrocodeine analgesia. 12·5 mgm./kgm. dihydrocodeine is potentiated by 25 mgm./kgm. metoxadone (a dose without any analgesic effect of its own), for the combination was as active as a dose of dihydrocodeine twice as high (25 mgm./kgm.). 50 mgm./kgm. metoxadone increased the effect of 12·5 mgm./kgm. of dihydrocodeine more than four times.

Table 2 shows that relatively low doses of metoxadone potentiated the effect of 1·25 mgm./kgm. morphine hydrochloride more than twice; the effect of 2·5 mgm./kgm. morphine salt alone was still somewhat less (2·7 sec.) than that of the combination (3·4 sec.). A higher dose of metoxadone (10 mgm./kgm.) increased the effect of morphine more than four times. (Permanence prolongation of the combination: 9·6 sec.; that of a fourfold dose of morphine alone 4·0 sec.)

Table 3 shows that the effect of aminopyrine is enhanced nearly four times by metoxadone.

According to our results, metoxadone markedly increases the analgesic actions of dihydrocodeine, morphine and aminopyrine.

E. FISCHER
J. L. J. SZABÓ
M. STAMBURGO

Research Dept.,
Szabó Hnos., Kessler and Cía. S.R.L.,
Humahuaca 4065, Buenos Aires.

[1] Fischer, E., Szabó, J. L. J., and Laviuzza, M., Comun Soc. Farm. Ter. Buenos Aires (June 25, 1957).

[2] Isgro, A., thesis Fac. Farm. Bioquim, Univ. Buenos Aires (1958).

[3] Fischer, E., and Szabó, J. L. J., Comm. Twenty-first Int. Congr. Physiol Sci., Buenos Aires (1959); cf. *Rev. Asoc. Med. Arg.* 74, 82 (1960).

[4] Gray, W. D., Osterberg, A. C., Rauh, C. E., and Hill, R. T. (in preparation).

[5] Cook, L., and Weidley, E., *Ann. N.Y. Acad. Sci.*, 66, 740 (1957).

[6] Courvoisier, S., Fournel, J., Ducrot, R., Kolsky, M., and Koetschet, P., *Arch. Intern. Pharmacodyn.*, 92, 305 (1953).

[7] Friebel, H., Flick, H., and Reichle, C., *Arzneimittelf.*, 4, 171 (1954).

[8] Schneider, J. A., *Amer. J. Physiol.*, 181, 64 (1955).

[9] Woolfe, G., and Macdonald, A. D., *J. Pharm. Exp. Ther.*, 80, 300 (1944).

[10] Eddy, N. B., Touchberry, C. F., and Liberman, J. E., *J. Pharm. Exp. Ther.*, 98, 121 (1950).

[11] Eddy, N. B., and Leimbach, D., *J. Pharm. Exp. Ther.*, 107, 385 (1953).

HÆMATOLOGY

Variations in Electrophoretic Position of Haptoglobin Mixtures in Agar-gel Electrophoresis

BY means of agar-gel electrophoresis, sera can be put into different haptoglobin groups. Sera belonging to *Hp* 1-1 give a fast migrating spot stainable with benzidine, while sera belonging to *Hp* 2-2 have a slowly migrating component and sera belonging to *Hp* 2-1 give a spot occupying an intermediate electrophoretic position. The spots are easily stained with a benzidine reagent if hæmoglobin has been added to the sera before electrophoretic separation[1].

When sera belonging to *Hp* 2-1 as determined by starch-gel electrophoresis[2] with a discontinuous buffer system[3] were investigated in agar-gel electrophoresis[1], it was found that these sera could be divided into further groups depending on variations in electrophoretic positions of the spot stainable with benzidine.

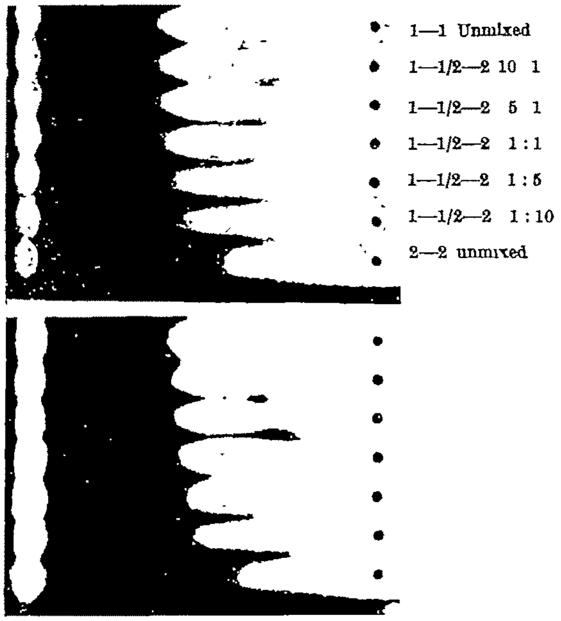


Fig. 1. Agar-gel electrophoresis of sera belonging to *Hp* 1-1 and 2-2 and mixtures of these sera in different relative amounts. To the far left is the albumin spot. The circular holes represent the point of application. The photographs represent duplicate experiments

Sera presenting a weak, or even absence of the *Hp* 1-1 band in starch-gel electrophoresis were found, in agar-gel electrophoresis, to give a spot more displaced towards the cathode than sera presenting a strong *Hp* 1-1 band but weak other bands characterizing the *Hp* 2-1 type in starch-gel electrophoresis.

In Fig. 1 duplicate separations of mixtures of a serum belonging to *Hp* 1-1 and *Hp* 2-2 in different relative amounts are shown. By mixing these sera in different relative amounts, varying electrophoretic positions of the spot stainable with benzidine will be obtained as judged by the position of the part of the spot which is situated nearest to the anode.

Thus, if the serum belonging to *Hp* 1-1 is quantitatively predominant in the mixture, for example, in the ratio of 10 : 1, a rapidly migrating spot will be obtained, which, however, migrates slightly slower than the spot of the unmixed *Hp* 1-1 serum, but more rapidly than a mixture of these sera in the proportions of 5 : 1. When the same mixtures were subjected to starch-gel electrophoresis, no differences in electrophoretic positions of the haptoglobin bands were seen. If serum belonging to *Hp* 1-1 was mixed with the serum belonging to *Hp* 2-2 in the relative amounts of 10 : 1, only a single *Hp* 1-1 band was seen in starch-gel electrophoresis under the experimental conditions employed. Therefore it seems as if the agar-gel electrophoretic technique is slightly more sensitive than the starch-gel electrophoretic technique as carried out in this laboratory.

If the ratio between *Hp* 1-1 and *Hp* 2-2 is 1 : 20 or greater, the electrophoretic position of the mixture is identical with that of an unmixed serum belonging to *Hp* 2-2.

Thus, within certain limits, the electrophoretic position of the haptoglobin spots in mixtures of sera belonging to *Hp* 1-1 and 2-2 will vary, depending on relative amounts of these sera in the mixture. This is not the case when the same mixtures are subjected to starch-gel electrophoresis.

Therefore it seems as if the agar-gel electrophoretic technique might be a valuable supplement to starch-gel electrophoresis, especially as regards sera, where suspicion might exist that the phenotype as revealed by starch-gel electrophoresis does not correspond to the genotype as indicated by, for example, family studies[4]. My work on some mother–child material also seems to indicate that, especially among children, haptoglobin grouping might be difficult, as originally pointed out by Smithies[2]. In some instances, repeated starch-gel electrophoretic investigations of certain sera did not demonstrate any haptoglobin in these sera, although in agar-gel electrophoresis haptoglobins were demonstrable enabling us to group these sera (unpublished work).

The fact that variations in electrophoretic positions of components in agar-gel electrophoresis as well as in immunoelectrophoresis[5] may depend on quantitative relations between electrophoretically different molecule populations, giving rise to a single spot with the technique employed, may be of theoretical interest when the 'microheterogeneity' of different components is studied, and of practical importance when further electrophoretic differences are found in different human sera.

Thus, it has recently been found that another component in the α_1-globulin region presents electrophoretic differences when different sera are investigated in agar-gel electrophoresis and developed with an indoxyl–acetate reagent. In general, sera can be grouped into a fast, a slow and an intermediate type, depending on the electrophoretic position of this component[6]. It was found that sera belonging to the intermediate group gave rise to spots with slightly varying electrophoretic positions characteristic for the serum investigated (unpublished work).

In analogy with the findings here, it seems suggestive that this intermediate group depends on the concomitant presence of the fast and slow components although in different relative amounts, thereby allowing a further sub-grouping within this group, as has been the case with sera belonging to *Hp* 2-1.

Further work is in progress to investigate the influence of quantitative factors on the electrophoretic position of proteins in agar-gel and starch-gel electrophoresis.

JAN HIRSCHFELD

Department of Bacteriology,
Karolinska Institutet,
Stockholm 60,
and
State Institute for Blood Group Serology,
Statens Rattskemiska Laboratorium,
Stockholm.

Feb. 10.

---

[1] Hirschfeld, J., *Acta Path. et Microbiol. Scand.*, **47**, 160 (1959).

[2] Smithies, O., *Biochem. J.*, **61**, 629 (1955).

[3] Poulik, M. D., *Nature*, **180**, 1477 (1957).

[4] Harris, H., *Nature*, **182**, 1324 (1958).

[5] Hirschfeld, J., *Nature*, **185**, 164 (1960).

[6] Hirschfeld, J., *Nature*, **186**, 321 (1960).

Oxygen Equilibrium of Hæmoglobin from *Thunnus thynnus*

FEW data can be found in the literature dealing with the functional properties of hæmoglobin of lower vertebrates[1–3]. Moreover, these investigations were carried out using whole blood or unpurified hæmolysate as working material, particularly in the case of fishes; this procedure may make the interpretation of the results misleading since the blood of these animals rapidly deteriorates after collection[3].

In this communication we report results on the oxygen equilibrium of crystalline hæmoglobin from *Thunnus thynnus*. Crystalline hæmoglobin was prepared from freshly collected blood as previously described[4], and was stored under saturated ammonium sulphate. Since during the preparation and storage the hæmoglobin is in part transformed into the ferric form, in all cases, before the determination of the oxygen dissociation curves, the pigment was completely reduced by an enzymic system[5].

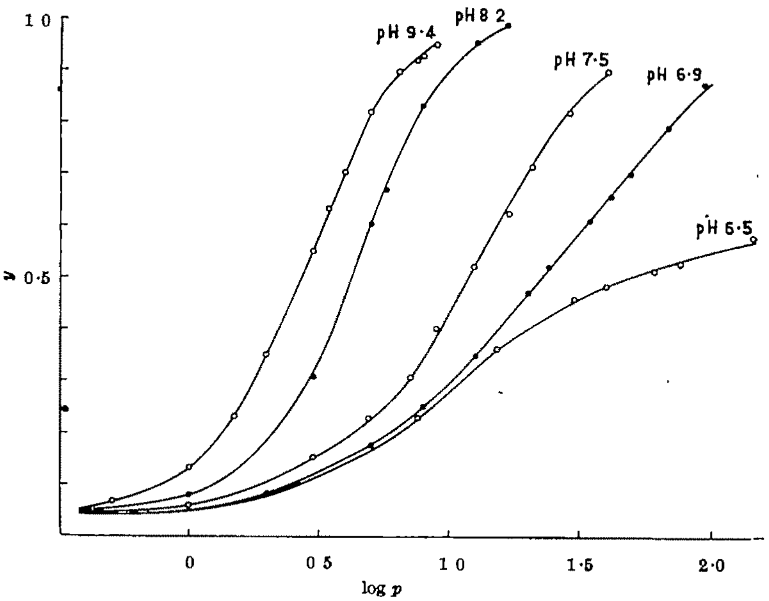


Fig. 1. Oxygen dissociation curves of *Thunnus* hæmoglobin at different values of pH at 20° C.; *tris*(hydroxymethyl)amino-methane buffers, ionic strength 0·1; hæmoglobin concentration: $2 \cdot 5–3 \times 10^{-4}$ *M* (as Fe); $y = \frac{(\mathrm{HbO_2})}{(\mathrm{Hb}) + (\mathrm{HbO_2})}$. p, partial pressure of oxygen in mm. mercury

The oxygen dissociation curves were determined by the spectrophotometric method previously described[5].

In all the conditions the pigment was stable, and the spectrophotometric data obtained during the progress of oxygenation could be ascribed to the presence of only hæmoglobin and oxyhæmoglobin.

Fig. 1 shows the oxygen dissociation curves of *Thunnus thynnus* hæmoglobin at different pH's. It may be seen that on varying the pH both the shape of the curve and the oxygen affinity change greatly. At alkaline pH's the curve is sigmoid in shape, but the inflexion rapidly decreases with lowering of the pH-value. Indeed, the curve of the dissociation factor y versus oxygen partial pressure was found to be hyperbolic at pH 6·9; below this value of pH, the curve, for values of y greater than 0·3, tends to become

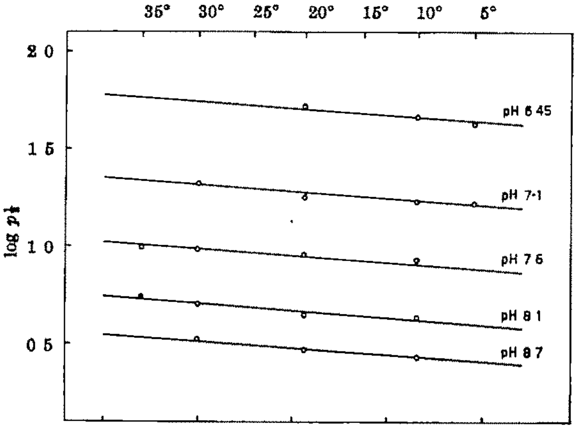


Fig. 2. Effect of temperature on the oxygen affinities of tuna hæmoglobin. Same conditions as in Fig. 1

parallel to the abscissa ; the oxygen affinity decreases on lowering the pH.

The changes in shape of the curve and in oxygen affinity are readily reversible over the entire pH range examined.

The effect of temperature on the oxygen equilibrium of tuna hæmoglobin has been studied at several pH values (Fig. 2). It was found that the temperature has very little effect on the oxygen affinity, at all the pH values examined. The shape of the oxygen dissociation curve did not change appreciably with temperatures.

The overall heat of the reaction :

$$\text{hæmoglobin} + O_{2(\text{gas})} \rightarrow \text{oxyhæmoglobin}$$

was calculated from the data for various pH-values[6] as $-1{\cdot}8$ kcal. mole^{-1} ; taking into account the heat of solution of oxygen, the heat of reaction would be nearly zero.

The results reported in the present communication show some important and characteristic differences between the oxygen equilibrium of the hæmoglobin of *Thunnus thynnus* as compared with that of mammalian hæmoglobin.

The effect of pH is to affect the oxygen affinity in the same direction as in mammalian hæmoglobin, but this is accompanied, in the case of the hæmoglobin of tuna by a great change in the shape of the oxygen dissociation curve. The inflexion of the curve is in this case a function of pH. In the case of mammalian hæmoglobin, differences in the shape at different pH's are observed only at very low or very high oxygen saturation[7] and do not affect the general shape of the curve.

The effect of temperature is even more unusual ; in the case of mammalian hæmoglobin the temperature has a great effect on the oxygen affinity, corresponding to an overall heat of reaction about equal to -13 kcal. mole^{-1} at pH 9·5[6]. On the other hand, the oxygen affinity of tuna hæmoglobin is practically unaffected by temperature.

The physiological meaning of these findings should be discussed in relation to the particular functional needs of the tuna fish ; for example, the insensitivity of the oxygen equilibrium of tuna hæmoglobin to changes in temperature could represent a sort of molecular adaptation which would enable the animal to live in waters of very different temperatures without modification of the functional properties of its respiratory pigment.

From a physico-chemical point of view, the study of hæmoglobin of lower vertebrates may represent a promising field for further knowledge of the kinetics and thermodynamics of the oxygen reactions of the respiratory proteins.

A. ROSSI-FANELLI
E. ANTONINI

Institute of Biological Chemistry,
University of Rome.

[1] Redfield, A. C., *Quart. Rev. Biol.*, 8, 31 (1933).
[2] Green, A. A., and Root, R. W., *Biol. Bull., Marine Biol. Lab.*, 64, 383 (1933).
[3] Brown, M. E., "The Physiology of Fishes", 1 (Academic Press, Inc., New York, 1956).
[4] Rossi-Fanelli, A., and Antonini, E., *Arch. Biochem. Biophys.*, 58, 498 (1955).
[5] Rossi-Fanelli, A., and Antonini, E., *Arch. Biochem. Biophys.*, 77, 478 (1958).
[6] Wyman, J., "Advances in Protein Chem.", 4, 407 (1948).
[7] Roughton, F. J. W., Otis, A. B., and Lyster, R. L. J., *Proc. Roy. Soc.*, B, 144, 29 (1955).

Oxygen Equilibrium of Myoglobin from *Thunnus thynnus*

MYOGLOBIN from several species of fishes has been recently purified and quite extensively studied[1–3], but no data on the oxygen equilibrium of these pigments have yet been reported.

In connexion with studies on the oxygen equilibrium of *Thunnus thynnus* hæmoglobin[4], it seemed of interest to examine the functional properties of myoglobin from the same animal.

Myoglobin was crystallized from the deep red muscles of the lateral line of an adult specimen of *Thunnus thynnus*. The absence of hæmoglobin from the preparation was checked by paper electrophoresis and spectrophotometry[3]. As previously reported[3], even crystalline preparations of tuna myoglobin are heterogeneous in electrophoresis for the presence of three myoglobin components, Mb I, Mb II and Mb III, which account respectively for about 80, 20 and 5 per cent of the total pigment. Such components have identical light-absorption spectra in the visible and Soret zone ; they are present also in the water extract of muscles. Owing to the small quantity of crystalline myoglobin of tuna available no separation of the different myoglobin components could be attempted, and the experiments have been performed with the total crystalline pigments.

In the case of human myoglobin no difference was noted in the oxygen equilibrium of the components Mb I and Mb II (ref. 5).

The reduction of ferrymyoglobin and the determination of the oxygen dissociation curves have been performed according to Rossi-Fanelli and Antonini[5].

Fig. 1 shows the oxygen dissociation curves of tuna myoglobin in 0·1 *M tris* buffer at pH 7·45. The curves obey the Hill equation :

$$y = \frac{K(pO_2)^n}{1 + K(pO_2)^n}$$

for a value of $n = 1$ (pO_2 = partial pressure of oxygen in mm. mercury). The oxygen affinity is high and very similar to that of mammalian myoglobins : at 20° C. the partial pressure of oxygen for 50 per cent oxygen saturation ($p\frac{1}{2}$) is 0·9 mm. mercury ; the value for human myoglobin in the

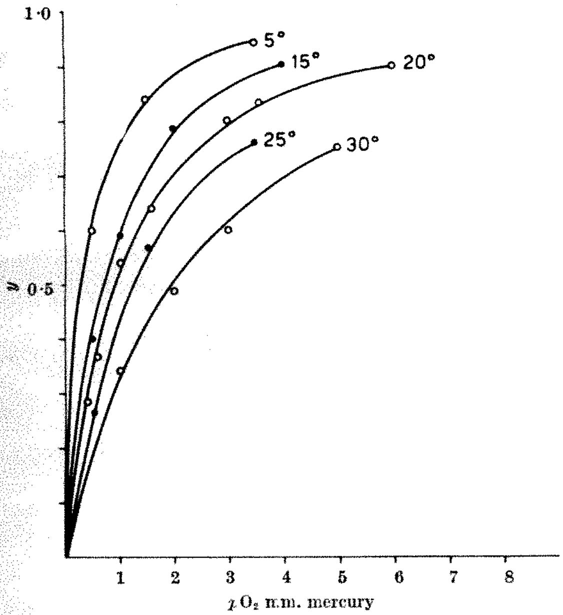


Fig. 1. Oxygen dissociation curves of tuna myoglobin at different temperatures: *tris*(hydroxymethyl)amino-methane buffer, ionic strength 0·1; pH 7·5; myoglobin concentration = 2×10^{-4} *M*; $y = \frac{(\text{MbO}_2)}{(\text{Mb}) + (\text{MbO}_2)}$

same conditions is 0·73 mm. mercury[5]. The effect of temperature on the oxygen affinity is also shown in Fig. 1; the overall heat of the reaction:

$$\text{myoglobin} + \text{oxygen} \rightarrow \text{oxymyoglobin}$$

calculated by the van't Hoff equation[6] between 5° and 30° C. was found to be $-13 \cdot 2$ kcal. mole^{-1}. The Bohr effect has been studied at 20° C. in 0·1 *M* tris buffers and was found, between pH 7·1 and 8·7, practically absent:

$$(\text{d} \log K)/(\text{d}p\text{H})_{20^\circ} = +0 \cdot 02$$

The results reported above show that tuna myoglobin has functional properties very similar to those of mammalian myoglobin: hyperbolic shape of the oxygen-dissociation curve, high oxygen affinity and absence of Bohr effect.

These results indicate that the functional and structural properties of the myoglobin do not change appreciably in animals belonging to different classes, and that this pigment has retained through all the species the same simple characteristic properties. On the contrary the blood hæmoglobin shows a greater structural complexity accompanied with a large functional variability according to the different biological needs of the various animal species.

A. Rossi-Fanelli
E. Antonini
R. Giuffrè

Institute of Biological Chemistry,
University of Rome.

[1] Rossi-Fanelli, A., and Antonini, E., *Arch. Biochem. Biophys.*, **58**, 498 (1955).

[2] Rossi-Fanelli, A., and Antonini, E., *Boll. Soc. Ital. Biol. Sper.*, **32**, 1156 (1956).

[3] Dollar, A. M., Duane Brown, W., and Olcott, H. S., *Biochem. Biophys., Res. Comm.*, **1**, 276 (1959).

[4] Rossi-Fanelli, A., and Antonini, E. (see preceding communication).

[5] Rossi-Fanelli, A., and Antonini, E., *Arch. Biochem. Biophys.*, **77**, 478 (1958).

[6] Wyman, J., "Adv. in Protein Chem.", **4**, 407 (1948).

RADIOBIOLOGY

Degradation of γ-Methyleneglutamic Acid by Plants

Many new amino-acids have been isolated from higher plants in recent years[1]. However, little is known concerning the function and metabolism of the majority of these acids. Frequently they have been considered to be rather akin to alkaloids; they are often found to be randomly distributed among the members of the plant kingdom, and yet they accumulate in large amounts in certain plants, sometimes being confined mainly to particular organs. These features suggest that a number of the acids are perhaps secondary products (by-products) of metabolism that can only slowly re-enter the main pathways of metabolism operative in plants.

γ-Methyleneglutamic acid and its amide, γ-methyleneglutamine, were among the first of the newer acids to be isolated[2]. The initial isolations were made from peanut plants; but now the substances are known to occur also in tulips[3], peas[4], hops[5] and bean seedlings[6]. Although γ-methyleneglutamic acid and γ-methyleneglutamine show the restricted distribution typical of the newer amino-acids, they are atypical from the metabolic point of view. The substances appear to be synthesized readily from carbon-14 labelled pyruvate, acetate, or glucose by cotyledon tissue of peanut seedlings, and the branched-chain carbon skeleton may arise by condensation of two pyruvate molecules[7]. Active preparations of a deamidase for γ-methyleneglutamine[8] and a transaminase utilizing γ-methyleneglutamic acid[9] have been obtained in extracts of peanut plants, while a decarboxylase capable of using γ-methyleneglutamic acid was present in tulip leaf extracts[10]. However, these *in vitro* reactions could be the result of non-specific action of glutaminase, glutamic–aspartic transaminase, and glutamic decarboxylase respectively, and they may inaccurately portray the true position regarding the degradation of γ-methyleneglutamic acid and γ-methyleneglutamine within intact plant tissues. The present experiments, which used carbon-14 labelled γ-methyleneglutamic acid, established with certainty that degradation of the acid occurs *in vivo*.

γ-Methyleneglutamic acid was synthesized by a procedure which introduced a carbon-14 label into the α-carbon atom. α-Iodomethylacrylic acid was synthesized from ethyl di(hydroxymethyl)malonate by the method of Welch[11], and this was esterified to give ethyl α-iodomethylacrylate. This ester was then condensed with ethyl [2-^{14}C] acetamidomalonate, following the method of Hellmann and Lingens[12], and subsequent hydrolysis of the condensation product with 6 *N* hydrochloric acid gave [α-^{14}C] γ-methyleneglutamic acid. By paper chromatographic methods, the acid was obtained radiochemically pure, when it had a specific activity of 1 mc./m*M*.

A solution of carbon-14 labelled γ-methyleneglutamic acid was supplied to shoot tips of peas (Carter's Little Marvel variety) and to immature peanut leaves through the cut ends of the shoots and petioles respectively. The labelled material was introduced into leaf disks of tulip by vacuum infiltration. In this way, each gram of fresh pea or peanut tissue received about 0·8 mgm. carbon-14 labelled γ-methyleneglutamic acid (5 μc.), while 0·3 mgm. carbon-14 labelled γ-methyleneglutamic acid (2 μc.) was introduced into each gram of tulip leaf disks. The plant tissues were then kept in continuous light

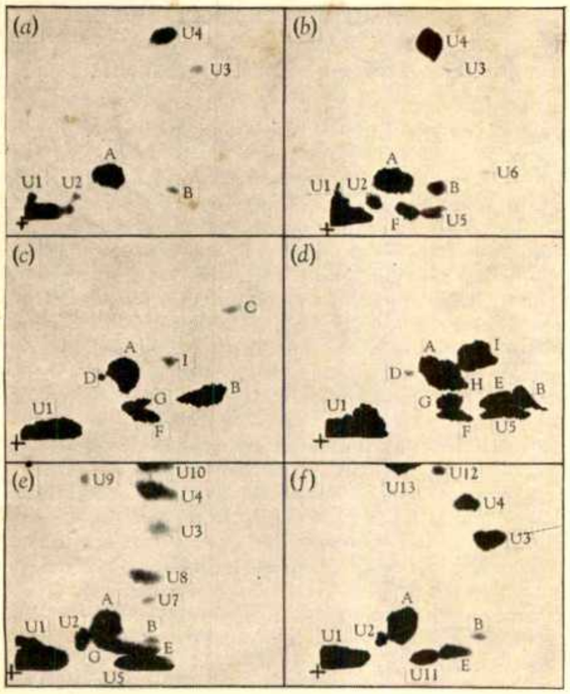


Fig. 1. Reproductions of radioautographs prepared from extracts of plants metabolizing [α-^{14}C] γ-methyleneglutamic acid. (*a*) Peanut leaves after 24 hr., and (*b*) after 48 hr. (*c*) Tulip leaves after 24 hr., and (*d*) after 48 hr. (*e*) Pea shoots after 24 hr., and (*f*) after 48 hr. The chromatograms were developed in phenol-ammonia (horizontal direction) and then *n*-butanol–acetic acid–water (vertical direction). The origin is marked +. Key to spots: *A*, γ-methyleneglutamic acid; *B*, γ-methyleneglutamine; *C*, γ-amino-α-methylenebutyric acid; *D*, glutamic acid; *E*, glutamine; *F*, asparagine; *G*, sucrose; *H*, glucose; *I*, fructose; *U*1, unknown radioactive substances probably including triose and hexose phosphates; *U*2–*U*13, other radioactive compounds of unknown identity

(900 ft.-candles) under humid conditions at 20°. After suitable time intervals, samples were killed by dropping into boiling 75 per cent (v/v) ethanol. After complete extraction of the aqueous-ethanol-soluble compounds, portions of the concentrated extracts equivalent to 50 mgm. of initial plant tissue were applied to two-dimensional paper chromatograms run in 75 per cent (w/w) phenol, followed by *n*-butanol–acetic acid–water (4 : 1 : 5). Radioautographs were prepared from each chromatogram and representative examples are reproduced in Fig. 1.

The radioautographs show that an extensive degradation of γ-methyleneglutamic acid occurred in all three species. Complete loss of the carbon-14 label from γ-methyleneglutamic acid could not be expected because the synthetic material was a DL-racemate.

Some products of γ-methyleneglutamic acid metabolism were common to pea, peanut, and tulip tissues; these included the labelled materials (designated *U*1) running near the origin on the paper chromatograms. This is the general area in which triose and hexose phosphates are encountered. The formation of glucose, fructose and sucrose was more marked in tulip leaves than in pea tissues: when peanut leaves were used, no activity could be detected in the simple sugars.

γ-Methyleneglutamine was labelled in all species at 24 and 48 hr. When the activity of the amide is expressed as a percentage of the activity present in the aqueous-ethanol-soluble fraction, this percentage is far higher for tulip leaves than for pea or peanut tissues. This observation is in agreement with previous findings. Pea shoots contain very small amounts of γ-methyleneglutamine, and therefore the rate of its synthesis may be expected to be low. The contrasting position found in tulip and pea leaves can be explained by the relative deamidase activities previously observed in extracts of these tissues; peanut leaves gave a very active enzyme preparation whereas negligible activity was associated with tulip leaf extracts[8]. A further relationship exists between the observations made in the enzymic and radioisotopic experiments. Labelling of γ-amino-α-methylenebutyric acid (the decarboxylation product of γ-methyleneglutamic acid) was observed only in tulip leaves. These leaves contain a powerful decarboxylase, but no γ-methyleneglutamic acid decarboxylation activity was detected in pea or peanut leaves[10].

The introduction of the carbon-14 label into glutamic acid, glutamine, and asparagine, in addition to sugars and sugar phosphates, suggests that at least a portion of the carbon skeleton of γ-methyleneglutamic acid, including the α-carbon atom, quickly enters intermediate metabolites associated with the reactions of the tricarboxylic acid cycle. However, the present preliminary results do not allow any detailed metabolic pathway for γ-methyleneglutamic acid degradation to be formulated.

L. FOWDEN

Department of Botany,
University College,
Gower Street,
London, W.C.1.

[1] Virtanen, A. I., "Festschrift Arthur Stoll", 565 (Sandoz, Basle 1957). Fowden, L., *Biol. Rev.*, **33**, 393 (1958); *Ann. Rep. Chem Soc.* (in the press).
[2] Done, J., and Fowden, L., *Biochem. J.*, **51**, 451 (1952).
[3] Zacharius, R. M., Pollard, J. K., and Steward, F. C., *J. Amer. Chem. Soc.*, **76**, 1961 (1954).
[4] Hyde, T. G., *Biochem. J.*, **55**, xxi (1953).
[5] Harris, G., and Tatchell, A. R., *J. Inst. Brewing*, **59**, 371 (1953).
[6] Engelbrecht, L., *Flora*, **142**, 25 (1954).
[7] Fowden, L., and Webb, J. A., *Ann. Bot.*, N.S., **22**, 73 (1958).
[8] Fowden, L., *J. Exp. Bot.*, **6**, 362 (1955).
[9] Fowden, L., and Done, J., *Nature*, **171**, 1068 (1953).
[10] Fowden, L., *J. Exp. Bot.*, **5**, 28 (1954).
[11] Welch, K. N., *J. Chem. Soc.*, 257 (1930).
[12] Hellmann, H., and Lingens, F., *Chem. Ber.*, **89**, 77 (1956).

Clearance Rates of Sodium-24, Potassium-42 and Iodine-131 in Normal Dog Hip Joints

A METHOD of assessing the vascularity of the femoral head using sodium-24 or iodine-131 clearance-rates has been previously described by Laing and Ferguson[1]. In a further study of osteoarthritis of the hip joint in the dog being conducted in this Laboratory it has become necessary not only to know the state of vascularity of the bone but also that of the joint itself, or more strictly, that of the synovial membrane.

The absorption of sodium-24 from the knee joint in humans has been studied by Jacox, Johnson and Koontz[2], and Harris and Millard[3]. Scholer, Lee and Polley[4] studied the clearance of sodium-22 and tritium from human knees. These workers estimated the arterial blood-levels of sodium-22 and tritium by a rather complicated method and deduced the clearance-rate for the joint. They found 70 per cent of the sodium-22 remained in the joint 20 min. after injection. The other two research groups and ourselves used an external counting method similar to that of Kety[5].

The present work was initiated in an attempt to discover the rates of clearance of substances of various molecular sizes from normal and abnormal joints, starting with simple salts and working up to layer organic molecules afterwards.

Sodium-24 and potassium-42 in the form of the labelled chlorides were obtained from Oak Ridge National Laboratory. The iodine-131 as sodium iodide was obtained from Squibb and Sons. All three are γ photon emitters. Sodium-24 with a half-life of 15·06 hr. emits γ photons of 1·368 MeV. and 2·753 MeV. and a β particle of 1·39 MeV. Potassium-42 with a half-life of 12·5 hr. emits γ photons of 1·5 MeV. and 0·32 MeV. and negative β particles of 3·5 and 2·0 MeV. Iodine-131 has a half-life of 8·05 days and emits negative β particles of 0·61, 0·25, 0·81 MeV. and γ photons with several peaks, the most important being at 0·36 MeV.

The fate of these isotopes following their injection into a joint can thus be easily followed by a surface-counting technique since they all emit suitable γ photons. For this purpose a columnar scintillation detector, with a half-inch thallium activated sodium iodide crystal, held in an adjustable detector arm (Tracerlab Model *SC* 52 No. 29) was used with a precision rate-meter (Atomic Accessories, Inc. *PCR* 105) and the results were recorded with a Texas instrument rectilinear recorder.

Fifty-seven adult dogs, including mongrels and pure bred of both sexes, were used in this study. Following injection of the radioisotope into a hip joint, a scintillation counter was then swung over the area and continuous recordings were made for 20 min. About 10–20 μc. of sodium-24 and potassium-42 and about 30 μc. of iodine-131 were injected to get suitable surface counts. Only one isotope was injected at any one time. Sodium-24 was injected into 29, potassium-24 into 24, and iodine-131 into 38 hip joints.

The results are presented in Fig. 1. The clearance rates for sodium-24 were 34·76 ± 6·33 per cent in 10 min., 57·06 ± 7·84 per cent in 20 min., for potassium-42, 46·95 ± 7·88 in 10 min. and 62·85 ± 8·59 per cent in 20 min., and for iodine-131, 56 ± 10·84 per cent in 10 min. and 75·15 ± 8·72 per cent in 20 min. Statistical analysis revealed no significant difference between the variances of the groups as calculated by the *F*-test, which is a measure of the dispersion of the values around the means. The means of the groups, however, differed significantly when examined by Fisher's *T*-test. At 10 min., the clearance of iodine-131 is significantly faster than that of potassium-42 ($P = 0{\cdot}0008$), which in turn is significantly faster than that of sodium-24 ($P = 0{\cdot}0001$). At 20 min., the clearance of iodine-131 is significantly faster than that of potassium-42 ($P = 0{\cdot}0001$), which is significantly faster than that of sodium-24 ($P = 0{\cdot}013$).

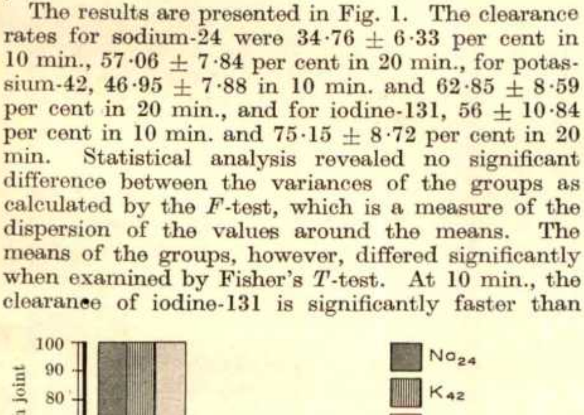


Fig. 1. Residual percentages of sodium-24, potassium-42 and iodine-131 remaining in normal dog hip joints after 10 and 20 min.

It is hoped that this work will form a basis for the study of clearance-rates in osteoarthritic and chemically and bacteriologically inflamed joints. Whether or not clearance is entirely by way of the synovial membrane or whether electrolytes also pass through the articular cartilage into the bone is not known. This question is to be examined by autoradiographic techniques. In addition, the fate of the β-emitting isotopes phosphorus-32, chlorine-36 and sulphur-35 injected into the hip joints of dogs is to be studied using needle Geiger–Müller probes.

PATRICK G. LAING
IK DONG KIM

Orthopedic Research Laboratory,
University of Pittsburgh,
Pittsburgh 13.

---

[1] Laing, P. G., and Ferguson, jun., A. B., *Nature*, **182**, 1442 (1958); **183**, 1595 (1959).

[2] Jacox, R. F., Johnson, M. K., and Koontz, R., *Proc. Soc. Exp. Biol. and Med.*, **80**, 655 (1952).

[3] Harris, R., and Millard, J. B., *Clin. Sci.*, **15**, 9 (1956).

[4] Scholer, J. F., Lee, P. R., and Polley, H. F., *Arthritis and Rheumatism*, **2**, 426 (1959).

[5] Kety, S. S., *Amer. Heart J.*, **38**, 321 (1949).

BIOLOGY

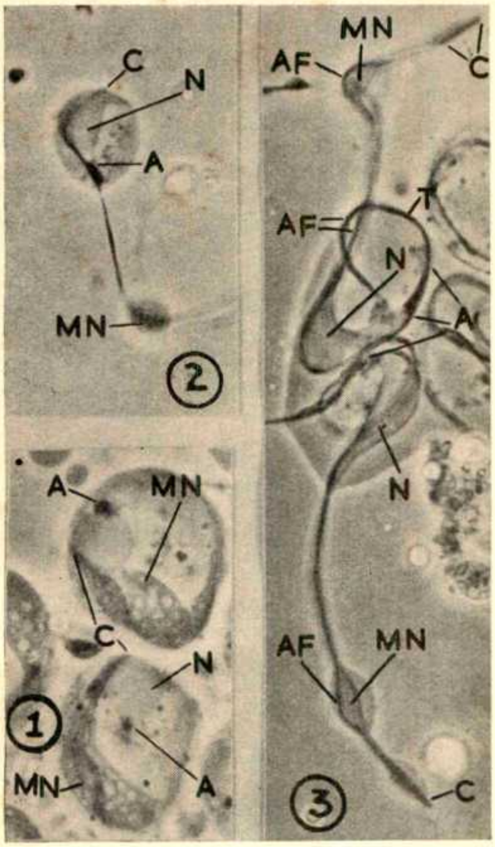
Position of the Proximal Centriole in Flagellate Spermatozoa

Gatenby and Mathur[1] have recently published a preliminary report on their investigations an the spermatogenesis of *Petrobius maritimus* (Thysanura; Machiloidea); but unfortunately they have made a number of sweeping generalizations which we cannot accept.

It is surprising that Gatenby and Mathur[1], while criticizing the work of Bowen[2] and Nath and Bhatia[3] on *Lepisma* sperm, have disowned the previous work of Gatenby and Mukerji[4], and Mukerji[5], who clearly supported Bowen[2] with regard to the anterior position of the centriole immediately behind a small structure considered by them as the acrosome. Indeed, these authors have gone to the extent of stating: "Thus we consider that in Fig. 7, after Bowen and Nath, the anterior bead (*C*) is not the centriole, but is the acrosome (whole or part). . .". They further state that the centriole remains in the neck region.

Gatenby and Mathur[1] quote, in support of their view, results obtained by electron microscopists with the sperms of mammals, molluscs, insects, oligochaetes and sea-urchins; but not one of these workers has worked on the sperm of *Lepisma*, *Cicindela*, *Lepas*, *Balanus*, schizopods, and *Bombinator*, quoted by Nath[6] as examples of sperms in which the centriole is situated at the anterior end of the sperm nucleus.

We have nothing to say about the findings of Gatenby and Mathur[1] on the spermiogenesis of *Petrobius maritimus* except (1) that this thysanuran belongs to the superfamily Machiloidea, whereas *Lepisma* belongs to the second superfamily of the order Thysanura, namely, Lepismatoidea; and (2) that the cytological phenomena in spermatogenesis of different families of the same group of animals are known to vary considerably, as in scorpions.



Figs. 1–3

When reviewing the previous work of Wilson and Nath on scorpion spermatogenesis, Nath emphasized[7] important differences in the behaviour of the mitochondria in the sperms of *Centrurus* and *Buthus* (fam. Buthidae) on one hand, and *Vejovis* (fam. Vejovidae) and *Palamnaeus* (fam. Scorpionidae) on the other.

We have recently carried out extensive phase-contrast and histochemical studies of the male germ cells of *Lepisma saccharina* and *Ctenolepisma urbana* (both belonging to the superfamily Lepismatoidea; subfamily Lepismatinae); and we fully confirm the previous findings of Bowen[2], and Nath and Bhatia[3] with regard to the position of the centriole at the anterior end of the nucleus and that of the acrosome in the neck region.

Fig. 1 shows two early spermatids of *Lepisma saccharina*. The nucleus (*N*) is still spherical; the acrosome (*A*) has been formed at the posterior end of the nucleus; and the centriole (*C*) is at the anterior end, giving rise to the axial filament surrounded by the two clearly defined halves of the elongating mitochondrial *Nebenkern* (*MN*). In Fig. 2 the nucleus (*N*) has become beak-shaped; the centriole (*C*) is just behind the anterior beak of the nucleus, giving off the very much attenuated tail passing by the side of the nucleus (*N*) and the acrosome (*A*). In Fig. 3 the centriole (*C*) has become rod-like and has moved far forward, dragging behind it the axial filament (*AF*) surrounded by the very much attenuated mitochondrial *Nebenkern* (*MN*); the nucleus (*N*) is bent on itself; and the acrosome (*A*) in the neck region has become funnel-shaped.

We wish to emphasize that: (1) the rod-like structure at the anterior end of the maturing sperm is the centriole, since it gives off posteriorly the axial filament and the mitochondrial *Nebenkern*, and also it is completely negative to periodic acid–Schiff reagent; and (2) the funnel-shaped structure in the neck region of the sperm is the acrosome, since it arises from the acroblasts and is positive to the periodic acid–Schiff reagent[8].

Finally, we confirm[2] that the mitochondrial *Nebenkern* is of the typical insect type, forming the tail sheath of the sperm.

Vishwa Nath
Brij L. Gupta
L. C. Mittal

Department of Zoology,
Panjab University,
Hoshiarpur, India.

[1] Gatenby, J. B., and Mathur, R. S., *Nature*, **185**, 861 (1960).

[2] Bowen, R. H., *J. Morph.*, **39**, 351 (1924).

[3] Nath, V., and Bhatia, C. L., *Res. Bull. Panjab Univ.* (Old Series), **27**, 33 (1953).

[4] Gatenby, J. B., and Mukerji, R. N., *Quart. J. Micr. Sci.*, **73**, 1 (1929).

[5] Mukerji, R. N., *J. Roy. Micr. Soc.*, **49**, 1 (1929).

[6] Nath, V., *Int. Rev. Cytology*, **5**, 395 (1956).

[7] Nath, V., *Res. Bull. Panjab Univ.* (Old Series), **97**, 69 (1957).

[8] Schrader, R., and Leuchtenberger, C., *Chromosoma*, **4**, 404 (1951). Moriber, L. G., *J. Morph.*, **99**, 271 (1956). Clayton, B. P., Deutsch, K., and Jordan-Luke, B. M., *Quart. J. Micr. Sci.*, **99**, 15 (1958). Gupta, B. L., and others (unpublished work).

We do not see anything in the *Lepisma* light microscope photomicrographs of Dr. Nath and his collaborators which either lead us to consider that his (*C*) in Fig. 2 is a centriole and not an acrosome, and his (*A*) is not a centriole plus the large insect centriole adjunct, or which persuades us that these two thysanurans could possess spermatozoa fundamentally different.

As to possible fundamental cellular variations in closely allied animals, the grouping of mitochondria in various scorpion spermiogeneses refers to growth and maturation divisions chiefly, but in all these animals where the spermiogenesis is known, the acrosome is anterior, and the centriole posterior, in the nucleus. Dr. Nath *et al.* state that it is surprising that we disowned some of the previous work of Mukerji and Gatenby. The point here is the question of the nature of the longitudinal line (their *AF*) on the nucleus. At one time it was thought (by J. B. G.) to be a part of the flagellum, but recently in *Lumbricus*, Gatenby and Dalton[1] found a similar line by electron microscopy which is not flagellar, and this has thrown doubt on the previous identification in *Lepisma*. This doubt has been strengthened by the discovery that the anterior centriole (*C*) in several Orthoptera and in *Dytiscus* lies within the cushion-shaped centriole adjunct (*CA*) as in the micrograph reproduced here (Fig. 1). Dr. Nath comments that it is surprising that electron microscopists have not studied *Lepisma*, *Lepas*, schizopods, and *Bombinator*. Not really, because the conventional light-microscope 5-μ section using Fleming with acetic-Heidenhain is easy, quick, and cheap to make: our sole chance recently to get micrographs of *Petrobius* resulted in a failure. In any event, referring to *Bombinator*, M. Burgos and Don Fawcett[3] studied another toad (*B. arenarum*) and found the two centrioles post-nuclear, and only the acrosome at the sperm tip.

Now as regards the clear microphotographs shown by Dr. Nath *et al.*, we all agree that their lettering in Fig. 1 is correct. But by Fig. 2, the acrosome has thinned out and become pointed, the adnuclear

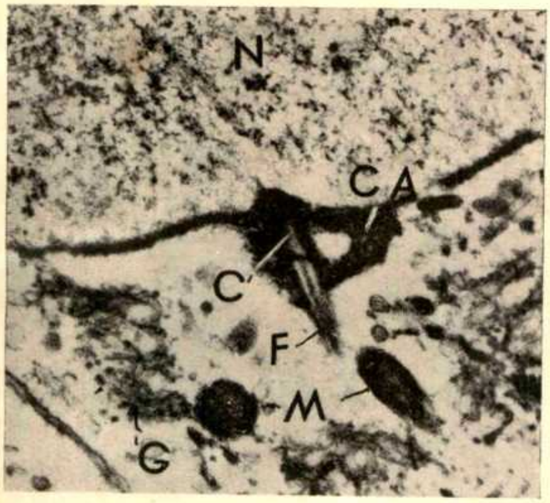


Fig. 1. Micrograph at × 24,000 of part of spermatid of *Pachyrhamma fiasifer*, showing nucleus (*N*), centriole (*C*) embedded in centriole adjunct (*CA*), flagellum (*F*), heads of mitochondrial *Nebenkern* (*M*). (Photograph by W. S. Bertaud, Dominion Physical Laboratory, New Zealand. By kind permission of the Director)

thread has developed, and the centriole adjunct (*A*) has grown quickly, as has been shown to be the case in *Nemobius* by Gatenby and Tahmisian[3]. The long body (*C*) in their Fig. 3 is the acrosome, the dark edge (*AF*) the adnuclear thread, and below it some sort of modification of the body (*A*) in their Fig. 2. The orientation of the cells is correct, the acrosome being anterior in all figures, except the lower spermatid in Fig. 1.

As regards the periodic acid–Schiff, formalin-fixed material of *Petrobius*, we have not succeeded in such small cells in getting useful preparations and are unable at present to comment on evidence arising from this method.

J. Brontë Gatenby
R. S. Mathur

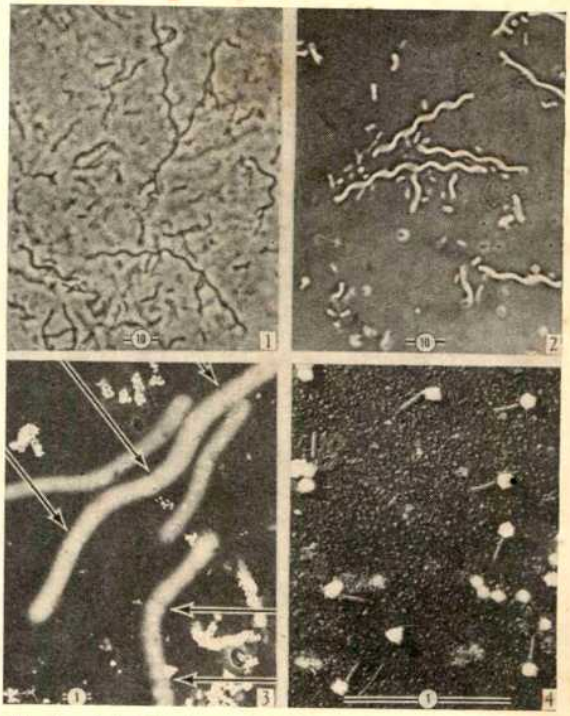
Cytological Laboratory,
Trinity College, Dublin.
May 10.

[1] *J. Biophys. Biochem. Cytol.*, **10**, 49 (1959).
[2] *J. Biophys Biochem. Cytol.*, **2**, 223 (1950).
[3] *La Cellule*, **60**, 2 (1959).

A *Spirochaeta* Phage

A micro-organism identified provisionally as *Spirochaeta rosea* nom. prov. has been isolated from a marine upper littoral rock-pool at Woods Hole, Mass. The filaments are spiral, 5–200μ long, 0·7μ wide, with a regular pitch of about 7μ and an amplitude of 2μ (Figs. 1 and 2). Transverse cell walls, approximately 2·5μ apart, are revealed by phase-contrast or electron microscopy (Fig. 3). In size and form the organism resembles *S. plicatilis* Ehrbg. (= *Ehrenbergia plicatilis* (Ehrbg.) Gieszczykiewicz)[1–4], but in mass the cells are seen to be pinkish or brick red. Growth is markedly aerophilic, with an optimum temperature of 35° C. In sea water supplemented with yeast extract (0·5 per cent) and tryptone (0·5 per cent), the doubling time is 100–120 min. At concentrations less than one-half sea water, growth is suppressed.

The mode of movement of the filaments, a slow creeping over solid substrata, accompanied by bending, undulation and rotation, recalls that of filamentous Cyanophyceae (cf. *Spirulina*, in which non-chlorophyllous species have been described). These features, and the relatively large size of the organism, distinguish *Spirochaeta* from parasitic spirochaetes of the Microspirochaetaceae[3]. The pigments, which can be readily extracted with organic solvents and separated on paper chromatograms, comprise a small amount of carotene and one or more xanthophylls. The predominant pigment exhibits absorption maxima at 448, 474 and 506 mμ in 95 per cent ethanol, and 454, 483 and 515 mμ in chloroform. These peaks agree closely with those of myxoxanthophyll[5], providing additional evidence for cyanophycean affinities.



Figs. 1 and 2. *Spirochaeta rosea* (phase contrast : J. W. Watson).
Fig. 3. *Spirochaeta rosea* (electron micrograph : D. E. Philpott).
Fig. 4. Particles of phage (electron micrograph : D. E. Philpott).
(Scales in μ)

An enrichment mixture of *S. rosea* with marine mud from the Eel Pond, Woods Hole, was left at room temperature for a few days. A portion of the supernatant sea water was then shaken with chloroform to kill bacteria, and sampled in a dilution series in poured plates containing nutrient medium, 0·7 per cent agar, and a liberal inoculum of *S. rosea*. Clear plaques, 4 mm. in diameter, appeared within 24 hr., and indicated a concentration of about 500 phage particles per millilitre of original suspension. From these, pure phage strains were isolated by routine subculture procedures. Titres of 10^{10}–10^{11}/ml. were readily obtained. Virulence was not reduced by incubation in distilled water at 23° C. for 24 hr.

The phage particles from an infected culture were concentrated by centrifugation at 2,800*g* for 45 min., washed, dried in air, shadowed with chromium, and examined by electron microscopy. They appeared similar to those of the *T*-2 series of coli-phages, with a polyhedral 'head' 90 mμ in diameter, a 'neck' 15 mμ long, and a 'tail' 140 mμ long and 25 mμ wide (Fig. 4).

Though the taxonomic position of *Spirochaeta* remains uncertain, it may be regarded as a non-photosynthetic member of the blue-green algae. The only previous record of a virus infecting an alga is a preliminary report of an agent causing lysis in *Chlorella* cultures[6]. The immediate interest of phycophages arises from the possibility that they may resemble the viruses of angiosperms in containing ribonucleic acid. Though the *Spirochaeta* phage described here superficially resembles the bacteriophages containing deoxyribonucleic acid, its nucleotides will be investigated.

This work was supported by a research grant *E*.1445, from the U.S. National Institutes of Health

Ralph A. Lewin

Marine Biological Laboratory,
Woods Hole, Mass.

[1] Dyar, M. T., *J. Bact.*, **54**, 483 (1947).
[2] Ehrenberg, C. G., "Die Infusionstierchen", 83 (1838).
[3] Gieszczykiewicz, M., *Bull. Int. Acad. Pol. Sci.* (*Cl. Sci. Math. Nat.*), Ser. B, **1**, 9 (1939).
[4] Zuelzer, M., *Arch. Protistenk.*, **24**, 1 (1912).
[5] Heilbron, I. M., and Lythgoe, B., *J. Chem. Soc.*, 1376 (1936).
[6] Zavavzina, I. B., and Protsenko, A. E., *Doklady Akad. Nauk S.S.S.R.*, **122**, 936 (1958).

Ethylene Production by Tomato and Apple Fruits

The development of the flame ionization detector for gas chromatography has made it possible to investigate in detail the production of ethylene by tissue slices and mitochondria from fruits. We have constructed a gas chromatograph for this purpose following the design of Meigh[1]; but by modifying certain details the sensitivity has been increased some tenfold, making it possible to detect 0·03 µl. of ethylene per litre of air in a 1-ml. gas sample. The improved sensitivity can be attributed largely to the amplifier and to the use of a stationary phase having very low volatility.

The detecting system consisted of a single flame ionization detector constructed (Fig. 1) in the simplest possible manner. Air to support combustion was filtered and supplied at a rate of 30 l./hr. from a cylinder fitted with the usual type of pressure-reducing valve. The detector output was amplified by a vibrating reed electrometer (Applied Physics Corp., model 31), using the 10^8 ohm input resistance. The output was recorded on a galvanometer recorder. The eluent gas was a 1 : 1 mixture (v/v) of nitrogen and hydrogen taken from a cylinder fitted with the usual type of pressure-reducing valve, which was used to control the column input pressure at 36·3 cm. mercury above atmospheric. The column, which was kept at about 22° by immersing it in an unheated water bath, was 5-mm. bore, length 5·5 m., packed with Johns Manville *C*22 firebrick 60–80 mesh-range, impregnated with silicone oil 550 in the ratio 100 : 30 by weight. The column, after packing, was heated to 100° and flushed continuously with nitrogen for several days. This reduced to a minimum the background caused by volatile impurities evolved by the stationary phase.

This system was used to determine the evolution of ethylene by whole fruit, fruit segments, tissue slices, homogenates, mitochondria, microsomes and supernatant fractions from apple and tomato fruit. Results from these studies indicated that the evolution of ethylene by tomatoes is greatly stimulated by cutting the fruit into segments and tissue slices. On the other hand, ethylene evolution by apples was not greatly changed by this treatment (Table 1).

Maceration of the tissues caused a very considerable decline in ethylene evolution in both the apple and tomato fruit. The mitochondria and microsomes isolated from these homogenates evolved a negligible amount of ethylene.

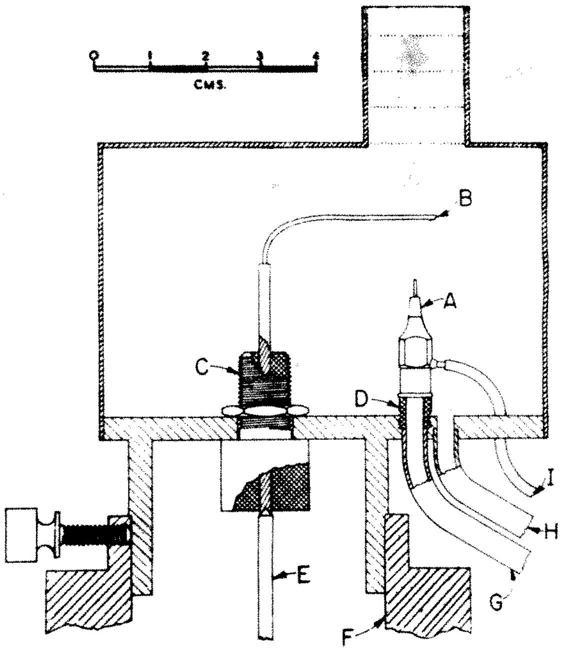


Fig. 1. Diagram of flame ionization detector. *A*, Hypodermic needle No. 22; *B*, collector electrode, 3 mm. loop of No. 23 nichrome wire; *C* and *D*, 'Teflon' insulators; *E*, electrometer input; *F*, electrometer shield; *G*, column connexion; *H*, air inlet; *I*, polarizing voltage, 90 V. positive

Although Spencer[2] identified ethylene in emanations from mitochondrial preparations from tomato fruit, and Burg and Thimann[3] implicated cytoplasmic particles as the source of ethylene production in apples, we could not detect significant amounts of ethylene in mitochondrial or microsomal systems derived from apples or tomatoes. It is especially significant that the apple mitochondria in these studies were able to oxidize Krebs cycle intermediates and could carry out oxidative phosphorylation[4].

It must be concluded from these results that the biosynthesis of ethylene is not directly associated with Krebs cycle organic acid metabolism. Burg[5] reached a similar conclusion from studies in which

Table 1. ETHYLENE PRODUCTION BY WHOLE FRUIT, SEGMENTS, SLICES, HOMOGENATES AND SUBCELLULAR PARTICLES OF APPLES AND TOMATOES

	µl. ethylene/hr./kgm. at 30° C.						
Fruit	Whole	Segments	Tissue slices	Homogenate	Mitochondria	Microsomes	Supernatant
Apples	29·6	35·4	20·3	6·8	<0·003	<0·003	<0·03
Tomato (ripe)	4·4	58·6	102·0	2·2	<0·003	<0·003	<0·03

Measurements were made after the ethylene had accumulated for 2–4 hr. from the apple tissue and 4–6 hr. from the tomato tissue.

The whole fruit was cut into 16 equal segments. Only pericarp wall tissue was used from tomato segments.

Apple slices were disks 1 cm. in diameter and 2 mm. thick. Tomato slices were 4-mm. cubes of the pericarp wall. Both were floated in 0·4 *M* sucrose.

Homogenates were prepared at 2–4° C. by blending in a Waring blendor for 2 min. at reduced speed in 0·2 *M* *tris* buffer, 0·25 *M* sucrose, 0·01 *M* ethylenediamine tetraacetic acid and 0·01 *M* ascorbate. The *p*H of the homogenates was 8·4.

The mitochondria were incubated in a medium containing 3 m.moles adenosine triphosphate, 10 m.moles glucose, 60 m.moles phosphate, 20 m.moles magnesium, 30 m.moles malate, 10 m.moles sucrose, 2 mgm. yeast concentrate and 2 mgm. bovine serum albumin.

The microsomes were isolated at 100,000*g* in the No. 30 rotor of the 'Spinco' preparative ultracentrifuge and incubated in the same reaction mixture as the mitochondria.

apples were treated with sucrose and acetate labelled with carbon-14.

D. F. Meigh

Agricultural Research Council,
Ditton Laboratory,
Larkfield, Maidstone, Kent.

K. H. Norris
C. C. Craft
M. Lieberman

Market Quality Research Division,
Agricultural Marketing Service,
U.S. Department of Agriculture,
Beltsville, Maryland.

[1] Meigh, D. F., *J. Sci. Food Agric.* (in the press).

[2] Spencer, M. S., *Nature*, **184**, 1231 (1959).

[3] Burg, S. P., and Thimann, K. V., *Plant Physiol.*, **35**, 24 (1960).

[4] Lieberman, M., Proc. Ninth Int. Bot. Congr., Abstracts, 2, 227 (1959).

[5] Burg, S. P., *Arch. Biochem. Biophys.*, **84**, 543 (1959).

Is *Nectria haematococca* Berk. and Br. the Perfect Stage of *Fusarium oxysporum* Schl. forma *pisi* (Lindf.) S. and H.?

In a recent communication[1], Dr. E. W. Buxton reported the discovery of mature perithecia in a nutritionally deficient mutant isolate of *Fusarium oxysporum* Schl. forma *pisi* (Lindf.) S. and H. after ultra-violet irradiation. These perithecia were shown to be the perfect stage of this particular isolate and were identified as *Nectria haematococca* Berk. and Br. (=*Hypomyces solani* Rke. and Berth. emend. S. and H.).

As *Nectria haematococca*[2,3] has long been known to be the perfect stage of another species of *Fusarium*, namely, *F. solani* (Mart.) App. and Wr. emend. S. and H., classified in the section Martiella, I was surprised to learn that this same *Nectria* sp. had been found to be the perfect stage of *F. oxysporum* f. *pisi*, classified in the section Elegans. Furthermore, this phenomenon was quite unexpected as it has always been assumed by *Fusarium* taxonomists that, should a perfect stage be formed by a representative of the section Elegans, it would be a *Gibberella* sp. This assumption is based on the fact that the perfect stage characteristic of each of the sections, Lateritium and Liseola, which are most closely related to the section Elegans, is a *Gibberella*.

As isolates of *Fusarium* species that form their perfect stage in culture have been of particular interest to me for several years, duplicate subcultures of the homothallic isolate of *F. oxysporum* f. *pisi*, in which mature perithecia of *Nectria haematococca* were found by Dr. Buxton, were obtained for the purpose of observation and study from the Commonwealth Mycological Institute, Kew, England, through the courtesy of Dr. C. Booth. When they were received by me they appeared to be identical and in each of them the red perithecia characteristic of *Nectria haematococca* could be distinguished readily.

I followed my usual procedure in examining and identifying isolates of *Fusarium*[4]. Several transfers, using the mass culture method, were made from one of the sub-cultures to slants of potato sucrose agar. Numerous monosporous cultures were established by transferring single macroconidia of the *Fusarium* stage present in one of the sub-cultures as received, and others by transferring single ascospores taken from the mature perithecia of *Nectria haematococca* present in the sub-culture. After these various cultures had been kept at room temperature in the laboratory for about ten days, they were examined macroscopically and microscopically and all were identified as *F. solani*, not as *F. oxysporum*.

Hildreth[5] reported recently that he sometimes found it difficult to distinguish between certain isolates of *F. oxysporum* f. *pisi* race 2 and *F. solani* f. *pisi*. Close similarities in the virulence and development of symptoms exhibited by these two species of *Fusarium* were evident to him. For example, *F. solani* f. *pisi* invaded the upper stem of the pea plant with vascular penetration resembling that accomplished by *F. oxysporum* f. *pisi* race 2. Similarly, *F. oxysporum* f. *pisi* produced a root rot accompanied by severe cortical decay in certain varieties of peas identical with that effected by *F. solani* f. *pisi*.

It is my opinion that the culture in which perithecia of *Nectria haematococca* were found by Dr. Buxton, is an isolate of *F. solani* f. *pisi* (Jones) S. and H. that is apparently capable of vascular penetration similar to that produced by *F. oxysporum* f. *pisi*. As the perfect stage of *F. solani* f. *pisi* has not been known previously, its occurrence has been reported for the first time by Dr. Buxton.

W. L. Gordon

Plant Pathology Laboratory,
Canada Department of Agriculture
Research Station, Winnipeg.

[1] Buxton, E. W., *Nature*, **184**, 1258 (1959).

[2] Snyder, W. C., and Hansen, H. N., *Amer. J. Bot.*, **28**, 741 (1941).

[3] Wollenweber, H. W., and Reinking, O. A., "Die Fusarien" (Paul Parey, Berlin, 1935).

[4] Gordon, W. L., *Can. J. Bot.*, **30**, 209 (1952); **32**, 576, 622 (1954); **34**, 833, 847 (1956); **37**, 357 (1959).

[5] Hildreth, R. C., *Diss. Abstr.*, **18**, 4, 1196 (1958) (Abstr. in *R.A.M.*, **38**, 345 (1959)).

CYTOLOGY

Nuclear Phenomena in *Trametes cingulata* Berk.

Initiation of dikaryophase has been studied in considerable detail by a number of workers[1] on various species of hymenomycete. I have studied the nuclear phenomena in the life-history of *Trametes cingulata* Berk.

For the study of the nuclear conditions in the basidia, small rectangular pieces (5 mm. × 5 mm.) of fresh fruit bodies of *T. cingulata* with well-developed pore-tubes were fixed while growing on the living host in Nature. Different killing and fixing reagents were tried. Of these, the Bouin–Allen fixative gave the most suitable preparations. The materials were fixed in two lots and during different intervals of time, one between 12.30 and 2.30 p.m. and the other between 12 and 1 a.m. Washing, dehydration and embedding were done by following the standard schedule. Sections of 8–10μ in thickness were cut and were found to be suitable for observations. Of the stains, Heidenhain's iron–hæmatoxylin gave the most satisfactory result. Nuclear conditions in spores, germinating spores and in the primary and secondary mycelia were studied from whole preparations on slides, following Kniep's[2] agar-film technique.

A mature basidium is always found to be tetrasterigmatic, quadrisporous and broadly clavate in shape. The young basidia, on the other hand, show all stages of transition from slightly inflated terminal hyphal cells to broadly clavate mature ones. At the beginning, they are always binucleate and the two small unpaired nuclei are found lying one above another and at a little distance apart (Fig. 1*a*). Each nucleus is of the homogeneous unexpanded type, as defined by Pinto-Lopes[3], and in each its chromatin and nucleolus are contracted into an intensely stained homogeneous body. However, this conjugate pair of nuclei within the young basidium soon fuse and a synkaryon is formed which moves to the upper part of the basidium. The structure of the large and prominent fusion nucleus at the resting stage consisted of a deeply stained nucleolus and several deeply stained heterochromatin bodies on a feebly stained chromatin reticulum.

Karyogamy was soon followed by two successive divisions together constituting a meiotic phase at the end of which four daughter nuclei are formed. Six chromosomes can be seen to pass to each pole of the spindle in the anaphase stage of the first division, so that the haploid number of chromosomes in *T. cingulata* is six ($n = 6$). This is further corroborated by the presence of the same number of chromosomes in the metaphase and anaphase stages during the second division of the daughter nuclei. The orientation of the spindle within the basidium is not definite in all cases. The four daughter nuclei are conspicuous and are of homogeneous and unexpanded type. Four sterigmata appear at the apex of the basidium while it is in the quadrinucleate stage. When fully developed, the tips of the sterigmata become gradually swollen, and finally a spore is formed at the apex of each sterigma. After nuclear migration, the basidia become empty and appear somewhat collapsed.

The spores of *T. cingulata* are unicellular, uninucleate, apiculate, hyaline and without any evident endospore. The nucleus is situated almost at the centre of the spore, and shows itself as a large deeply stained body when stained with iron–hæmatoxylin. During germination, when the germ-tube is formed, the nucleus of the spore divides and either one or both the nuclei migrate immediately into the germ-tube (Fig. 2*e*). After this migration the first cross-septum is laid down at the base of the germ-tube. As the germ-tube elongates, it branches, and due to irregular formation of septa, uni-, bi-, or multinucleate hyphal cells make their appearance. In later stages, the hyphal cells appear mostly monokaryotic.

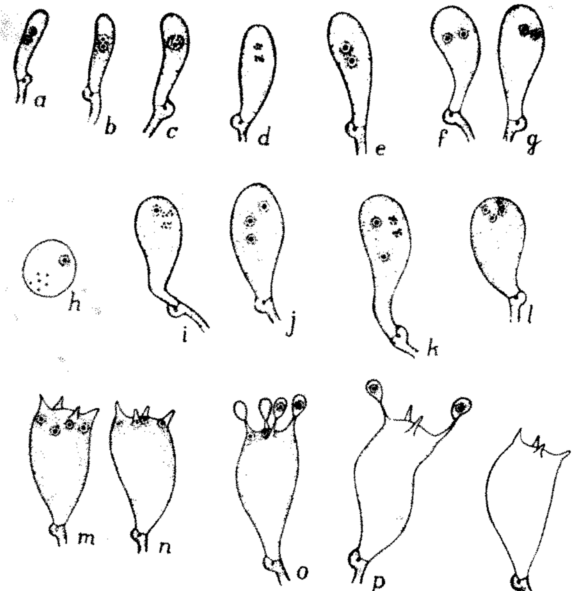


Fig. 1. Nuclear phenomena in the basidium and the development of basidiospores; *a*, *b*, young basidia each with a dikaryon; *c*, formation of synkaryon; *d*–*l*, two divisions of synkaryon forming a meiotic phase (*h*, a polar view of second metaphase division from the top of the basidium; *i* and *k*, anaphasic spindle of second division showing six chromosomes at each pole); *m*–*p*, successive stages in the development of sterigmata and basidiospores; *q*, an old basidium after discharge of basidiospores

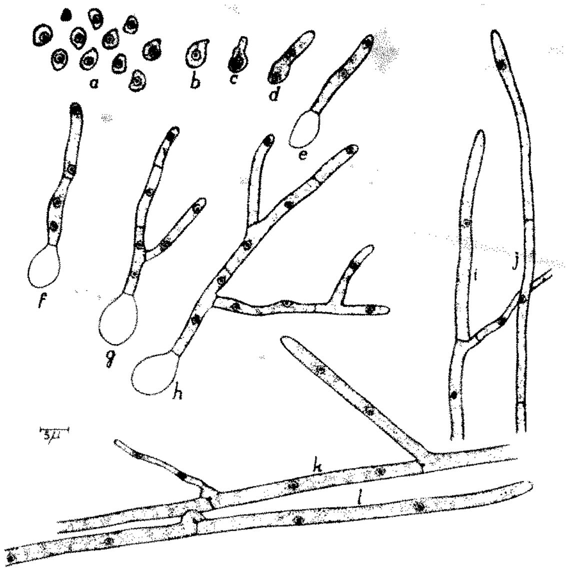


Fig. 2. Nuclear phenomena in basidiospores, spore germination and in the primary and secondary mycelia; *a*, basidiospores; *b*–*j*, successive stages of germination of basidiospores and formation of primary mycelium; *k*–*l*, some secondary hyphæ with clamp connexions and a dikaryon in each cell

In stained preparations of secondary mycelium, it is found that most of the hyphal cells are dikaryotic, but rarely a cell with two to four nuclei can be found. Clamp-connexions are found at most septa. The nuclei in the spores, germinating spores and the primary and secondary mycelia are found to belong to the 'homogeneous type'. Division stages of the vegetative nuclei, however, have not been observed.

I am grateful to Dr. S. N. Banerjee, Department of Botany, University of Calcutta, for his helpful advice in connexion with the present investigations.

PRITINDRA MOHAN NAHA*

Mycological Laboratory,
Department of Botany,
University of Calcutta.

* Present address: Department of Microbiology, Bose Institute, Calcutta 9.

[1] Buller, A. H. R., *Nature*, **126**, 686 (1930); "Researches on Fungi", **4**, 1 (1931). Noble, Mary, *Ann. Bot. Lond.* (N.S.), **1**, 67 (1937). Quintanilha, A., *Bot. Soc. Broteriana (Coimbra)*, **8**, 3 (1932); *Agronomi aLusitana*, **3**, 241 (1940).

[2] Kniep, H., *Z. Bot.*, **5**, 593 (1913).

[3] Pinto-Lopes, J., *Portugalie Acta Biologica*, **2**, 191 (1949).

A Simplified Method for the Study of Chromosomes in Man

GREAT advances in cytogenetics resulted from the use of the Feulgen 'squash' technique after pretreatment of cells with hypotonic solutions and colchicine. The cells are submitted to the action of colchicine chiefly to inhibit spindle formation, thus causing accumulation of metaphases and dispersal of chromosomes in the cytoplasm; in addition, the drug has the valuable effect of shortening the chromosomes and inducing sister chromatids to diverge, thus making clear the position of the centromeres. In this way, the whole character of the chromosome is easily and quickly recognizable. For these reasons colchicine is widely employed in plant and animal cytogenetics.

In man, however, tissue culture seems to be an obligatory step in the technique. Colchicine is added to the culture to obtain the desired effects on cells in mitosis. Tissue cultures, however, take time to prepare and demand technical conditions not always accessible to general laboratories. Moreover, alterations of chromosome pattern have been ascribed as due to culture procedures.

Searching for a simplified technique, we tried to submit human cells *in vivo* to the action of a derivative of colchicine and thus to avoid the inconvenience of tissue culture. We used desacetylmethylcolchicine ('Colcemid' or 'Demecolcine', Ciba), which has the same effects as colchicine, but is twenty to thirty times less toxic[1]. Initially, the drug was used in humans with malignant diseases and afterwards in normal humans and in other clinical conditions.

After preliminary trials, we chose a dose of 0·1 mgm./kgm. body-weight, diluted in saline and slowly administered intravenously. This amount is much less than those used in the therapy of gout and neoplastic disease in man[1] and in animal experiments.

The drug was allowed to act in the organism for 2 hr. and then bone marrow was obtained by sternal puncture. The marrow specimen was converted into a suspension of cells, treated with a hypotonic solution, filtered through a special sieve and stained with Feulgen reagent, according to the technique described by Ford and Hamerton[2]. After squashing, the preparations were sealed with hard paraffin and observed under an oil-immersion lens. The cells of eight individuals were studied in this way.

The preparations showed a satisfactory number of cells in mitotic metaphase, with good spreading of chromosomes which disclosed the characteristic effects of the drug (Fig. 1). Counting, sex identification and the study of individual chromosomes could be easily carried out. To avoid breaking the cells, no attempts were made to obtain permanent preparations. No departure from the normal number of chromosomes was observed in normal cases, except for the polyploid cells occasionally seen in bone marrow.

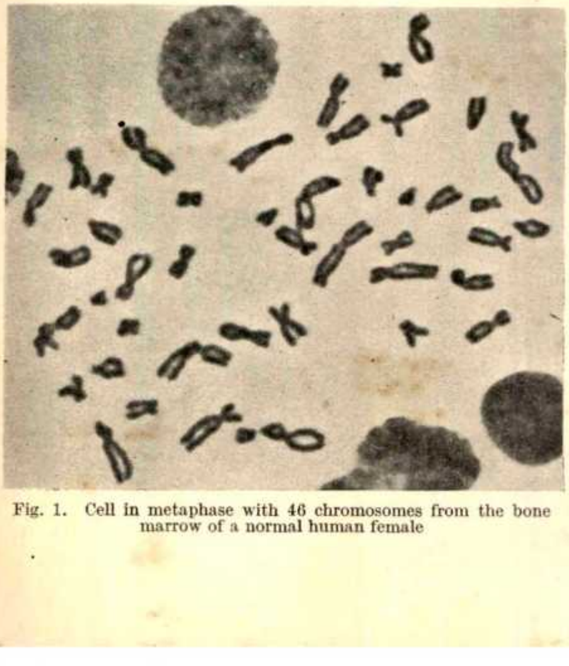


Fig. 1. Cell in metaphase with 46 chromosomes from the bone marrow of a normal human female

The simplicity of the method led us to use it in three patients for the study of the chromosomes of malignant cells in ascitic and pleural fluids. The same dose of the drug was injected into abdominal or pleural cavities. The fluids were obtained 2 hr. afterwards and, after spinning, the cells were treated by the same technique. The results were identical with those observed for bone marrow cells. Qualitative and quantitative data obtained with this method will be reported elsewhere.

All individuals were followed clinically and hæmatologically and no abnormality was detected that could suggest toxic effects of the drug.

We believe this method will be useful for chromosomal studies in other human tissues, whether neoplastic or not. These results were described at the fourth meeting of the Sociedade de Biologia de Ribeirão Prêto on November 11, 1959.

C. Bottura
I. Ferrari

Medical School of Ribeirão Prêto,
Department of Clinical Medicine,
Ribeirão Prêto, Estado de São Paulo,
Brazil.

[1] Dittman, W. A., and Ward, J. R., *Amer. J. Med.*, **27**, 519 (1959).

[2] Ford, C. E., and Hamerton, J. L., *Stain Tech.*, **31**, 247 (1956).

Blocking of Mitosis by Heat Shock

When eggs of *Trichogaster trichopterus* var. *sumatranus* (Teleostei: Anabantidae) are subjected to + 39/40° C. for 3–6 min., mitosis is temporarily halted, being resumed immediately once the eggs are brought back to normal temperature (+ 27° C.). At temperatures of 40·5/42° C. for 3–7 min. mitosis is halted, while the mitotic structures are changed to an extent which necessitates a re-organization after the termination of the heat shock before mitosis can be resumed. At still higher temperatures similar changes are invoked by the heat treatment, but with increasing temperatures the eggs rapidly lose the property of post-blocking restitution.

The present communication is concerned with the blocking of different mitotic stages in the first and second cleavage divisions in *Trichogaster* using heat shocks of + 40·5/42° C. for 30 sec.–7 min. as the blocking agent. The material of 240 heat-treated eggs was fixed (together with untreated controls) in *Kahle* without water (96 per cent ethanol, 15 parts; 40 per cent formaldehyde, 6 parts; glacial acetic acid, 1 part), and 10-μ serial sections were stained with Heidenhain's hæmatoxylin.

The changes invoked by the heat shock are as follow:

Prophase (Fig. 1). The nucleus shows a shrunken appearance, and the nuclear membrane may have broken down. In the latter case the chromosomes are found close together, suggesting that the breakdown has been preceded by nuclear shrinkage. In most cases the centrioles have approached one another. The asters have been temporarily reduced in size and appear generally as a monaster.

Prometaphase (Fig. 2). The chromosomes appear largely unchanged, having retained the condensed state of prometaphase. The position differs from that of normal prometaphase in that the chromosomes are found outside the original spindle field in the

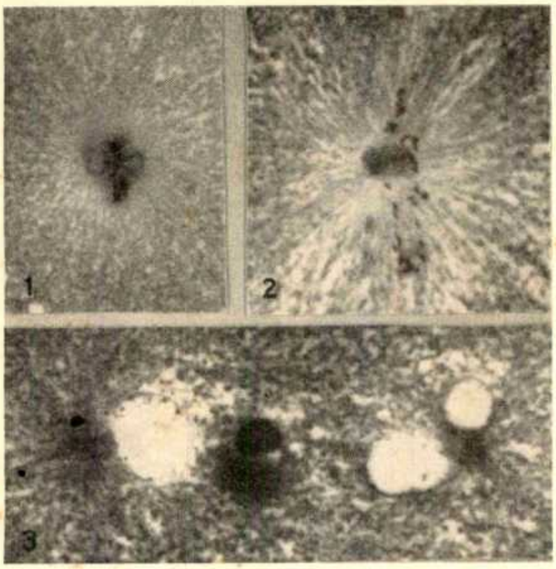


Fig. 1. Second prophase blocked by heat shock and fixed upon termination of the treatment. Mitotic axis approximately as in Fig. 3. × 1,000
Fig. 2. First prometaphase blocked by heat shock and fixed 1½ min. after the termination of the treatment. Mitotic axis approximately as in Fig. 3. × 1,000
Fig. 3. First anaphase blocked by heat shock and fixed upon termination of the treatment. (The dark bodies between the nuclei are yolk granules.) × 1,000

plane of the metaphase plate. The centrioles have approached one another. The asters have been temporarily reduced in size; they appear as a monaster when they rapidly resume their normal size after the termination of the heat shock. The spindle is rapidly disorganized as a visible structure.

Metaphase. The chromosomes appear unchanged. The centrioles have retained their normal distance from one another, giving rise to an amphi-aster mitotic apparatus without a visible spindle after the heat treatment has terminated.

Anaphase (Fig. 3). The chromosomes undergo vesiculation in the course of the treatment, changing into telophase nuclei or tight groups of chromosomal vesicles. In cases interpreted as early anaphase, where the separation of the chromosomes had not been completed, one vesicular nucleus is found in the position of the metaphase plate. In later anaphase the chromosomal vesicles or the two nuclei are found close to each of the centrioles. The migration of the centrioles has been halted, but not reversed. The asters are rapidly reduced in definition. The spindle loses rapidly in definition, and the interzonal part appears to become disorganized before the half-spindles contract, bringing the chromosomes close to the centrioles.

Telophase. The features are similar to those found after blocking in late anaphase. In some cases, however, the nuclei have the same shrunken appearance as have nuclei treated in prophase.

None of the changes described above was found in the untreated controls.

The action of heat shock on the cell centre and the nuclear structures seems to be as follows. While the migration of the centrioles is halted in all mitotic stages, it is reversed in prophase and prometaphase. Prior to anaphase, the asters are able to resume their cycle of size increase once the heat shock is terminated. If anaphase has commenced, new asters are not formed until after the lapse of some minutes. In the nuclear cycle of condensation and extension[1], the process of the mitotic stage concerned appears to proceed during the heat shock, while the switch from condensation to extension at the onset of anaphase does not take place during heat treatment. The switch in the nuclear cycle in the transition from telophase to prophase appears also to be inhibited. (The shrinkage found in some telophase nuclei may indicate that the nuclear transition to prophase has already commenced before any morphological changes can be identified. In the present material the processes of the first- and second-cleavage divisions overlap to a considerable extent (unpublished work).)

It appears then that the mode of response to heat shock varies during the mitotic cycle, and the changes in the mode of response—which cannot be explained by the methods employed in the present investigation—appear to take place simultaneously with the change in the number of organizing structures, that is, centrioles and centromeres.

This work was supported by a grant from the Norwegian Research Council for Science and the Humanities.

Per Bergan

Zoological Laboratory,
University of Oslo,
Oslo–Blindern,
Norway.

---

[1] Ris, H., and Mirsky, A. E., *J. Gen. Physiol.*, 32, 489 (1949).

GENETICS

'Sage': a Colour Modifier in *Aspergillus nidulans*

Conidia of wild-type *Aspergillus nidulans* are green, but mutants occur with yellow and white spores. The genetical basis for these colour differences has been shown by Pontecorvo[1] to be due to two unlinked genes; one, *Y*, controlling spore colour and giving green spores, its mutant form *y* being yellow, and the other, *W*, controlling presence or absence of spore colour. The mutant form of this gene, *w*, produces a white phenotype whether *Y* or *y* is present. We have confirmed this with our material.

While irradiating a green-spored, biotin-requiring strain (*W Ybi*) with ultra-violet light, a pale green, biotin-requiring mutant was isolated, which is clearly distinct from the colours hitherto described. In a cross with yellow (*y BI*) this pale green mutant gave progeny of four classes of spore colour in equal proportions: normal green and normal yellow together with pale green and a pale yellow spored class. It would seem that the pale yellow and pale green strains carry the mutant gene. This mutant modifies both yellow and green pigments and the four classes indicate that the mutation has occurred at a gene locus not linked with *Y*. We have called this mutant 'Sage', its symbol being *sa* and that of the non-mutant allele *SA*.

In order to test this idea a further cross was made using the pale yellow of presumed genotype (*W*) *sa y* (*BI*) and a white-spored strain which is known to carry *Y* and requires biotin for growth. Biotin and *Y* are linked by 5–7 units of recombination. The results are given in Table 1.

From these results it can be concluded that: (1) the expression of the phenotypes *sa Y* and *sa y* is

Table 1. Cross : *W sa yBI* × *w SA Ybi*

Colours	White	Pale yellow	Pale green	Yellow	Green
Frequency	554	186	146	91	81

Colour	Biotin requiring	Biotin independent	Total
Pale yellow	9	117	126
Pale green	121	7	128
Yellow	6	74	80
Green	56	7	63

dependent on the presence of the non-mutant allele at the *W* locus (whites 554 : colours 504). (2) *SA* and *Y* segregate independently. (3) *SA* is linked with white (*W*). This is apparent from the following :

Parental classes	*W sa*	332	34 per cent recombination
Recombinant classes	*W SA*	172	

Two other classes, *w SA* and *w sa*, occur, but are white spored and cannot be used in the analysis. (4) *SA* and *BI* segregate independently.

It is clear that at least three genes control the formation of conidial pigment in *Aspergillus*.

The change brought about by the mutation at the *SA* locus has been studied by extracting pigment from the pale yellow spores and comparing it with pigment obtained from normal yellow spores. The method used depends on the acidic nature of the pigment and it is extracted presumably as the sodium salt. Acidification of the solution of this salt in dilute aqueous sodium hydroxide with dilute hydrochloric acid results in precipitation of the pigment, and it is possible to purify it in this manner. Consistent curves of absorption against wave-length were taken as an indication of purity ; but in order to test the method, the pigment purified in this way was taken and adsorbed on to a cation exchange resin ('Zeo-karb 225') and eluted at controlled *p*H's. A well-defined band was obtained giving identical curves with those obtained previously.

A comparison of the absorption curves as shown in Fig. 1 indicates a certain similarity between the curves of the two pigments. The points of difference are the reversal of the heights of the peaks at 228 mμ and 280 mμ and the appearance of an additional upward trend at 200 mμ in the case of the pale yellow pigment. Besides the peaks shown, there is an additional peak at 410 mμ in both pigments, but this is slight compared with the absorption at the shorter wave-lengths.

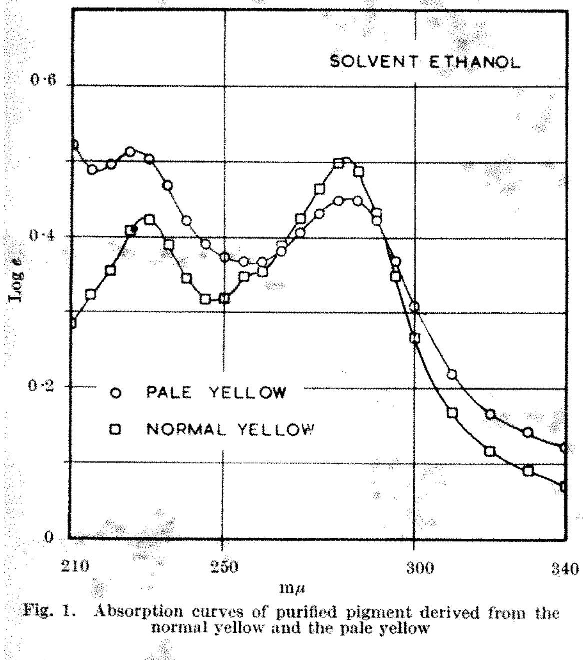


Fig. 1. Absorption curves of purified pigment derived from the normal yellow and the pale yellow

The difference promoted by the *sa* mutation is therefore one of quality rather than of quantity, and it seems reasonable to suppose that a chemical change has occurred in the structure of the pigment. The nature and biosynthetic significance of the change is not yet clear.

My thanks are due to Prof. D. Lewis and Dr. D. Wilkie for their help and criticisms. This work has been carried out with the help of a grant from the Medical Research Council.

B. J. Kilbey

Department of Botany,
University College,
London, W.C.1.

---

[1] Pontecorvo, G., "Advanc. Genet.", 5, 142 (1953).

Inheritance of β-Globulins in Serum and Milk from Cattle

Using starch-gel electrophoresis Smithies and Hickman[1] recognized five cattle β-globulin phenotypes. In a preliminary communication Ashton[2] also described five phenotypes, but after critical examination of some matings he detected a sixth phenotype[3]. The results indicated that the β-globulin types were determined by three alleles named β^A, β^D and β^E, with no dominance[1,3]. However, usually it seems to be difficult to distinguish the two phenotypes *D*/*E* and *E*/*E*.

In order to improve the separation of the β-globulins some modifications of the technique of Smithies[4] with horizontal gel were applied in the present work. A *tris*-buffer *p*H 8·9 (*tris*hydroxymethylaminomethane, sigma 7–9, 20·2 gm./l., ethylenediamine tetraacetic acid, 2·0 gm./l., and boric acid, 1·5 gm./l.) was used as electrolyte. A similar, but more concentrated, buffer has been described by Aronsson and Grönvall[5]. In the present work starch gels were prepared from 36·6 gm. acid-hydrolysed potato starch in a dilution of 90 ml. electrolyte and 210 ml. distilled water. A voltage gradient of 7 V./cm. was applied for 6 hr. with gels having a dimension of 220 × 130 × 6 mm. This system has the advantage that the separation of the β-globulins is improved, the procedure is of shorter duration, and only one kind of buffer is needed. Eight samples inserted with the starch grain method can be analysed every time. A slice, 2 mm. thick, in the middle of the gel is stained in a solution of amido-black 10 *B*. For routine work, it is possible with the present method to insert 2 × 8 serum samples on pieces of Whatman *E*17 filter paper (8 samples 3 cm. and 8 samples 12 cm. from the cathodic side) and to reduce the time for the experiment from 6 to 4 hr.

The six β-globulin types are shown in Fig. 1. There is a close agreement between these types and those shown diagrammatically by Ashton[3]. However, the phenotype *E*/*E* often has a faint fourth band but it is always possible to distinguish it from the *D*/*E*-type. The type *A*/*E* has five bands only, but the middle band is sometimes a little broader than the others. Ashton[3] recognized six bands in this phenotype.

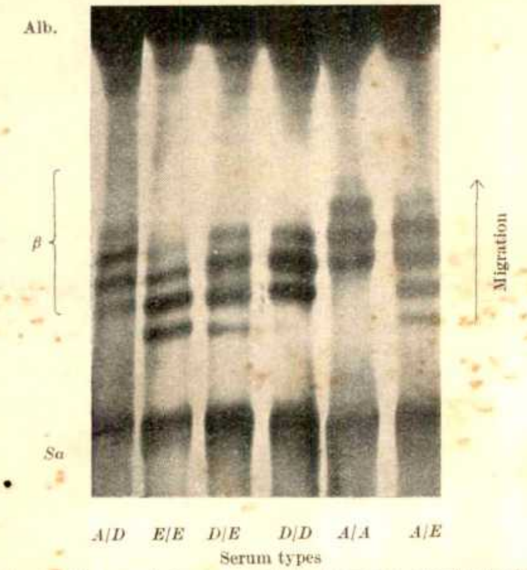


Fig. 1. Photograph from an analysis of cow sera, showing typical examples of the six β-globulin serum phenotypes. Alb., albumin; β, β-globulin; Sa, slow α-globulin

Serum samples from 707 animals of the Swedish Red and White Cattle breed (*SRB*) belonging to four different herds have been analysed. The estimated gene frequencies, $\beta^A = 0{\cdot}4682$, $\beta^D = 0{\cdot}2263$, and $\beta^E = 0{\cdot}3055$, are quite different from those found by Ashton[3] and Højgaard[6]. The results in Table 1 indicate a close agreement between the observed distribution of serum types and that expected under genetic equilibrium. It is, however, noteworthy that there is a deficiency of individuals in all three homozygous classes, and a corresponding excess of the three heterozygous types.

Table 1. OBSERVED AND EXPECTED DISTRIBUTIONS OF SERUM TYPES IN CATTLE FROM FOUR DIFFERENT HERDS OF SWEDISH RED AND WHITE BREED

	Serum types						Total
	A/A	*A/D*	*D/E*	*D/D*	*E/E*	*A/E*	
Observed Expected	147 154·97	151 149·82	103 97·76	33 36·21	56 65·99	217 202·25	707
DF = 3	$\chi^2 = 3{\cdot}57$			$0{\cdot}50 > P > 0{\cdot}30$			

Serum samples from 25 pairs of like-sexed cattle twins classified as possibly monozygous because of morphological similarity were analysed. In 6 twin pairs the two members showed different serum types. They were also shown to be dizygous in red cell antigen tests. The twins in one of these 6 pairs had distinctly different erythrocyte types while the remaining 5 sets showed erythrocyte mosaicism (an admixture of two different red cell types). Therefore, it is evident that the β-globulin types are not influenced by the fœtal vascular anastomosis occurring in most twin pairs. The red cell antigen test for dizygosity is relatively laborious and sometimes also difficult to interpret in dizygous twins having erythrocyte mosaicism[7]. Thus, the β-globulin test provides a short method with which at least a part of the dizygous pairs will be detected.

Some samples of cow milk (colostral as well as normal) treated as described by Aschaffenburg and Drewry[8] in their investigation on β-lactoglobulins were also subjected to starch gel electrophoresis. In addition to the rapidly moving β-lactoglobulin and α-lactalbumin the colostrum samples showed some components with a pattern and a migration-rate corresponding to the serum β-globulins of the same cows (Fig. 2); also a protein band in the post albumin zone could be seen. With normal milk taken 2 months after parturition the globulin-like pattern was very faint. A component with a migration-rate comparable to fast α_2-globulin appeared clearly.

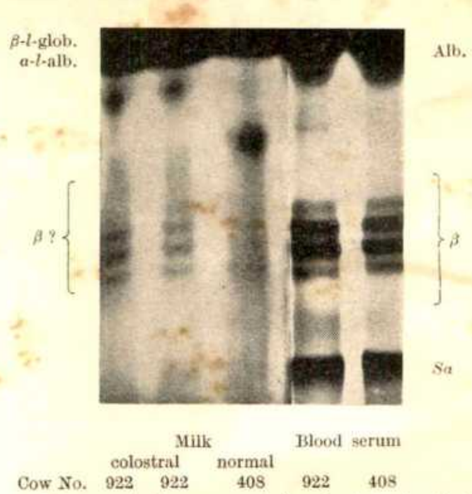


Fig. 2. Photograph from an analysis of colostral milk from cow No. 922 (3 days after parturition), normal milk from cow No. 408 (2 months after parturition), and blood serum from the same cows, classified as *D/E*. β-l-glob., β-lactoglobulin; α-l-alb., α-lactalbumin

Financial support for this work was provided by the Swedish Agricultural Research Council.

BO GAHNE
JAN RENDEL
OLE VENGE

Institute of Animal Breeding,
Royal Agricultural College,
Uppsala 7.

[1] Smithies, O., and Hickman, C. G., *Genetics*, **43**, 374 (1958).
[2] Ashton, G. C., *Nature*, **180**, 917 (1957).
[3] Ashton, G. C., *Nature*, **182**, 370 (1958).
[4] Smithies, O., *Biochem. J.*, **61**, 629 (1955).
[5] Aronsson, T., and Grönvall, A., *Scand. J. Clin. Lab. Invest.*, **9**, 338 (1957).
[6] Højgaard, N., Ann. Rep., Steril. Res. Inst., Roy. Vet. and Agric. Coll. (Denmark), 226 (1959).
[7] Rendel, J., *Acta Agric. Scand.*, **8**, 162 (1958).
[8] Aschaffenburg, R., and Drewry, J., *Nature*, **180**, 376 (1958).

VIROLOGY

Crystallization of Purified Mouse Encephalomyocarditis Virus Particles

MOUSE encephalomyocarditis virus is one of a group of viruses known to be pathogenic to a variety of animals[1]. Partial purification of the virus has been reported using protamine precipitation of extracts of infected mouse brain and the virus particle was found to be 27 mμ in diameter[2]. Recently, it was shown that the virus could be adsorbed on and eluted from columns of calcium phosphate without destroying infectivity[3]. In order to obtain analytical data on the composition of the virus and to perform biochemical studies on the effect of virus multiplication on the metabolism of Krebs ascites cells, we have developed a method for the purification and crystallization of encephalomyocarditis virus.

The strain of encephalomyocarditis virus used was obtained through the courtesy of Dr. Kingsley Sanders, and its origin has been described[4].

Complete details of the method of growing this virus on a large scale will be published shortly. An outline of the method is given here. Krebs II mouse ascites cells were suspended in Earle's medium to a final concentration of 2×10^7 cells/ml. and were inoculated with an unpurified virus suspension containing about three infective particles per ascites cell. The suspension of infected cells (in 100-ml. lots) was incubated at 37° for 18 hr. After this time the cells were spun down at 2,000*g* for 10 min. at 4° C. The supernatant was then centrifuged at 11,000*g* for 10 min. at 4° C. and the supernatant centrifuged for 60 min. at 105,000*g* in a 'Spinco' preparative ultracentrifuge. The 'Spinco' pellets from three such cultures were combined and suspended in 0·02 *M* sodium phosphate buffer, *p*H 7·0. Purified trypsin was added to a final concentration 0·01 per cent and the suspension incubated 60 min. at 37° C. The brownish-coloured solution was diluted threefold (usually to 30 ml.), and applied to a column (25 mm. diameter, 8 cm. long) previously packed with calcium phosphate in 0·02 *M* phosphate buffer, *p*H 7. Calcium phosphate used for chromatography was prepared as described by Taverne, Marshall and Fulton[3]. A phosphate gradient was then applied to the column by allowing 125 ml. 0·5 *M* sodium phosphate (*p*H 7·0) to siphon from a 175-ml. conical flask into a cylindrical mixing chamber (4·5 cm. diameter) which initially contained about 90 ml. 0·02 *M* phosphate (*p*H 7·0). The virus was eluted when the inorganic phosphate concentration of the eluate was between 0·2 and 0·3 *M*. Virus concentration in the fractions was measured by hæmagglutination.

Concentrated virus was usually contained in about 15 ml. of column effluent. This was dialysed for 3 hr. at 4° C. against 0·02 *M* phosphate buffer. After dialysis the material was applied to a second calcium phosphate column (9·5 mm. diameter, 10 cm. length) and eluted as described for the first column. Fractions rich in virus were again pooled and centrifuged for 60 min. at 105,000*g* in the ultracentrifuge. The white pellet which formed was drained free of the supernatant and dispersed in 0·1 ml. sterile saline (0·9 per cent w/v sodium chloride). The tube containing the virus suspension in saline was stoppered and left at 4°, and within 48 hr. crystals had deposited.

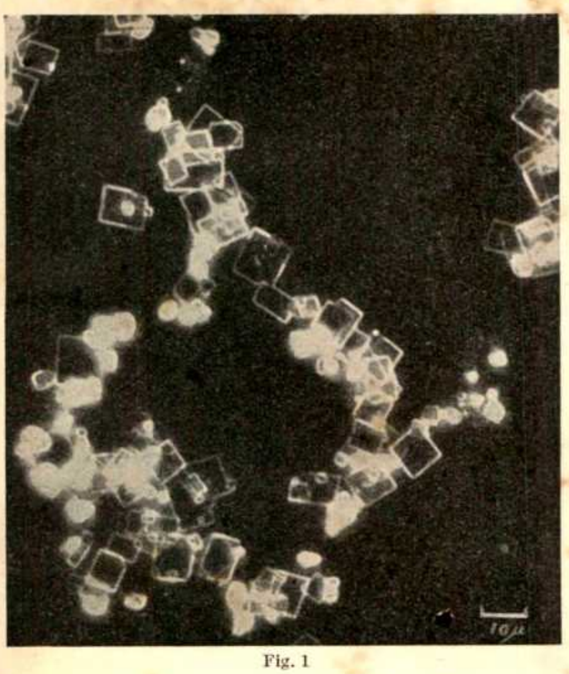


Fig. 1

A photograph of the crystals obtained by dark-field microscopy is given in Fig. 1 (× 600). The crystals have the form of rectangular wafers. When mounted in saline they exhibit Brownian movement and are quite thin, their thickness being about 10 per cent of their length. An X-ray scatter diagram of a suspension of the crystals was obtained by Mrs. Kennard of this Institute. The photograph showed a repeating pattern characteristic of macromolecular organization.

The crystals dissolved in phosphate-buffered saline at *p*H 7·3 show an absorption maximum in the ultra-violet at 258 mμ and a minimum at 240 mμ. Analysis of the crystals showed that the ratio ribonucleic acid/total nitrogen was 2·12. This result indicates that the virus contains about 30 per cent ribonucleic acid.

Dispersion of the crystals in phosphate-buffered saline gave a suspension containing infective virus particles with the following biological activities:

Hæmagglutination units/mgm. ribonucleic acid = $2 \cdot 32 \times 10^6$

Plaque-forming units/mgm. ribonucleic acid = 5×10^{12}

Although encephalomyocarditis virus particles have approximately the same shape and ribonucleic acid composition as those from *MEF*-1 poliomyelitis[5], the crystal form of the two viruses is quite distinct. Poliovirus crystals are tetragonal prisms with pyramids at each end, whereas the encephalomyocarditis virus forms rectangular wafers.

P. FAULKNER*
E. M. MARTIN
S. SVED†
T. S. WORK

National Institute for Medical Research,
The Ridgeway,
Mill Hill, London, N.W.7.

---

* On temporary transfer from the Insect Pathology Research Institute, Sault Ste. Marie, Ontario, Canada.

† Present address: McGill University, Department of Psychiatry, Allan Memorial Institute, 1025 Pine Avenue, W. Montreal, Canada.

[1] Jungeblut, C. W., in "Handbuch der Virusforschung", **4**, 459 (Springer-Verlag, Vienna, 1958).

[2] Weil, M. L., Warren, J., Breese, S. S., Russ, S. B., and Jeffries, H., *J. Bact.*, **63**, 99 (1952).

[3] Taverne, J., Marshall, J. H., and Fulton, F., *J. Gen. Microbiol.*, **19**, 451 (1958).

[4] Hoskins, J. M., and Sanders, F. K., *Brit. J. Exp. Path.*, **38**, 268 (1957).

[5] Schaffer, F. L., and Schwerdt, C. E., *Proc. U.S. Nat. Acad. Sci.*, **41**, 1020 (1955).

Influence of Route of Inoculation and Strain of Mouse on Infectivity Titrations of the Virus of Foot-and-Mouth Disease

In the original experiments in which fatal infection of unweaned white mice with strains of the virus of foot-and-mouth disease was first demonstrated[1], the mice appeared to be equally sensitive to inoculations by the intracerebral and intraperitoneal routes. Because of its greater convenience, the intraperitoneal route has been adopted as a standard method of infecting mice four–eight days old. We have now found that mice of this age are more susceptible to infection with most strains of the virus if the inoculation is made at other sites, namely, the muscles of the hind limbs and the pectoral region, or subcutaneously beneath the raised dorsal skin.

Virus strains of widely different history were titrated simultaneously using the intraperitoneal route, and one or more of these other routes in mice four–eight days old. The volume of inoculum was constant in any one experiment, but in different experiments volumes varied between 0·02 and 0·05 ml. Using a five-fold series of virus dilutions, at least six mice were inoculated at each dilution by each route.

To reduce the variation between litters and to obtain an error estimate (H. S. S., in preparation) the unweaned mice were randomized among the mothers —eight–ten mice per mother—and all the dilutions distributed within every litter. Two mice per dilution per litter and separate litters for each route were usually used. 50 per cent end-point dilutions were estimated by the Spearmann–Kärber method[2]. Under these conditions, a measure of the precision of the 50 per cent end-point estimates is given by the average variance of individual litter end-points ($\overline{V}x$). Our $\overline{V}x$ estimates, in $\log_{10}$ units, for randomized five–seven day old mice of the Pirbright *P* strain with the number of degrees of freedom on which these estimates are based (in brackets) are: Intraperitoneal, 0·1119 (158); intramuscular pect., 0·1258 (41); subcutaneous, 0·1307 (20); intramuscular, one limb 0·1701 (12); intramuscular, two limbs, 0·1137 (71).

In a few experiments the unweaned mice were not randomized, but different routes of inoculation at the same dilution were randomly distributed within every litter.

Our results with the Pirbright *P* strain of mouse are shown in Fig. 1. The following are our general conclusions. (1) *P* strain mice are almost invariably more sensitive to these virus strains when inoculated by the intramuscular limb, intramuscular pect. or subcutaneous routes. The difference is significant at the 5 per cent level in about 60 per cent of the comparisons. (2) There is good agreement between the 'route difference' results obtained with any one virus strain in repeated experiments. These were often done after an interval of many weeks and different virus suspensions were generally used. The estimated 95 per cent fiducial limit of the difference between two such 'route difference' results is 0·62 $\log_{10}$ units. (3) The magnitude of the difference between any two routes depends on, and is a characteristic of, the strain of virus used. We could not establish a correlation with any viral property such as myotropicity, dermotropicity, immunological type or passage history. (4) Tests using the two intramuscular routes are of about equal sensitivity within the limits of our experimental error, and appear to be more sensitive than tests using the subcutaneous route. In some of the experiments simultaneous comparisons were made also in older mice. Susceptibility to infection diminished with increase in age less rapidly in intramuscularly than in intraperitoneally inoculated mice.

The effect of the volume of inoculum on the 50 per cent end-point dilution was investigated in mice a week old in several experiments with the 119 mouse-passaged strain. Volumes of 0·01 ml. and less were inoculated with a microsyringe. The efficacy of the various volume-levels was compared by calculating the *ID*50/ml. of the initial virus suspension. The intraperitoneal and subcutaneous routes were tested by inoculating volumes ranging from 0·001 to 0·27 ml., and no significant or consistent variation in the *ID*50/ml. was detected. The intramuscular limb route (inoculating only one limb) also showed no such variation over the volume range 0·0001–0·01 ml.; but when increased to 0·03 and 0·05 ml. (two experiments) the *ID*50/ml. was less than that expected by $\log_{10}$ 0·46, 0·53 and 0·71 respectively. For maximum efficiency of this route, the volume inoculated per limb should not therefore exceed 0·01 ml.

Only *P* strain mice were used in the experiments so far discussed. Using this strain as a control, the relative susceptibilities to infection by the intraperitoneal and intramuscular (two limbs) routes of inoculation have been investigated in mice of the same age from six of the other strains of mice maintained at this Institute. Experiments were so designed that any change in the infectivity of virus

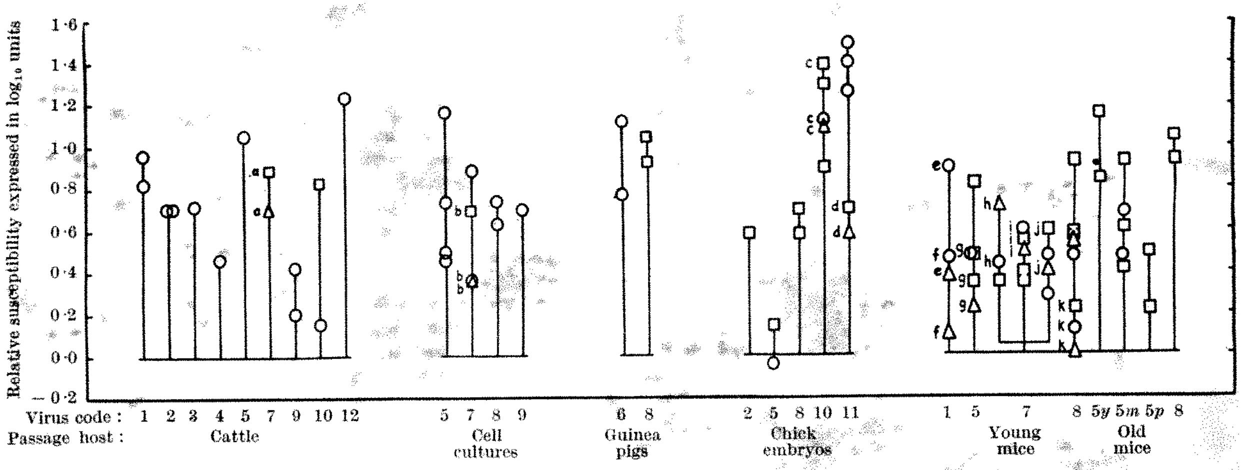


Fig. 1. Relative susceptibility of *P* strain mice to infection with strains of the virus of foot-and-mouth disease inoculated by different routes using the intraperitoneal route end-point as a base-line (0·0). Simultaneous comparisons are indicated by the same letter. ○, Intramuscular, limb; □, intramuscular, pect.; △, subcutaneous.

Virus code: 1–6. Strains 39, Ven. 1, A.S.J., Dutch 0, M.11, and 1, respectively, all type Vallée 0. 7–12. Strains 119, 997, R.V.11, Rho.1, R.V.7, and Pak. 1, types Vallée A, Waldmann C, S.A.T.1,2,3, and Asia 1 respectively dilutions during the period of the inoculations could not enhance or minimize any differences attributable to the mouse strain or route of inoculation. Usually, four or five randomized litters of ten mice were used per mouse strain per route. The results will be published in detail elsewhere (H. S. S., in preparation).

The following general points have emerged:

(1) Some of these mouse strains differ by as much as 1·3 $\log_{10}$ units in their susceptibility to infection by the intraperitoneal route used.

(2) Irrespective of the susceptibility to infection of a mouse strain, the intramuscular limb 50 per cent end-point is with almost all virus strains higher than the intraperitoneal 50 per cent end-point. Actually, 19 out of 22 experiments with 14 different virus strains showed a difference from 0·1 to 1·5 $\log_{10}$ units in favour of the intramuscular route (43 separate comparisons). In the remaining 3 experiments the difference varies from 0·0 to 0·5 in favour of the intraperitoneal route (6 separate comparisons).

(3) Two mouse strains (Pirbright *B* and *G*) are less susceptible to infection than the *P* strain. They consistently gave lower 50 per cent infective end-point dilutions when the intraperitoneal route and the intramuscular (two limbs) route were compared. In addition they appear to be more variable, as the $\overline{V}x$ estimates for these strains are considerably higher than the corresponding *P* strain estimates.

(4) Three mouse strains (Pirbright *A*, *C* and *C*57) are more susceptible to infection than the *P* strain. With one exception, the only mouse-passaged strain tested (see 6, below), they consistently gave higher end-points when the intraperitoneal route was compared and also in 16 out of 21 comparisons of the intramuscular route. The $\overline{V}x$ estimates of these strains are very similar to those of the *P* strain.

(5) The magnitude of the difference between the intramuscular and intraperitoneal routes with any given virus strain depends also on the mouse strain in which the comparison is made. Thus in two experiments with virus strain *RV* 7, differences found in *P* strain mice were 1·4 and 1·5, while in *A* strain mice they were respectively 0·4 and 0·7 $\log_{10}$ units.

(6) Experiments with virus strain 119 at its 292nd intraperitoneal passage in unweaned *P* strain mice suggest specific adaptation of the virus to the unweaned *P* strain mice, when the accustomed route of inoculation is used. We have found the intraperitoneal end-point consistently higher in *P* strain than in *A* strain, but the reverse is true for the intramuscular end-point.

As the $\overline{V}x$ estimate for tests made by the intraperitoneal route is as low as that of more sensitive tests made by the intramuscular or subcutaneous routes, the intraperitoneal route of inoculation remains a suitable one for titrations of infectivity when relative concentrations of virus are being estimated. However, when materials suspected of containing only traces of virus are tested, the more sensitive test routes should be used. These routes should also be of value when particle counts are being correlated with infectivity. Additional improvement of sensitivity may be achieved by choosing a more sensitive mouse strain than the one which is in use. Our results indicate that different laboratories may at present be using mouse strains differing in their susceptibility to infection by at least a factor of ten.

When an attempt is made to compare the susceptibility of different mouse strains, virus pre-adapted to one of the strains should not be used.

Simultaneous titrations of most cattle strains of virus intraperitoneally in unweaned mice (0·03 ml.) and intradermally on the tongues of two steers at multiple sites (0·1 ml. per site)[3] have been shown to result in similar 50 per cent end-point dilutions in both species[4], although there is a threefold difference in the volume inoculated. Our colleagues, Martin, Mowat and Pay, have since made the same observation on several occasions (personal communications). Using three cattle strains of virus, we have, in collaboration with our colleagues Davie, Davies and O'Reilly, made simultaneous titrations as above in cattle and intramuscularly (0·02 ml.) in *P* strain mice. The 50 per cent end-point dilutions in mice exceeded those in cattle by $\log_{10}$ 0·4, 0·5 and $\geqslant$ 1·7. Allowing for the difference in volume inoculated, our results indicate that the mice in these tests were $\log_{10}$ 1·1, 1·2 and $\geqslant$ 2·4 times more susceptible to infection than the cattle tongue epithelium. Alternatively, assuming that the mice and epithelium were of equal susceptibility, then, in the latter, only a fraction of the virus dose succeeds in initiating a lesion at the site of inoculation.

WENDY HEATLEY
H. H. SKINNER
H. SUBAK-SHARPE

Research Institute
(Animal Virus Diseases),
Pirbright, Surrey.

[1] Skinner, H. H., *Proc. Roy. Soc. Med.*, **44**, 1041 (1951).
[2] cit. Finney, D. J., "Statistical Method in Biological Assay" (C. Griffin and Co., London, 1952).
[3] Henderson, W. M., Agric. Res. Council Rep. Ser. No. 8 (H.M. Stationery Office, London, 1949).
[4] Skinner, H. H., Henderson, W. M., and Brooksby, J. B., *Nature*, 169, 794 (1952).

PSYCHOLOGY

"Self-Regulation for Children"

IN the review of our book "The Free Family", in *Nature* of April 2, p. 38, Prof. Vernon says that "it is clear that the children experienced considerable difficulty in adapting themselves to the society of children very differently brought up", and he asks for independent evidence for their "spontaneity, poise and stability".

Allow me to say that Prof. Vernon could only have gained the first false impression because we describe in detail the kind of conflicts one of our children had in a specific instance. This certainly does not imply that our children had more difficulties in 'socialization' than other children. This is particularly true for the second, third, fourth and fifth child. All their school reports have tended to stress their ability to co-operate.

The independent evidence Prof. Vernon asks for can also be supplied in part: the oldest child is one of 19 children in Nottingham to have received a free place at the Nottingham Girls' High School; further, two 'television teams' spent a whole day with the family shortly after the book came out, and although adverse points were of course made, none doubted "spontaneity, poise and stability".

We started self-regulating children when I was a student on a very meagre grant and I have always had little inclination for leisure. Flexibility we have had, more so than the normal parents, and it is useful; but money and leisure are not important criteria. We agree with Prof. Vernon that self-regulation will be practised only by a fortunate few, but the criteria of selection is likely to be vitality and capacity to love, both symptoms of psycho-somatic health.

PAUL RITTER

7 Magdala Road,
Nottingham.

IT may well be that enthusiasm on the part of the parents is a more essential condition than are any material circumstances for carrying out 'self-regulation' in the family successfully. Nevertheless, the success of this procedure can be adequately assessed only from studies made by independent psychological observers of a fair sample of such families and of the personal and social adjustment of the children.

M. D. VERNON

The University,
Reading.

MISCELLANY

The Problem of Language in Publications of Works in Scientific and Other Fields of Learning

THE predominance of the English language in modern scientific and technical literature, of which the research workers and writers of reviews are well aware, was clearly demonstrated in an important report published by Unesco[1] on different aspects of the language problem in science and technology. It would indeed be interesting to obtain similar information on published works in other fields of knowledge.

The problem of language is not a new one and has been discussed by men of learning at different times. Significant and prophetic in this respect was the letter[2] by David Hume to Gibbon dated October 24, 1767. It concerns one of the early attempts by Gibbon to write a historical essay which he devoted to the history of the Swiss Republic. In the selection of this subject he was influenced by his Swiss friend Deyverdun and the feeling he had for Switzerland as his country by adoption. He began to work on this essay in 1764 when, as he wrote: "The *Decline and Fall of Rome* I still contemplated at an awful distance. . . ".

"It is but a few days ago," wrote Hume, "since Deyverdun put your manuscript into my hands, and I have perused it with great pleasure and satisfaction. I have only one objection derived from the language in which it is written. Why do you compose in French, and carry faggots into the woods, as Horace says with regard to Romans who wrote in Greek? I grant that you have a like motive to those Romans, and adopt a language much more generally diffused than your native tongue: but have you not remarked the fate of those two ancient languages in following ages? The Latin, though then less celebrated, and confined to more narrow limits, has in some measure outlived the Greek, and is now more generally understood by men of letters. Let the French, therefore, triumph in the present diffusion of their tongue. Our solid and increasing establishments in America, where we need less dread the inundation of Barbarians, promise a superior stability and duration to the English language.

"Your use of the French tongue has also led you into a style more poetical and figurative, and more highly coloured, than our language seems to admit of in historical production. . . ."

Reflecting on some defects of his essay, Gibbon wrote[2]:

"My ancient habits, and the presence of Deyverdun, encouraged me to write in French for the continent of Europe; but I was conscious myself that my style, above prose and below poetry, degenerated into a verbose and turgid declamation. Perhaps I may impute the failure to the injudicious choice of a foreign language. Perhaps I may suspect that the language itself is ill adapted to sustain the vigour and dignity of an important narrative. . . ."

One may ask to what extent Hume's letter and these reflexions influenced Gibbon, when he was ready for his work on the "Decline and Fall of the Roman Empire", in adopting for it a language more suitable "to sustain the vigour and dignity of an important narrative"[2]. Hume's letter reflected no prejudice on his part against France, where he lived for several years, enjoying the friendship of many distinguished persons, and where he found more admirers than in his own country[3]. On the contrary, this letter illustrates the generally accepted unrivalled position then occupied by the French language among men of learning, a position which had already been recognized before Hume's time and which was held for almost a century following his letter to Gibbon. Educated people and scholars of different countries read in French the works of the great French philosophers, writers and scientists, and many of them could write and speak in French as well as in their mother tongues. It is therefore not surprising that many of the universally admired works of learning both in science and letters, published in France from the beginning of the eighteenth until the middle of the nineteenth century, were not translated into other languages, including English.

The fact that the English language is on the way to occupying, at least in some respects, the position previously held by the French language, fulfils Hume's prophecy beyond anything he could have contemplated, especially if we consider the rapidly growing activity in different fields of learning and the production of works of marked scholarship in the country which he referred to as our "solid and increasing establishments in America".

Although there is no sign yet that the prevalent use of the English language is abating, or has even reached its peak, one must not forget Hume's remark as to the fate of other, once dominant, languages. Moreover, the prevalence of one language does not necessarily imply a loss of interest in the others. On the contrary, this interest, being freed from more practical purposes, will not cease to be stimulated by the desire to appreciate and enjoy more fully the cultural life of the corresponding country, which can scarcely be satisfied without the knowledge of its language.

D. KEILIN

Molteno Institute,
University of Cambridge.

---

[1] "Scientific and technical translating and other aspects of the language problem". Documentation and Terminology of Science. Unesco. (Atar, Genève, 1957).

[2] "The Miscellaneous Works of E. Gibbon, with Memoirs of His Life and Writings", edit. by Lord Sheffield, in 5 vols. Vol. 1, "Memoirs and Letters" (see pp. 204–205), new edition, 1814 (John Murray, London).

[3] Greig, J. Y. T., "David Hume" (Jonathan Cape, London, 1931).

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, June 13

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8 p.m.—Annual General Meeting.

British Society for the Philosophy of Science (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. S. Sambursky: "Conceptual Developments in Greek Science".

Tuesday, June 14

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

University of London (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 5.45 p.m.—Mrs. S. J. Hallam: "Some Aspects of Romano-British Settlements Round the Wash".* (Last of nine lectures on "Recent Archæological Discovery in Britain").

Wednesday, June 15

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 10 a.m. and 2.15 p.m.—Meeting on "Oxidation of Mild Steel".

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. B. J. Mason and Mr. J. Maybank: "The Fragmentation and Electrification of Freezing Water Drops"; Mr. R. J. Murgatroyd and Mr. M. P. Garrod: "Observations of Precipitation Elements in Cumulus Clouds"; Mr. F. Singleton: "Aircraft Observations of Rain and Drizzle from Layer Clouds".

University College, Department of Pharmacology (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Dr. H. Wirz (Basle, Switzerland): "The Mechanism of Urinary Concentration and Dilution"* (The Renal Association—Tenth Anniversary Lecture).

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. A. H. Cottrell, F.R.S.: "The Strength of Solids".

Thursday, June 16

British Institute of Radiology (in the Library, 32 Welbeck Street, London, W.1), at 4 p.m.—First Meeting of the Discussion Group.

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. Sir John Eccles, F.R.S.: "The Nature of Central Inhibitory Action" (The Ferrier Lecture).

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. R. V. Kadison: "Some Aspects of Spectral Theory".

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Annual General Meeting, followed by Sir Philip Manson-Bahr: "Around the World in 35 Days", illustrated by lantern slides.

Friday, June 17

British Institute of Radiology (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 2 p.m.—Radiobiology Meeting.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Biochemist (non-medical), for research on problems connected with tropical diseases—The Secretary, Hospital for Tropical Diseases, 4 St. Pancras Way, London, N.W.1 (June 17).

Research Fellows (2) in the Department of Physics—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (June 17).

Assistant, Grade "B", in Physics—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4 (June 18).

Assistant in the Department of Moral Philosophy—The Secretary, The University, Edinburgh (June 18).

Lecturer (graduate in engineering or physics, and preferably experience of experimental reactor physics or heat transfer) in Nuclear Engineering—The Registrar, The University, Manchester 13 (June 18).

Lecturer to take charge of Metallurgical Teaching and Research in the Department of Mechanical Engineering—The Secretary, University College, Gower Street, London, W.C.1 (June 18).

Chair of Biochemistry—The Secretary of the University Council, Trinity College, Dublin (June 20).

Lecturer (preferably with experience with high vacuum and plasma devices, and a serious interest in research) to teach the theory and practice of electronics as applied to vacuum and gas discharge devices—Prof. A. Tustin, Department of Electrical Engineering, Imperial College of Science and Technology, London, S.W.7 (June 20).

Research Student (with a good honours degree, preferably in organic chemistry or in biochemistry) in Pharmacology—The Registrar, Trinity College, Dublin (June 20).

Scientific Officer or Senior Scientific Officer (honours graduate in chemistry, preferably Ph.D. with experience in research in radiation chemistry or microbiology, and familiar with the use of radiation sources, dosimetry and protection of personnel) at the Low Temperature Research Station, Cambridge, to work in a group studying the preservation of foods with ionizing radiations—The Secretary, Low Temperature Research Station, Downing Street, Cambridge (June 21).

Assistant Lecturer in Applied Mathematics (Digital Computing)—The Secretary, The Queen's University, Belfast (June 22).

Lecturers (with a good honours degree, and preferably with teaching experience) in (*a*) Physics and (*b*) Chemistry at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (June 24).

Mycologist (preferably with some postgraduate experience) in the Soil Bureau, Department of Scientific and Industrial Research, Wellington, New Zealand, to join a team doing research in soil processes—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting Ref. No. B.11/21/28 (June 24).

Assistant in Applied Mathematics—Joint Clerk to the University Court, Queen's College (University of St. Andrews), Dundee (June 25)

Assistant Lecturer in Geology—The Secretary, The University, Exeter (June 25).

Sub-Librarian (Science Library) (graduate preferably in science, or with good experience in scientific librarianship)—The Registrar, The University, Nottingham (June 25).

Lecturer (with good academic qualifications and industrial or other experience in electric power engineering, electrical machines, electrical measurements, or control engineering) in the Department of Electrical Engineering—The Registrar, The University, Leeds 2 (June 27).

Temporary Lecturer or Assistant Lecturer in Zoology—The Secretary, The University, Exeter (June 27).

Curator (with a good general knowledge of botany and wide experience of all branches of horticulture, ability to control a large staff and a knowledge of all aspects of running a large scientific horticultural establishment, and preferably a degree in an appropriate subject or with the National Diploma of Horticulture) of the Royal Botanic Gardens, Kew, Surrey—The Civil Service Commission, Burlington Gardens, London, W.1, quoting 5148/60 (June 28).

Assistant Keeper (with a university degree, and preferably with the Museums Association Diploma or museums' experience) of Archæology—The Curator, Castle Museum, Norwich (NOR 65b), Norfolk (June 30).

Assistant Lecturer (with a degree in botany with some zoology) in Biology—The Registrar, University College of North Staffordshire, Keele, Staffs (June 30).

Chair of Electrical Engineering—The Secretary, The University, Old College, South Bridge, Edinburgh (June 30).

Demonstrator in the Department of Geology—The Registrar, University College of North Staffordshire, Keele, Staffs (June 30).

Lecturer in Statistics—The Registrar, University College of North Staffordshire, Keele, Staffs (June 30).

Lecturer (with a registrable veterinary qualification and postgraduate experience in bacteriology) in Bacteriology in the School of Veterinary Medicine—The Registrar, Trinity College, Dublin (June 30).

Lecturers (2) in Civil Engineering—The Registrar, The University, Nottingham (June 30).

Research Fellows or Associates in the Department of Chemistry, for work on either biochemical or chemical aspects of bacterial cell walls and related subjects—The Registrar, King's College (University of Durham), Newcastle upon Tyne (June 30).

Leverhulme Research Fellow (with previous experience of homografting or related fields) in the McIndoe Memorial Research Unit, to investigate the problem of homografting—The Secretary, East Grinstead Research Trust, Queen Victoria Hospital, East Grinstead, Sussex (July 1).

University Assistant Lecturer (preferably with a knowledge of either East or Central Africa, or the Pacific area) in Social Anthropology—The Secretary of the Appointments Committee, Faculty of Archæology and Anthropology, The University, Downing Street, Cambridge (July 2).

Research Assistant (with a university degree in physics or chemistry, and preferably experience in the investigation of dusts) in Industrial Hygiene in the Department of Social and Preventive Medicine—Prof. John Pemberton, The Queen's University, Belfast (July 6).

Lecturer in the Department of Physics—Prof. P. M. S. Blackett, F.R.S., Physics Department, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7 (July 7).

Reader in Physiology at the Royal Free Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (July 8).

Research Assistant (with a good honours degree in botany or agricultural botany and an interest in experimental ecology and/or genetics) in Agricultural Botany, for investigations on the mineral nutrition of natural populations of agriculturally important grass species—The Registrar, University College of North Wales, Bangor, North Wales (July 15).

Senior Assistant (with a degree or substantially equivalent qualifications in physics or electrical engineering or other approved subject, and experience in previous employment) in Research in the Cavendish Laboratory—Dr. F. B. Kipping, Chemical Laboratory, The University, Lensfield Road, Cambridge (July 15).

Second Chair in Agriculture at King's College, Newcastle upon Tyne—The Registrar, University Office, 46 North Bailey, Durham (July 30).

Assistant Lecturer or Lecturer in Veterinary Parasitology—The Registrar, The University, Liverpool, quoting Ref. CV/T (July 31).

Senior Lecturer in Chemistry at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 31).

Laboratory Technician (with experience in laboratory procedures in hæmatology) in the Department of Physiology in the University of New England, Armidale, N.S.W., Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 15).

BIOCHEMIST (Basic grade) IN THE LABORATORY, Ayrshire Central Hospital, Irvine—Area Medical Superintendent, Ayrshire Hospitals, 1 Hill Street, Kilmarnock, Ayrshire.

CATALOGUER/ABSTRACTOR (competent cataloguer with scientific or technical library experience) in the Headquarters of the Technical Information Service at Hatfield Technical College—The Registrar, Hatfield Technical College, Roe Green, Hatfield, Herts.

LECTURER (preferably with experience in high polymer chemistry, together with teaching and/or industrial experience) IN THE DEPARTMENT OF CHEMISTRY, COLOUR CHEMISTRY AND DYEING, to teach physical chemistry to the Dip.Tech. and G.R.I.C. standard—The Principal, Huddersfield College of Technology, Huddersfield.

MEDICAL LABORATORY TECHNICIAN (qualified A.I.M.L.T., or with a science degree or equivalent)—The Administrative Officer, North London Blood Transfusion Centre, Deansbrook Road, Edgware, Mddx.

RESEARCH ASSISTANT, and EXPERIMENTAL OFFICERS (2) (PHYSICISTS or ENGINEERS interested in working on high temperature hypersonic flow research)—Head of the Aeronautics Department, Imperial College of Science and Technology, London, S.W.7.

RESEARCH ASSISTANT (with a Ph.D. degree in physical chemistry or physics) IN CHEMISTRY, to work on the reaction of metals with gases at elevated temperatures—The Secretary, The University, Exeter.

RESEARCH STUDENTS (with a good honours degree or equivalent qualification, undergraduates in their final year will also be considered, IN CHEMISTRY, CIVIL ENGINEERING, ELECTRONICS, METALLURGY) PHARMACY AND PHYSICS—The Registrar, Technical College, Sunderland, Co. Durham.

SENIOR EXPERIMENTALIST (with G.C.E. at "A" level, H.N.C. or their equivalent, and (*a*) considerable experience in the design and manufacture of special electronic devices, and (*b*) a knowledge of the latest advances in pulse counting and timing techniques), to be responsible for the operation, maintenance and improvement of a complex electronic counting installation associated with a linear accelerator—The Personnel Manager (1695/34), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

SENIOR TECHNICIAN (fully conversant with general workshop practice, and with practical electrical experience) IN THE DEPARTMENT OF X-RAY TECHNOLOGY of the Churchill Hospital, Oxford—The Assistant Administrator, Radcliffe Infirmary, Oxford.

TECHNICAL OFFICER (with a degree or diploma in agriculture or agricultural botany) IN THE CEREALS SECTION OF THE SEED PRODUCTION BRANCH—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Bulletin of the British Museum (Natural History). Entomology. Vol. 8, No. 7. The Acrometopae of the Ethiopian Region—a Revision, with Notes on the Sexual Dimorphism Shown by the Group (Orthoptera: Tettigoniidae). By D. R. Ragge. Pp. 267–333. 20*s*. Vol. 8, No. 8: New Siphonaptera from Eastern Mediterranean Countries. By F. G. A. M. Smith. Pp. 335–366. 10*s*. Vol. 8, No. 9: Studies in *Pontania* (Hym. Tenthredinidae). By Robert B. Benson. Pp. 367–384. 7*s*. 6*d*. Vol. 8, No. 10: The Pseudococcidae (Coccoidea: Homoptera) of the Solomon Islands. By D. J. Williams. Pp. 385–430. 15*s*. Zoology. Vol. 6, No. 3: British Slugs (Pulmonata; Testacellidae, Arionidae, Limacidae). By H. E. Quick. Pp. 103–226+2 plates. 45*s*. Vol. 6, No. 4: A Revision of the Lake Victoria *Haplochromis* Species (Pisces, Cichlidae), Part IV. By P. H. Greenwood. Pp. 227–281. 20*s*. Vol. 6, No. 5: On a *Stygiomysis* from the West Indies, with a Note on *Spelaeogriphus* (Crustacea, Peracarida). By Dr. Isabella Gordon. Pp. 283–324+plates 3 and 4. 15*s*. (London: British Museum (Natural History), 1960). [188

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 696, Vol. 242 (17 March 1960): The Genetics of Homostyly in Populations of *Primula vulgaris*. By W. F. Bodmer. Pp. 517–549. 10*s*. No. 697, Vol. 242 (17 March 1960). The Use of Electronic Computation in the Study of Random Fluctuations in Rapidly Evolving Populations. By J. L. Crosby. Pp. 551–573. 7*s*. 6*d*. (London: Royal Society, 1960.) [188

Proceedings of the Royal Irish Academy. Vol. 60, Section A, No. 4: Charge Equilibrium in Aerosols According to the Boltzmann Law. By D. Keefe, P. J. Nolan and T. A. Rich. Pp. 27–45. 2*s*. 6*d*. Vol. 60, Section B, No. 7: The Basis of the Constancy of the Body Temperature. By J. M. O'Connor. Pp. 243–276. 4*s*. Vol. 60, Section B, No. 8: Some Harpacticids from Lough Ine, with descriptions of Two New Species. By Katharine M. Roe. Pp. 277–289. Vol. 60, Section B, No. 9: The Ecology of a Raised Bog in Co. Tyrone, Northern Ireland. By M. E. S. Morrison. Pp. 291–308+plates 22 and 23. 3*s*. 6*d*. (Dublin: Hodges, Figgis and Co. Ltd., 1959.) [188

Plant Breeding Institute, Cambridge. Annual Report, 1958/59. Pp. viii+69. (Cambridge: Plant Breeding Institute, 1960.) 5*s*. [218

Institution of Gas Engineers. Publication No. 563: Recommendations for the Laying of Steel Gas Service Pipes. Pp. 24. (London: Institution of Gas Engineers, 1959.) [213

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 62: Tree Planting, Advice on Planting, Maintenance and Financial Assistance. Pp. 19. (Belfast: Ministry of Agriculture, 1959.) [218

Publications of the Royal Observatory, Edinburgh Vol. 2, No 5: Spectrophotometric Measurements of Early Type Stars. 6: Results and Discussion of 25 stars of M.K. Types B.. By H. E. Butler and H. Seddon. Pp. 1+187–221. (Edinburgh and London: H.M. Stationery Office, 1960.) 10*s*. net. [228

Bulletin of the British Museum (Natural History). Entomology. Vol. 9, No. 1: The Early Literature of Mallophaga (Part IV, 1787–1818.) By Theresa Clay and G. H. E. Hopkins. Pp. 1–61+plates 1–6. 27*s*. 6*d*. Geology. Vol. 4, No. 2: Beetles from the London Clay (Eocene) of Bognor Regis, Sussex. By E. B. Britton. Pp. 27–50+plates 2–7. 12*s*. Vol. 4, No. 3. The Morphology and Relationships of *Rachiopteris cylindrica* Williamson. By Henry Smith Holden. Pp. 51–69+plates 8–10. 9*s*. (London: British Museum (Natural History), 1960.) [233

1960–61 Civil Estimates for the year ending 31st March 1961. Class IV. Education and Broadcasting. Pp. 102+xvi. (London: H.M. Stationery Office, 1960.) 7*s*. net. [283

H.M. Treasury. Assistance from the United Kingdom for Overseas Development. Pp. 20. (Cmnd. 974.) (London: H.M. Stationery Office, 1960.) 1*s*. net. [283

Other Countries

Notulae Naturae of the Academy of Natural Sciences of Philadelphia. No. 319 (May 29, 1959): A New Cardinal Fish (Apogonidae) from the Bahamas. By James E. Böhlke. Pp. 5. No. 320 (May 29, 1959) The Characters and Synonomy of the Western Atlantic Snake Eel, *Ophichthus ophis* Linnaeus. By James E. Böhlke. Pp. 9. No. 321 (September 25, 1959): A New Fish of the Genus *Hypsoblennius* (Blenniidae) from the Bahamas. By James E. Bohlke. Pp. 5. No. 322 (September 25, 1959): Notes on Philippine Birds. By R. Meyer de Schauensee and John E. du Pont. Pp. 5. No. 323 (September 25, 1959); The Correct Placement of the Genus *Prionacris* (Orthoptera; Acrididae; Cyrtacanthacridinae). By James A. G. Rehn and Harold J. Grant, Jr. Pp. 3. No. 324 (October 30, 1959): New Subgenera and Two New Species of the Genus *Navicula* (Bacillariophyceae) By Ruth Patrick. Pp. 11. No. 325 (October 30, 1959): Studies on Fishes of the Family Ophidiidae. IV: Two New Dwarf Cusk-Eels (Genus *Ophidion*) from the Tropical Western Atlantic. By C. Richard Robins and James E. Bohlke. Pp. 9. (Philadelphia: Academy of Natural Sciences, 1959.) (213

Universidad Nacional del Sur, Extension Cultural, Bahia Blanca. Algunos Aspectos de la Biologia de Suelos. Por E. H. Rapoport. Pp. 23. (Bahia Blanca, Argentina. Universidad Nacional del Sur, 1959.) [213

Instituto Antartico Argentino. Antarctic Symposium of Buenos Aires, November 17–25, 1959. Document No. 19: Resolutions Adopted by the Closing Plenary Session. Pp. 4. Document No. 20: Reports on the Scientific Sessions. Pp. 2. Informe de Resultados sobre el Simposio Antartico de Buenos Aires, 1959 Por Rodolfo N. Panzarini. Pp. 81. (Buenos Aires: Instituto Antartico Argentino, 1959). [213

Boletin del Instituto Antartico Argentino, Vol. 1, No 1 (Mayo, 1957). Pp. 48. (Buenos Aires: Instituto Antartico Argentino, 1957.) [213

Instituto Antartico Argentino. Publicacion No. 1: Contribucion al Conocimiento del Sector Antartico Argentino. Por I. Rafael Cordini. Pp. 277+57 plates. Publicacion No. 2: Contribucion a la Geologia de la Antartida Occidental. Por Jean Olsacher, Horacio Diaz y Mario Teruggi. Pp. 152. Publicacion No. 3: El Conocimiento Geomagnetico de la Antartida Sudamericana. Por Leonidas Slaucitajs. Pp. 114. Publicacion No. 4: Algunus Observaciones Geologicas y Criopedologicas en la Antartida. Por Horacio H. Camacho, Jorge Villar Fabre, Arturo E Corte y Arturo L. Somoza. Pp. 131. Publicacion No. 5: Diatomeas y Silicoflageladis del Sector Antartico Sudamericana. Por Joaquin Frenguelli y Hector A. Orlando. Pp. 191 (17 plates). (Buenos Aires: Instituto Antartica Argentino, 1955, 1957 and 1958.) [218

Instituto Antartico Argentino. Contribucions. No. 8: La Presencia de *Nuttallochiton hyadesi* (Roch.) en la Fauna Antarctica (Moll. Poliplacoforos). Por Z. J. A. de Castellanos. Pp. 9. No. 10: Observaciones sobre los Escombros de Isla Media Luna, Shetland del Sur. Por Juan Olsacher. Pp. 5. No. 17: El Antartico en el Año Geofisico Internacional. Por Rodolfo N. Panzarini. Pp. 29. No. 19: La Compaña Antarctica 1956–57. Por Gelvio Guozden. Pp. 31. No. 22: La Campaña Antarctica 1950–51. Por Rodolfo N. Panzarini. Pp. 8. No. 21: Supervision del Planeo Logistico de la Campañas del Instituto Antartico Argentino. Por Carlos A. Perticarari. Pp. 23. No. 24: La Campaña Antartica 1952–53. Por Rodolfo N. Panzarini. Pp. 11. No. 25. Rocas Eruptivas de Caleta Armonia, Isla Nelson, Shetland de Sur. Por Bernabe J. Quartino. Pp. 26. No. 26: La Operacion "Congelamiento I" (Operation Deepfreeze I) Por R. G. Kolbe. Pp. 10. (Buenos Aires: Instituto Antartico Argentino, 1959.) [218

Instituto Antartico Argentino. Contribucions. No. 27. La Operacion "Congelamiento II" (Operation Deepfreeze II). Por Daniel L. A. Canova. Pp. 11. No. 29: Antartica a Traves de sus Faunas y Floras Fosiles. Por Horacio Homero Camacho. Pp. 18. No. 32: La Funcion Educativa y Cientifica de un Museo Antartico. Por Juan M. Ageitos y Carlos A. Meneses. Pp. 16. No. 33: Notas Sobre un Ejemplar Albino de Pinguin de Adelia. Por Ricardo Novatti. Pp. 11. No. 34: Notas Sobre una Roqueria de Pinguin Emperador en el Mar de Weddell. Por Ricardo Novatti. Pp. 10. No. 35: Estudiod Microbiologicos en Aves y Fitoplancton Marino Antarticos. Por John McNeill Sieburth. Pp. 41. No. 41: Intereses Cientificos Argentinos en el Antartico. Por Rodolfo N. Panzarini. Pp. 14. (Buenos Aires: Instituto Antartico Argentino, 1959.) [218

Population Reference Bureau, Inc. *Population Bulletin*, Vol. 16, No. 2 (March 1960): Population Growth and Economic Development in the ECAFE Region—Part II. Pp. 25–42. (Washington, D.C.: Population Reference Bureau, Inc., 1960.) 50 cents. [293

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

THE TRAINING OF POSTGRADUATE STUDENTS

A JOINT committee appointed by the Institute of Physics and the Physical Society has prepared an admirable report on the postgraduate training of physicists in British universities. Besides university professors of physics its members included industrialists of the standing of Dr. R. Beeching, who is a director of Imperial Chemical Industries, Ltd., and some twenty other physicists attended one or more of its meetings to give their views. The report[*] does not claim to be more than a first step in investigating a very big problem, and is, in fact, concerned mainly with problems arising in training those who are working for the Ph.D. degree, including the suitability of that degree as a preparation for fundamental and applied research. It is packed with common sense and, taken with the lecture on "The Education of Chemists" which Prof. T. L. Cottrell delivered at Edinburgh last November, with which the report may appropriately be read, it affords clear evidence of fresh thought about the nature and content of university courses, and indeed of professional courses both inside and outside the universities. In fact, issues are raised if not fully discussed which should certainly be considered by the Royal Institute of Chemistry in determining points of policy arising out of the tentative proposals for a new grade of membership and category of affiliation.

In British universities postgraduate training in science has been essentially preparation for the Ph.D. degree: the bachelor's degree with honours has been, and is still, the qualification which often represents the completion of a future scientist's formal university education, and at this stage many graduates, including some of the ablest, enter government and industrial laboratories for careers which may include original and fundamental research. The view was put to the Committee that in any foreseeable circumstances the recruitment of adequate numbers of Ph.D. students is essential for the vitality of university departments which are actively concerned with the advancement of knowledge. Without questioning the view that the prosecution of original research is a major university responsibility, and recognizing the existence since the Second World War of a large and only partly satisfied demand from industry and from government departments for graduates in physics for research and development, the Committee sees postgraduate training as an aspect of the wider issue of the most effective use of scientific ability of a high level. Its scrutiny is penetrating and some of its comments are strikingly similar to those of Prof. Cottrell on the training of chemists.

The report points out that the training of the research worker in British universities rests upon four assumptions. First, it presupposes enlightened supervision in an atmosphere of maturity. Secondly, it assumes that all the research students have the innate qualities that will allow them to profit by this form of training. Implied in this assumption is successful selection, and that those who gain a research degree will be characterized by manifest research ability and maturity. Thirdly, it assumes that physicists of the highest potential ability will benefit from a broadly similar method of research training whatever their ultimate work may be, though it is recognized that in the past theoretical physicists have tended to come from those trained as mathematicians. Fourthly is the assumption that the present level of the first degree is the appropriate stage at which the basic and common education of a scientist may cease, and that additional knowledge required to be gained beyond this stage is knowledge of a specialized nature determined by the field of research being undertaken.

It is against this background that the Committee examined criticisms made of present practice in Britain, some of which imply a complete denial of one or more of the assumptions. From within the universities the adequacy of the three-year undergraduate course has been questioned and a four-year course has been advocated purely on the ground of the growth of physics itself in recent years. While the report makes no comment on an important point made by Prof. Cottrell that scientific advances, by including more facts in the scope of a wider generalization, may reduce rather than increase the amount of information to be memorized, the Committee clearly recognized serious practical difficulties in increasing the length of undergraduate courses; and the practical suggestion made by the Committee is rather the desirability of a further one-year university course for selected students.

It is the industrial criticism that is strikingly parallel with Prof. Cottrell's comments on the training of chemists. The chief defects in the quality of Ph.D. graduates recruited are lack of scientific originality, lack of good theoretical knowledge of physics and lack of flexibility and adaptability. The first is primarily a criticism of the selection of research students, or of the unwillingness of universities to refuse to award the degree to those once accepted; but it could also be a criticism of poor supervision and of bad selection of problems tackled, which might stifle scientific originality. It is the most serious of the criticisms that can be made against the universities in this respect.

The second criticism is widespread, but is made on two different grounds. First, it is suggested that the Ph.D. graduates sometimes lack adequate theoretical knowledge of even the fields in which they have undertaken their research, though from Prof. Cottrell's criticism of the graduate in chemistry it could be due to failure to apply theory and instead to resort to the purest empiricism. With this could also go the absence of a sufficiently critical and inquiring attitude to a research problem. Secondly, some employers seem to expect the holder of a Ph.D. degree to possess a deeper theoretical knowledge of physics over quite a wide front than could be expected in a graduate with a first degree. That criticism, however, could scarcely be advanced if the graduate had, as Prof. Cottrell insists, been adequately trained and encouraged to read and think for himself and to make adequate use of the literature.

---

[*] The Postgraduate Training of Physicists in British Universities: The Report of a Joint Committee appointed by the Institute of Physics and the Physical Society. Pp. 19. (London: Institute of Physics, 1960.) 2*s*.

The third criticism is also widely held and certainly strongly held, and though it is the most surprising of the criticisms noted in this report, it finds some support in Prof. Cottrell's observations on chemists. All these criticisms, however, are essentially criticisms of detail and do not necessarily imply that university postgraduate training leading to a Ph.D. degree is not fundamentally a highly desirable method of preparation for entry to industry and government service. Much more fundamental criticism is implied in the view held by some important and distinguished industrialists that the necessary preparation for, or apprenticeship to, research is more profitably undertaken in a large industrial laboratory than in the atmosphere of a university research school. Industry has only a limited need for people who will work on difficult problems of pure physics; but it has great need for men of similar intellectual ability and basic training who can apply their abilities and knowledge to the varied problems of industry. These men need to be able to cross with ease the boundaries that conventionally delineate the various sciences taught and organized in universities, and the report notes that the view is widely held that postgraduate training of the Ph.D. pattern may make a man less able or willing to do this. The Committee states that it was put with force that only a small minority, probably fewer than 10 per cent, of those recruited into industry will be engaged on research for the whole of their careers of forty years or so. Evidence was presented that the possession of a Ph.D. degree had no significant bearing upon a future career, as measured, in any event, in financial terms.

It is at this point that the relevance of Prof. Cottrell's comments on the training of chemists becomes most apparent. The demand from industry for men who have had a Ph.D. training is real, but is smaller than the output of such graduates; at present, industry is compelled to take Ph.D.s whom it would have preferred to take at an earlier stage; and it was equally clear to the Committee that the number of Ph.D.s who would be sought by industry might be increased if the average quality, measured by originality, knowledge and flexibility, were raised.

The Committee states its reasoned conclusions in ten paragraphs. First, for its purpose, which is fundamentally the introduction of an undergraduate to the procedure of fundamental research, working for the Ph.D. is an admirable training; but if it is to retain its value as a hallmark of capacity for original research, the universities must be jealous of the high standard of those on whom it is conferred. Next, the research student plays an important part in maintaining the vitality of a university physics department: without a sufficient number of such students the Committee believes it would not be possible to maintain an appropriate output of fundamental research, or to retain or recruit academic staff of suitable character. It points out, however, that the universities must ensure—which is not always the case at present—that research students are not employed partly as high-grade technicians; but it passes off a problem which is very real in some university departments, involving questions of status and prejudice, and it may be wondered whether the implications of the proposals of the Royal Institute of Chemistry to form a Registered Chemical Assistants Group, affiliated to the Institute, have been thought out sufficiently.

It may be recalled that Prof. Cottrell roundly challenged the value of much of the manipulative work customary in the training of the chemist, and his analysis is highly suggestive in respect of the physicist as well as of the physical chemist. This is not to deny the importance of such work, or to suggest that the career of laboratory technician should not be satisfying and highly regarded in its own right: not nearly enough is, in fact, done to encourage young people with manual dexterity and skill to take up such a career. What is wrong is to suggest that the career of laboratory technician is necessarily a stepping-stone to that of scientist or technologist, or that the technician's skill is necessarily linked with high intellectual ability. There may be the odd technician with such gifts which will carry him naturally to a seat on the main board of such a company as Imperial Chemical Industries, Ltd.; but he is the exception, and the technician is best served by honouring his or her special skill in its own right, rather than by encouraging ambitions which will generally be doomed to disappointment.

The appropriate and more extensive use of technicians is a problem which deserves much more attention than it has yet received and itself bears closely alike on the most efficient use of highly trained man-power and on the research output of a university department. Further, it is possible that some way may be found here of diminishing the pressure on the academic staff and thus helping to meet other criticisms of postgraduate training. While the Committee believes that the standard of the Ph.D. degree in physics is at least as high as in most other subjects, it accepts the view that the degree is sometimes awarded to candidates of inadequate calibre and concludes that the universities should be more critical in their selection of research students, and readier to refuse the award, even after the completion of the prescribed period of study and research. There is a strongly held opinion among employers that the standard of the Ph.D. has deteriorated significantly in the past twenty years.

Fourthly, the Committee is satisfied that industry needs physics graduates of wide knowledge, adaptability and first-class intellectual capacity, but that it would prefer that only a small proportion of its recruits had had research training for a Ph.D. degree in a university. Comparatively few jobs in industry will involve research in pure physics, and graduates who contemplate staying at the university for a Ph.D. should appreciate that the degree will not usually improve their prospects of advancement in industry. Some university teachers attribute industry's lack of enthusiasm for the Ph.D. degree to the fact that, in physics, fundamental research is very largely carried out in universities, and the Committee concludes that it would help to resolve the apparently conflicting demands of industry and the universities if more members of university staffs were aware of the problems of industry and the requirements of industrial research, and more industrialists appreciated the crucial place of research and the research student in the modern university.

Next, the Committee concludes that an extension of knowledge, beyond that appropriate to the present first-degree courses, should form part of university training at postgraduate-level, not narrowly centred on an immediate field of research, but such as to strengthen substantially the graduate's background knowledge of that part of physics in which his research is to be done. It is suggested that for most research students this teaching should be concentrated in the first postgraduate year. Many graduates who enter industry without taking a Ph.D. degree would benefit greatly from similar courses, and the Committee suggests the organization of courses so that they could be available to both groups of graduates; this would meet a real industrial need, and it might ease the problem of organization within the universities, and also assist in the assessment of students capable of staying on for research.

Finally, the Committee recognizes that the development of postgraduate courses would aggravate the serious problems of staffing which already face the universities and also that, since most university students are dependent on maintenance grants, no improvement of training on the lines suggested is feasible without provision of the necessary financial support by the grant-awarding bodies, particularly the Department of Scientific and Industrial Research.

As already noted, the Committee limited itself almost exclusively to problems arising in the training of those working for the Ph.D. degree, and it frankly recognizes that there are equally important problems involved in the further training of those who take up professional work in physics immediately after taking a first degree. Investigation of those problems involves consideration of the nature and extent of industry's need of scientific man-power, and it is to be hoped that such an investigation will be undertaken by a committee at least as representative of both the academic and the industrial aspects as that which, under Prof. N. Kemmer's chairmanship, has produced the present report, and before plans for further expansion of university and of technological education are too firmly set. Meanwhile, Prof. Kemmer and his colleagues are to be congratulated on a report which should be of considerable interest not simply to physicists but also to chemists, and to other scientists and their professional organizations, as well as to the universities.

NUCLEAR THEORY AND ITS UTILIZATION

Lectures on Nuclear Theory

By L. D. Landau and Ya. Smorodinsky. Translated from the Russian. Revised edition. Pp. vii+108. (New York: Plenum Press, Inc.; London: Chapman and Hall, Ltd., 1959.) 5.25 dollars; 45*s*. net.

Introductory Nuclear Theory

By Dr. L. R. B. Elton. Pp. xi+286. (London: Sir Isaac Pitman and Sons, Ltd., 1959.) 40*s*. net.

Soviet Reviews of Nuclear Science on the 40th Anniversary of the October Revolution

(Being Vol. 3, No. 11 of *Atomnaya Energiya*, November, 1957.) (International Series of Monographs on Nuclear Energy. Division 2: Nuclear Physics, Vol. 3.) Pp. v+110. (London and New York: Pergamon Press, 1959.) 30*s*. net.

Fundamental Aspects of Reactor Shielding

By Dr. Herbert Goldstein. Pp. xvi+416. (London and New York: Pergamon Press, 1959.) 66*s*. 6*d*. net.

Fundamentals of Nuclear Energy and Power Reactors

By Henry Jacobowitz. Pp. 118. (New York: John F. Rider Publisher, Inc.; London: Chapman and Hall, Ltd., 1959.) 2.95 dollars; 24*s*.

An Introduction to Thermonuclear Research

A Series of Lectures given in 1955. By Albert Simon. (International Series of Monographs on Nuclear Energy. Division 14: Plasma Physics and Thermonuclear Research, Vol. 1.) Pp. ix+182. (London and New York: Pergamon Press, 1959.) 35*s*. net.

THE six books listed represent a mixed bag. "Lectures on Nuclear Theory" by Landau has appeared before and is now available in book form, surprisingly without the name of the translator. The lectures are extremely clearly presented: they were, in fact, originally delivered to experimental physicists and the authors have been at great pains to describe most carefully the physical pictures they analyse mathematically, and to state the limit to which modern experimental results allow theory to go. What we have learned about forces between nucleons from scattering experiments occupies half of the book. Then follows a detailed statement of structure of light and heavy nuclei and a review of neutron and meson interaction with nuclei. A delightful book, not only for students but also for all physicists who enjoy clear exposition. Dr. Elton's "Introductory Nuclear Theory" covers the same ground in much greater detail and with more extensive mathematical proof. It is a text-book for the theoretical physicist of final honours and postgraduate standard and as such is an extremely thorough presentation based, as Dr. Elton describes in his preface, on the phenomenological approach to the nuclear data emanating from the large machines and cosmic ray plates.

The "Soviet Reviews of Nuclear Science" is rather old: the papers were prepared to mark the 40th anniversary of the October Revolution. Pontecorvo writes "In the glorious fortieth year of the October . . ."! The four papers on nuclear power in the U.S.S.R. are completely superseded by the Geneva 1958 papers and were not worth reprinting at this date: this might also be true of the two survey articles on radioisotopes and radiochemistry. It seems rather pointless to translate review articles; reviews on most subjects are prepared in many countries and the review here translated on interaction of slow neutrons with nuclei is based on world literature, and again all the material can be found in the Geneva papers. There remains one long article on research with the 6-metre synchro-cyclotron, a review article of the Soviet paper with no reference to foreign work. However, this is a valuable summary of experimental results and is well illustrated.

Two books on reactors stand at the top and bottom of their class. Goldstein's authoritative work on "Fundamental Aspects of Reactor Shielding" comes from the Division of Reactor Development of the Atomic Energy Commission, and clearly illustrates the great part the research physicist has to play in nuclear engineering. Reactor shielding is an expensive fraction of nuclear power costs, and "the proper design for a given reactor shield should start from first principles". This book deals very thoroughly with first principles, neutron and gamma-ray attenuation in isotopic and discontinuous media, and compares theory with the experimental results achieved over the past few years with the shielding facilities built on to the Oak Ridge reactor, the graphite and the original water-moderated 'pool'-type reactor. These facilities and the instrumentation for shield testing are well described; the latter illustrates how alert the experimenter must be in this subject if measurements in high and low fluxes are to be reasonably accurate. The book opens with a careful discussion of the biological effects of radiation. The reader notes the frequent references to results reported in Oak Ridge and other laboratory reports, apparently not submitted to any of the learned societies or established journals. Many were originally classified and appear now with references declassified or even still classified: the abstracting journals will be presented with a serious problem if this practice continues. The book will be essential to all engaged on shielding studies, and the references to original work are comprehensive.

One wonders for whom "Fundamentals of Nuclear Energy and Power Reactors" has been written, for it is neither comprehensive nor superficially accurate; but it sets out to attract the general interested public and the members of the atomic industry. For the latter, it does not even mention the important developments abroad, though the book does not state that it is merely reviewing the American scene. It dismisses the graphite-moderated natural uranium reactors as obsolescent, in spite of more than 4,000 MW. of such reactors under construction, and makes no reference to the Russian reactor incorporating the superheating of steam by nuclear energy. The book is well illustrated, but alas contains much slang—do we get "mileage" out of fuel? I would commend the author to Dr. Goldstein's impeccable style.

The appearance of "An Introduction to Thermonuclear Research" in 1959 in its present format is a little disappointing; the Geneva 1958 papers disclosed so much more information than can be found in this book. The preface states that the book is based on lectures of 1955 to which some 1956 information has been added: the basic science in the book is worthy of inclusion although it can all be found elsewhere, but the long catalogue of the American devices in which plasma studies have been made will be nearly meaningless to scientists not working in the field and is outdated information for those who are. The book makes no reference to work in other countries as it closes in 1956: the reviews in the Geneva 1958 papers (Volume 31) will repay study better than this little volume. T. E. Allibone

CONSTANTS GALORE

The Physico-chemical Constants of Binary Systems in Concentrated Solutions

By Prof. Jean Timmermans. Vol. 1: Two Organic Compounds (without Hydroxyl Derivatives). Pp. xiii+1259. Vol. 2: Two Organic Compounds (at least one a Hydroxyl Derivative). Pp. xi+1272. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 218*s*. a volume.

These two books are part of a series of four volumes prepared as a result of a systematic literature survey carried out between 1910 and 1957. Unfortunately no list of the journals abstracted is given. The National Science Foundation of Washington, D.C., gave a substantial grant to enable Dr. Lewin to have the records typewritten so that the publishers could produce the books by offset printing. The pages contain an immense amount of information, but they are disfigured by lack of uniformity; for example, the negative sign sometimes appears before every entry in a table but in other places it appears before the first entry only although it is applicable to all the entries. The arrangement of the mixtures follows a scheme devised by the author, but as the index and bibliography are reserved for volume 4 search for information can only be made by turning pages. Some assistance is afforded by the pair of names boldly printed at the head of each page and these usually refer to a mixture occurring somewhere upon that page, but unfortunately in some instances (for example, Volume 1, pp. 765 and 1191) the names do not coincide with the mixtures listed.

Once a mixture is located the existing data are found arranged in the following order: heterogeneous equilibria (critical constants, saturated vapour pressure curve, boiling curve, azeotropes, composition of liquid and vapour in co-existing phases, densities and rectilinear diameters, composition of the two liquid phases, critical solution point, freezing and melting curve, eutectic and transition points, equilibria of condensed phases under high pressure); properties of phases, first for the gas, then for the liquid and finally for mixed crystals (density, coefficient of expansion, compressibility, viscosity, surface tension, refractive index, optical dispersion, dielectric constant, electrical conductivity, optical rotating power, magnetic rotation, magnetic susceptibility); thermal constants (specific heat, heat of solution or mixing, heat of vaporization and fusion, thermal conductivity). All numerical data have been taken directly from the original papers and values read from graphs are indicated. A list of symbols and abbreviations is presented at the front and back of each volume, but the symbols do not conform to modern usage. In particular, a reader should note that the old *Q* convention for heat quantities is adopted.

The words "Systems in Concentrated Solutions" are unusual as applied to binary mixtures because a solution that is concentrated with respect to one component is dilute with respect to the other. The author says, however, that concentrations between 10 and 90 weight per cent are tabulated, although the tables do in fact contain some figures outside this range. The percentages recorded appear to refer to the concentration of the second named component, although this is not stated in the list of symbols or in the instructions to users.

The selection of values is not critical and many of them were originally published long before 1910. Thus, some systems are covered at great length and many discordant values for certain constants are recorded. Timmermans discusses in the preface to Vol. 2 the reasons for these divergent values and suggests that they arise in part because insufficient care has been taken by some authors in the purification of specimens. If the purity of the samples is employed as a criterion of worth, much of the recorded data has little value.

These volumes are expensive, but they provide such a useful guide to published data, particularly for a worker conversant with the substances under investigation, that many libraries will wish to acquire these books. E. F. G. Herington

THE BRAIN IN RESPONSE

Person Perception and Interpersonal Behavior

Edited by Renato Tagiuri and Luigi Petrullo. Pp. xx+390. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1958.) 60*s*. net.

The Problems of Perception

By R. J. Hirst. (The Muirhead Library of Philosophy.) Pp. 330. (London: George Allen and Unwin, Ltd.; New York: The Macmillan Company, 1959.) 30*s*. net.

In recent years, an increasing degree of attention has been devoted to the study of what is called 'person perception' or 'social perception'. The book "Person Perception and Interpersonal Behavior" consists of a symposium of 23 papers on these subjects. As is usual with such symposia, the relationship between the topics discussed in the various papers is often not clear. The value of the book, especially to the general reader, would have been greatly increased by the addition of some attempt to sum up and derive general conclusions from the papers as a whole. The reader will find all the more difficulty in doing this for himself because the terms 'person perception' and 'social perception' are used by different authors to include several different processes the inter-relationship of which has never been worked out. It is generally accepted that we not only perceive, more or less objectively, the physical characteristics and actions of other people; we also infer from these perceptions personal characteristics such as feelings of liking and disliking, motives and intentions, social status and background, etc. The original perceptions, and still more the inferences derived from them, are enormously affected by our own feelings, motives and social relationships to other people, and by the way in which we react to them. Sometimes the effects are relatively consistent, but often they vary according to the particular situation. Included in this book are studies by Ittelson and Slack and by Secord of the factors which affect the perception of faces and other physical characteristics. But there are many more studies of the inferences and judgments made about the personality characteristics of others, and how these vary with the personality and likes and dislikes of the judge, and with the social situation. There is an interesting paper by Jones and Thibaut on how people interact in a variety of social situations; and several papers discussing the reasons for one person being attracted by another —whether because the second fulfils the needs of the first, or because he appears to possess the same personality characteristics or interests. A final paper by Cronbach demonstrates the present limitations on the accurate analysis of these judgments, feelings and interactions, and the factors which determine them.

Little or no attempt appears to have been made to discover what is actually perceived, or what are the significant aspects of behaviour and expression which we observe in others; nor how these perceptions lead to the inferences and judgments described above. Granted this is a task of great difficulty and complexity, but it is hard to see how any real understanding of 'person perception' can be gained until some systematic analysis has been made of the psychological processes involved and their interrelationship. Thus, although the psychologist with some knowledge of these topics can find many points of interest in the papers included in this book, the general reader will be liable to become hopelessly confused by the mass of apparently unrelated hypotheses which are frequently expressed in bewilderingly esoteric language.

"The Problems of Perception" provides a philosophical study of the nature of perception in general. It presents a critical examination of the various philosophical theories as to the nature of perception, together with the author's own theory, which is more in accordance with present-day knowledge of the physiology and psychology of perception. The book should be of real interest and value not only to philosophers but also to psychologists and to the general reader. It is clearly written, and necessitates little previous knowledge of philosophy or of technical language.

The author demonstrates convincingly that earlier theories have never provided a satisfactory explanation for the high degree of veridicality of our perceptions on one hand, in spite of the restricted nature of the physiological information conveyed by the sensory nerves to the brain; and on the other hand, the modifications, errors and individual differences in perception which undoubtedly occur, and the apparently perceptual nature of hallucinations which arise in default of external stimulation. His own theory appears to provide a much better explanation. It makes due allowance both for the convincing objectivity and external reference in our perceptions of the surrounding world, and also for the undoubted influence on them of subjective factors; though whether in fact perception of external objects as such is inherent and arises even in early infancy is not perhaps as certain as he would have it to be.

There is one matter which his theory, depending as it does on the concept of 'perceptual consciousness', does not appear to cover adequately—namely, the unconscious perceptions which seem so frequently to guide our habitual and automatic actions. Psychological study of this type of perception, and of perception at the margin of consciousness, is only just beginning. But when rather more is known of these perceptions, philosophical theory may require further extension to cover them. M. D. VERNON

STRUCTURE AND GROWTH OF PLANT CELL-WALLS

The Plant Cell-Wall

By Prof. Pieter A. Roelofsen. (Encyclopedia of Plant Anatomy, Band 3, Teil 4.) Pp. vii+335+68 plates. (Berlin-Nikolassee: Gebrüder Borntraeger, 1959.) n.p.

IN this age, when man-made fibres are so very much in the news, it is a salutory lesson to recall that naturally occurring fibres were in existence upon the Earth long before man, and that they continue to be manufactured by living organisms with a perfection and in a complexity which man still cannot match. Such a lesson is given by Roelofsen's book for fibres made by plants.

The structure of the plant cell-wall has been under constant review ever since its observation by Robert Hooke in 1664, first by light microscopy then, largely after the influence of Carl v. Naegeli, by polarization microscopy, then by X-ray diffraction analysis and now by all these methods supplemented by electron microscopy. Up to this newest development, the study was in the hands of the relatively few botanists with the requisite knowledge of physical principles and training in physical techniques. The electron microscope has, however, thrown the field wide open, and this, coupled with the growing realization of the importance, both academic and technological, of the cell-wall, has led, during the past ten years, to a vast increase in the number of laboratories actively engaged in research and therefore in the number, range and variety of published papers. Prof. Roelofsen himself returned to this study some ten years ago after an absence of twenty years and has during this period of rapid expansion already established himself as an authority in this difficult field.

This book, in my opinion in many ways the best which has yet appeared on this subject, can only enhance Prof. Roelofsen's reputation. The deep appreciation of the powers of electron microscopy which all workers feel make it dangerously easy to fall into the trap of ignoring older work by older methods. This trap Roelofsen conscientiously avoids. It is, indeed, one of the most admirable features of his book that each topic he takes up is dealt with historically, in the sense that what may be called the classical key investigations are reviewed in detail and the later work is always placed in its proper context against this general background. To my certain knowledge very few lines of investigation are omitted and very few papers of lasting importance fail to receive due appreciation. Perhaps the biosynthesis, particularly of cellulose, does not have the attention it appears to merit in view of its importance in questions of wall growth, but this may be due to shortage of space.

The book is divided broadly into two sections. The first, in eight subsections covering 100 pages, deals with the nature, occurrence, chemical and physical properties and biosynthesis of the various components of plant cell-walls. This includes treatment not only of the 'standard' components—celluloses, hemicelluloses, polysaccharides, lignin, and chitin but also of low molecular weight polyoses, cutin, suberin and rarer compounds such as phytomelane. There is in these pages much useful information which, so far as I am aware, has not hitherto been gathered together in one volume.

The second, larger, section, in four subsections covering more than 200 pages, deals with the physical methods of investigation and a wide review, surprisingly detailed and comprehensive in view of the comparatively small space available, of wall structure in higher plants, in algae and in fungi. The treatment of the physical methods is, wisely, not detailed; even making allowances for difficulties in translation the text in various places makes it clear that Prof. Roelofsen is himself not a physicist and he refers his readers to other texts. There is, however, sufficient here to enable the intelligent reader to make a critical appraisal of the subsequent statements. As to these, it is not an exaggeration to say that the facts available up to the time of going to press are all here, clearly stated and documented by reference to the appropriate literature. Equally, both the older and the current theories concerning mechanisms of orientation and of surface growth of the primary walls in higher plants are dealt with, though here the treatment is not, perhaps, so comprehensive. Prof. Roelofsen is himself the author of a theory of growth which is very much to the fore at this moment and it is natural, and welcome, that he should pay to this a good deal of attention in his book. I find much in the hypotheses formulated in this part of the book to which I could not lend support—the author, for example, seems to repeat an older error in confusing *stress* with *strain* and this leads to a peculiar paragraph on p. 175 (the first paragraph in 228231)—but this again is natural and no criticism; the exposition is challenging and provocative and what more can be expected of hypotheses? It is perhaps unfortunate that the arrangement of the book precludes a unified consideration of growth both in higher and lower plants.

It is, however, a happy feature of his book that Prof. Roelofsen never hesitates to express his own opinion, for this builds what might have been to the general reader a dreary review into a well-knit whole, a fascinating easily read story.

The book is translated from an original manuscript in Dutch, and both the author and Prof. C. E. B. Bremerkamp, who assisted in the translation, are to be congratulated that it reads so easily. There are flaws in the English, but these are nowhere such as to mislead the reader, even the use of the word "bruto" on p. 173. The book is copiously illustrated by electron micrographs, all of them drawn from the published papers of the writers whose work is discussed; these are necessarily of uneven quality since some are drawn from earlier work and some refer to difficult material. There is a comprehensive bibliography of some 815 references, and both subject and author indexes as well as indexes of botanical and zoological names.

This is a book which no botanist—nor any technologist interested in cellulose fibres—can afford to ignore. It is a first-class reference book for the specialist, a fascinating unfolding story of research down the years for general readers, and an instructive, thought-provoking book for advanced students. To all these, it is recommended in the warmest terms.

R. D. PRESTON

A Biochemical Approach to Pathology

By M. J. R. Dawkins and Dr. K. R. Rees. Pp. vii+128. (London: Edward Arnold (Publishers), Ltd., 1959.) 18*s*. net.

As the advance of knowledge invades the old border-lines between the sciences, pathology becomes increasingly concerned with the chemistry of the cell, considered in topographical detail as an organized system of mainly enzymatically promoted reactions. Morbid states formerly described only in anatomical and histological terms have now to be interpreted in terms of chemical derangement in cytoplasm, microsome or other specified site. The first assertion is the justification of this book; the second describes the approach taken by its authors. Within the confines of 120 pages, two disciplines are bridged with an adequacy necessarily dependent on wise selection and enforced abbreviation. The authors have succeeded so well in combating these limitations that there is ground for some regret that more space could not be made available to them. Whereas pathologists may find difficulty with the assumption of extensive prior reading in chemistry, biochemical readers are less severely taxed in pathology, but both are aided by a wisely chosen short guide to further reading. Some of the present frontiers of knowledge are indicated in a stimulating manner.

The unfortunate tendency to write in initials (RNA, DPN and too many others) is strongly maintained without benefit of a glossary and detracts from an otherwise eminently readable text, while important substances such as adenylic acid appear only by name, assuming the glib role of shibboleth.

For a first edition, this well-produced volume is commendably free from errors, excepting the tri-valent carbon shown in the structure of bilirubin (p. 40) and the confusion of β-amino-α-naphthol with *o*-aminophenol (p. 115). R. W. R. Baker

Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy held in Geneva, 1 September—13 September 1958

Vol. 2: Survey of Raw Material Resources. Pp. x+843. (Geneva: United Nations; London: H. M. Stationery Office, 1958.) 80 Swiss francs; 132*s*.; 18.50 dollars.

The geological discussions at the second Geneva conference on atomic energy, reported in this volume, had a much more international character than those at the first conference in 1955. At the latter, the delegation from the United States contributed 85 out of 125 papers on geology and prospecting, Great Britain and Brazil each produced four contributions, and the remaining 32 works came from 22 different countries. In 1958 only 30 papers out of 84 were of American origin and there was a much larger presentation from other lands, notably from the U.S.S.R., France, Canada, South Africa and India. Discussions were also more open, for as a direct consequence of the Free World's glut of uranium no aspect of the economic geology of radioactive ores is now secret in the West—although information on the location and output of domestic deposits is still 'classified' in the U.S.S.R. The radiogeological studies printed in this "Survey of Raw Material Resources" range widely over the diverse fields of economic geology, prospecting, geochronology, uranium mineralogy, and geochemistry; and they make up what is undoubtedly the most comprehensive assemblage of new information on radioactive mineralization that has ever been brought together. C. F. Davidson

Sechzig Jahre Medizinische Radiologie

Probleme und Empirie. Von Prof. Hans R. Schinz. Pp. 275. (Stuttgart: Georg Thieme Verlag, 1959.) 19·50 D.M.

This book is a historical document written by Prof. H. R. Schinz of Zurich on the occasion of the Ninth International Congress of Radiology in 1959. It covers 60 years of medical radiology from the date of discovery of X-rays up to the present. The first section of the book deals with the discovery of X-rays by Rontgen. This is preceded by a short annotation leading up to this momentous achievement. The discovery of uranium and radium and their radioactive properties by Becquerel and the Curies is dealt with in a similar way, and so is the fundamental early work on nuclear and radiation physics by Rutherford and his co-workers. This first chapter covers all the important milestones in experimental and theoretical physics up to the 1950's, listing all the great names connected with this work throughout the world.

In the second section there is a short historical note on technical achievements and the development of X-ray apparatus. The main section of the book deals with the medical aspects of radiology, in particular radiobiology, X-ray diagnosis and radiation therapy and their advances during the past 60 years. Finally, some of the original papers of the early days of radiation physics by Rontgen, Rutherford, Becquerel, the Curies, Hahn and Strassmann are appended.

This book is a useful historical review of the past 60 years, mentioning all the outstanding workers in the field: it also contains a number of interesting historical photographs and charts referring to the very early fundamental work. R. E. Steiner

How Animals Move

By Sir James Gray. (The Royal Institution Christmas Lectures 1951.) Pp. 144. (Pelican Book A454.) (Harmondsworth, Mddx.: Penguin Books, Ltd., 1959.) 3*s*. 6*d*.

In 1951, Sir James Gray gave six Christmas lectures to a young audience at the Royal Institution. His task was ". . . to illustrate the more striking features of animal locomotion without assuming previous biological knowledge". The lectures, together with many admirable illustrations and revealing photographs, were published by the Cambridge University Press in 1953. It is good that the book will now be available to many more readers, who will discover an absorbing subject treated in clear and direct English. Young naturalists (and older ones) will learn that the movements of animals can be illusory or impossible to follow without suitable recording devices. Correct observations require much circumspection (for example, anglers should not be misled as to the speed of a hooked fish by the scream of a reel). Lastly, the reader, who could be an artist just as well as someone with an interest in biology, will find a lucid analysis of the living mechanics of locomotion, one that parallels the natural ease of the animals themselves. N. B. Marshall

PRIMARY STRUCTURE OF THE PROTEIN OF TOBACCO MOSAIC VIRUS

By F. A. ANDERER, H. UHLIG, E. WEBER and Prof. G. SCHRAMM
Max-Planck-Institut fur Virusforschung, Tubingen

THE tobacco mosaic virus, in spite of its limited economic importance, has continually played a noteworthy part in virology. It was the first infectious agent to be classified as a virus by the pioneering experiments of Iwanowski (1892) and Beijerinck (1898). It was also the first virus to be isolated in a pure paracrystalline state by Stanley in 1935 and to be identified as a nucleoprotein by Bawden and Pirie. The ribonucleic acid was isolated from tobacco mosaic virus and proved to be infectious by Gierer and Schramm[1] and by Fraenkel-Conrat and Singer[2]. Later, this experiment was successfully repeated with many other plant and animal viruses containing ribonucleic acid[3,4]. Thus we are led to the concept that ribonucleic acid is the genetic material of these viruses and determines the structure of the virus protein. Due to intense study in various laboratories the physical and chemical structure of tobacco mosaic virus is the best known of all viruses. Unfortunately, tobacco mosaic virus is less suitable for genetic studies; the bioassay is of limited sensitivity, single cells in culture media are not infected at a satisfactory rate, and combinations between different strains are not observed, making gene mapping impossible. But one can assume that tobacco mosaic virus will remain a favourite object for studies of the structural interrelationship between ribonucleic acid and its specific protein. One important step in this direction is the precise knowledge of the sequence of amino-acids in the protein.

Studies concerning the tobacco mosaic virus protein began shortly after its isolation, but the further progress, which depended upon the development of methods in protein chemistry, was slow. Using methods which now appear primeval, W. M. Stanley[5] and G. Schramm and H. Müller[6] isolated certain amino-acids by fractional crystallization. At that time the task of finding the complete amino-acid sequence in a particle with a molecular weight of 40×10^6 seemed quite hopeless. A solution of this problem seemed more possible after it was discovered that the virus protein consists of a great number of sub-units which appear identical in their physical and serological properties[7]. In weak alkaline solutions a dissociation into protein sub-units of a molecular weight of 90–100,000 was observed. This protein was called *A*-protein[8]. Later the virus protein could be dissociated further to the smallest sub-unit, which has a molecular weight of 17,500[9-11]. By re-aggregation of the *A*-protein[12] rod-like particles could be obtained which had a structure similar to the virus itself.

After development of chromatographical methods, especially paper chromatography, and the stimulating success of Sanger in the complete analysis of insulin (1949–55), the elucidation of the protein structure became experimentally possible. Using a combination of columns consisting of organic and inorganic adsorbents certain groups of amino-acids were estimated[13]. The first complete analysis was reported by Knight[14], who applied microbiological methods. More precise analyses became possible through the development of more reliable methods for the separation and quantitative estimation of amino-acids by ion exchange columns, a method for which we are indebted to Stein and Moore *et al.*

Further work of this group produced the automatic amino-acid analyser[15], without which the results described in this paper would have been virtually impossible. Cation-exchange columns have been extensively used for the separation and preparation of peptides. For the analyses of ribonuclease, Hirs, Stein and Moore[16] employed 'Dowex 50'. Braunitzer *et al.*[17] introduced an important modification by using the anion exchanger 'Dowex 1', with which the separation of peptides, particularly those containing basic amino-acids, was far more satisfactory. Using volatile buffer solutions containing pyridine and collidine, the laborious desalting process was avoided.

Before the analysis of the amino-acid sequence in a protein, the amino-acid composition and the number and nature of the terminal groups must be known. This is the most reliable way to prove the homogeneity of the material. The C-terminal group in the tobacco mosaic virus protein was identified by Harris and Knight[18] with carboxypeptidase. They found one mole of threonin per 17,300 gm. of tobacco mosaic virus. This value was confirmed by hydrazinolysis[19]. By short treatment with hydrazine the C-terminal peptide Pro-Ala-Thr was isolated[20,21], whereas by enzymatic hydrolysis Niu and Fraenkel-Conrat[22] determined the sequence of the last six amino-acids to be Thr-Ser-Gly-Pro-Ala-Thr. Since the virus does not contain a free terminal amino-group[23] the determination of the N-terminal configuration was more difficult. After treatment of the virus with trichloroacetic acid or hydroxylamine the imino-group of proline was released[24]. Therefore it was first assumed that proline, blocked by a labile substituent, was terminal. Later it was found that the Asp-Pro-bond inside the peptide chain is particularly labile and Pro could therefore not be N-terminal[25]. The correct N-terminal groups were found to be N-Acetyl-Ser-Tyr by Narita[26]. It was then clear that tobacco mosaic virus protein consists of about 2,200 peptide chains with the same terminal sequences.

It was then conceivable that the location of the other amino-acid residues in these peptide chains might also be identical. Therefore sequence studies were begun in several laboratories. Tryptic digestion of the protein was the first step, since the reaction of trypsin is quite specific, affecting only the carboxylic groups of the basic amino-acids. Because only a relatively small number of peptides is expected in the digestion mixture, the separation of these peptides ordinarily is not too difficult. In the Virus Laboratory in Berkeley a partial separation of the tryptic peptides, chiefly by counter-current distribution, was achieved and the sequence and composition of several of these tryptic peptides have already been described[27]. Wittmann and Braunitzer[28] separated all the tryptic peptides using 'Dowex-1' anion exchangers. They found twelve different peptides, accounting for all of the amino-acids. For the first time the amino-acid content of tobacco mosaic virus could be calculated exactly by summing up the composition of the peptides. According to these authors the peptide chain consists of 157 amino-acids and has a molecular weight of 17,400, which is in good agreement with the terminal group determinations and with physical, chemical and X-ray studies[9-11,18,19,21,22]. Furthermore, the N-terminal groups of eleven of these peptides were identified and the arrangement of several of these peptides inside the chain was elaborated by comparison of the tryptic peptides of different strains of tobacco mosaic virus[30].

Our own studies also began with the tryptic hydrolysis of the protein separated from the ribonucleic acid by extraction with phenol or acetic acid. In early experiments the separation of the peptide was tried by dinitrophenylation and subsequent paper electrophoresis and paper chromatography. The results were very unsatisfactory. Later we turned to column chromatography with the cation exchange resin 'Dowex 50' as the adsorbent. Most of the peaks arising in the effluent were mixtures of different peptides which had to be separated further by high-voltage electrophoresis and paper chromatography. Much better results were obtained with the anion exchange resin 'Dowex-1' according to the technique of Wittmann and Braunitzer. Only a few boundaries contained more than one peptide. While preparing the digest for column chromatography, we found a peptide insoluble in acidic solutions. This peptide was called *TU* (*tryptisch, unloslich*). A similar peptide was observed by Gish *et al.*[27] and by Ramachandran *et al.*[27] and designated as I-peptide (insoluble). The *TU* peptide was purified by several precipitations between *p*H 3 and 5 and by paper chromatography. It contains 41 amino-acids and has the same composition as the peptide No. XII of Wittmann and Braunitzer. The N-terminal group is N-Acetyl-Ser-Tyr. Therefore *TU* is the N-terminal peptide of the whole chain. The sequence of the amino-acids in this peptide is described by Anderer, Weber and Uhlig[31]. Besides the *TU* peptide eleven other tryptic peptides were found. The amino-acid compositions of all were determined with the automatic amino-acid analyser. The N- and C-terminal groups were identified, and the sequential structure elaborated so far as necessary to correlate with peptic and chymotryptic peptides described below. In Table 1 the amino-acid composition and the terminal groups of the twelve tryptic peptides are indicated in the order in which they occur in the peptide chain. The analytical data agree exactly with those of Wittmann and Braunitzer. Summing up the tryptic peptides, the molar ratios of the amino-acids in the total chain can be calculated. In the order of their frequency we obtain the following formula:

$$\mathrm{Asp_{18}Glu_{16}Ser_{16}Thr_{16}Ala_{14}Val_{14}Leu_{12}Arg_{11}Pro_{8}Ileu_{9}}$$
$$\mathrm{Phe_{8}Gly_{6}Tyr_{4}Try_{3}Lys_{2}Cys_{1}}$$

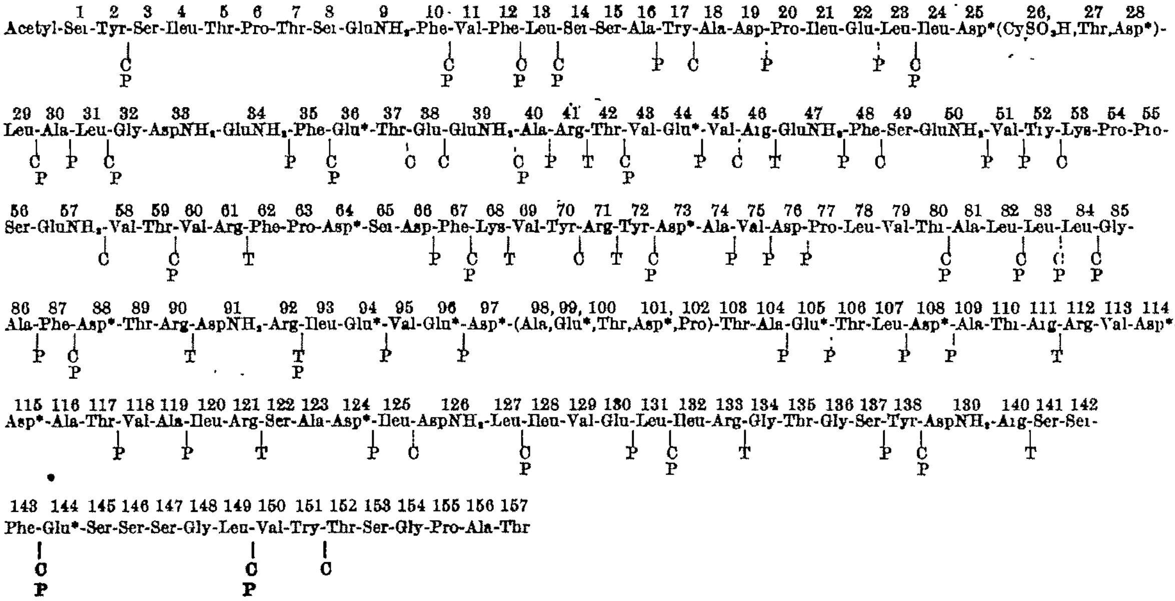
Analysis of the total protein confirmed these ratios. The time of hydrolysis for the analyses was varied between 17 and 60 hr. and the values obtained in five experiments were extrapolated to zero time.

In order to find the sequence of the tryptic peptides the protein was degraded with chymotrypsin and pepsin. Attention was primarily directed to peptic and chymotryptic peptides which formed bridges between two tryptic peptides (bridge peptides). Since all tryptic peptides end with Arg or Lys the bridge peptides must contain these basic amino-acids. In certain experiments only the Arg-containing peptides were selected by the Sakaguchi reaction. The peptides were separated on columns of 'Dowex-50' or 'Dowex-1'. Further purification was achieved by paper chromatography of the dinitrophenyl derivatives. In this way about 80 different peptides were isolated and their amino-acid composition and sequence determined. The C-terminal sequence was studied by hydrolysis with carboxypeptidase *A*. If the terminal group was Arg or Lys, a mixture of carboxypeptidase *A* and *B* was employed. The N-terminal groups were mainly identified by the dinitrophenyl method. In order to find the second residue the terminal dinitrophenyl amino-acid was removed by hydrogenation according to the method of Justisz[32] or of Uhlig[33], and the dinitrophenylation was repeated. Occasionally the Edman degradation was also applied. Further insight into the N-terminal configuration was obtained by degradation with aminopeptidase. Sequence analysis was completed by partial hydrolysis with 0·1 *N* or 12 *N* hydrochloric acid or further digestion with chymotrypsin or pepsin. Of the 80 peptides only the 22 bridge peptides are given in Table 2. We have been able to isolate all bridges which were necessary to connect the twelve tryptic peptides in an unequivocal way and thus to deduce the structure of the entire chain of 157 amino-acids. The derivation of the formula can be understood by comparison of Tables 1 and 2 with Fig. 1.

The peptides I–III (Table 2) contain the C-terminal sequence of the *TU* peptide followed by Thr. Since only one tryptic peptide exists beginning with Thr, this must be adjacent to the *TU* peptide. The peptides IV–VII contain the C-terminal sequence of the Thr-peptide and the N-terminal sequence of the $\mathrm{GluNH_2}$-peptide. Therefore, the $\mathrm{GluNH_2}$-peptide occupies the positions 47–61. This $\mathrm{GluNH_2}$-peptide contains one Lys residue which is resistant to trypsin. The peptides VIII–X demonstrate the sequence adjacent to this first Lys residue. The junction with the next peptide beginning with Phe and ending with Lys is given by the peptides XI and XII. The locations of the tripeptide Val-Tyr-Arg and the following peptide beginning with Tyr are deduced from the peptides XIII–XV. The peptic peptide XVI shows the location of the dipeptide $\mathrm{AspNH_2}$-Arg and the following Ileu-peptide. This is joined to the next peptide by an Arg-Arg-bond (see peptides XVII and XVIII). The carboxylic group of the second Arg residue is attacked slowly by trypsin, thus the tryptic peptide position 112–121 contains Arg as the N-ter-

Table 1. AMINO-ACID COMPOSITION OF PEPTIDES OBTAINED BY DIGESTION OF TOBACCO MOSAIC VIRUS PROTEIN WITH TRYPSIN

Position	
1–41	Acetyl-Ser($\mathrm{Asp_4,Thr_4,Ser_4,Glu_6,Pro_3,Gly,Ala_4,Val,Ileu_3,Leu_4,Tyr,Phe_2,Cys,Try}$)Arg (ref. 31)
42–46	Thr($\mathrm{Val_2,Glu}$)Arg
47–61	$\mathrm{GluNH_2}$($\mathrm{Thr,Ser_2,Glu_2,Pro_2,Val_3,Phe,Try,Lys}$)Arg
62–68	Phe($\mathrm{Asp_2,Ser,Pro,Phe}$)Lys
69–71	Val-Tyr-Arg
72–90	Tyr($\mathrm{Asp_2,Thr_2,Pro,Gly,Ala_2,Val_4,Leu_4,Phe}$)Arg
91–92	$\mathrm{AspNH_2}$-Arg
93–111	Ileu($\mathrm{Asp_3,Thr_4,Glu_4,Pro,Ala_3,Val,Leu}$)Arg
112–121	Arg($\mathrm{Asp_2,Thr,Ala_2,Val_2,Ileu}$)Arg
122–133	Ser($\mathrm{Asp_3,Glu,Ala,Val,Ileu_2,Leu_2}$)Arg
134–140	Gly(Asp,Thr,Ser,Gly,Tyr)Arg
141–157	Ser($\mathrm{Thr,Ser_4,Glu,Pro,Gly_3,Ala,Val,Leu,Phe,Try}$)Thr


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26, 27 28
Acetyl-Ser-Tyr-Ser-Ileu-Thr-Pro-Thr-Ser-GluNH$_2$-Phe-Val-Phe-Leu-Ser-Ser-Ala-Try-Ala-Asp-Pro-Ileu-Glu-Leu-Ileu-Asp*(CySO$_3$H,Thr,Asp*)-
C C C C P C P P C
P P P P P
29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55
Leu-Ala-Leu-Gly-AspNH$_2$-GluNH$_2$-Phe-Glu*-Thr-Glu-GluNH$_2$-Ala-Arg-Thr-Val-Glu*-Val-Arg-GluNH$_2$-Phe-Ser-GluNH$_2$-Val-Try-Lys-Pro-Pro-
C P C P C C C C P T C P C T P C P P C
P P P P P
56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85
Ser-GluNH$_2$-Val-Thr-Val-Arg-Phe-Pro-Asp*-Ser-Asp-Phe-Lys-Val-Tyr-Arg-Tyr-Asp*-Ala-Val-Asp-Pro-Leu-Val-Thr-Ala-Leu-Leu-Leu-Gly-
C C T P C T C T C P P P C C C C
P P P P P P P
86 87 88 89 90 91 92 93 94 95 96 97 98, 99, 100 101, 102 103 104 105 106 107 108 109 110 111 112 113 114
Ala-Phe-Asp*-Thr-Arg-AspNH$_2$-Arg-Ileu-Glu*-Val-Glu*-Asp*-(Ala,Glu*,Thr,Asp*,Pro)-Thr-Ala-Glu*-Thr-Leu-Asp*-Ala-Thr-Arg-Arg-Val-Asp*-
P C T T P P P P P P T
P P
115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142
Asp*-Ala-Thr-Val-Ala-Ileu-Arg-Ser-Ala-Asp*-Ileu-AspNH$_2$-Leu-Ileu-Val-Glu-Leu-Ileu-Arg-Gly-Thr-Gly-Ser-Tyr-AspNH$_2$-Arg-Ser-Ser-
P P T P C C P C T P C T
P P P
143 144 145 146 147 148 149 150 151 152 153 154 155 156 157
Phe-Glu*-Ser-Ser-Ser-Gly-Leu-Val-Try-Thr-Ser-Gly-Pro-Ala-Thr
C C C
P P

Asp* = Asp or AspNH$_2$; Glu* = Glu or GluNH$_2$

Points of cleavage by trypsin, chymotrypsin, and pepsin are marked by T, C, and P

Fig. 1. Sequence of amino-acids in the protein of tobacco mosaic virus

minal group. This is followed by the tryptic peptide beginning with Ser-Ala, and the location of the last two peptides is given by the peptides XX–XXII. Additional evidence for the C-terminal position of the Ser-peptide (141–157) is that its terminal sequence Pro-Ala-Thr is identical with that found to be the C-terminal sequence of the tobacco mosaic virus protein. Only the relative positions of the residues 26–28 and 98–102, which are set in parentheses, need reinvestigation. The amidation of the Glu and Asp residues marked with an asterisk has not been determined. Apart from this couple of uncertainties a good picture of this large peptide is obtained.

Discussing the reliability of these results we have to keep in mind the following facts. The amino-acid composition of the tryptic peptides agrees completely with that found by Wittmann and Braunitzer and the sequence of the first five tryptic peptides has also been confirmed by Wittmann[30] in quite a different way. Some of the tryptic peptides are also described by the Berkeley group. Errors are further restricted because all the positions are covered by several degradation products obtained from the total protein or the isolated tryptic peptides. The complete list of all degradation peptides for the positions 1–41 has already been published[31] and that for the other positions will be published elsewhere. In Fig. 1 the points of cleavage by trypsin, chymotrypsin, and pepsin are indicated to give a general idea of the number of peptides which were laboriously separated and characterized.

Table 2. SEQUENCES OF PEPTIDES CONTAINING ARG AND LYS OBTAINED BY DIGESTION OF TOBACCO MOSAIC VIRUS PROTEIN WITH CHYMOTRYPSIN (*C*) AND PEPSIN (*P*)

No.	Enzyme	Position	Sequences
I	*P*	40–42	Ala-Arg-Thr
II	*P*	36–42	Glu*-Thr-Glu-GluNH$_2$-Ala-Arg-Thr
III	*P*	35–42	Phe-Glu*-Thr-Glu-GluNH$_2$-Ala-Arg-Thr
IV	*P*	43–50	Val-Glu*-Val-Arg-GluNH$_2$-Phe-Ser-GluNH$_2$
V	*P*	43–47	Val-Glu*-Val-Arg-GluNH$_2$
VI	*P*	45–47	Val-Arg-GluNH$_2$
VII	*C*	46–48	Arg-GluNH$_2$-Phe
VIII	*C*	53–59	Lys-Pro-Pro-Ser-GluNH$_2$-Val-Thr
IX	*C*	53–57	Lys-Pro-Pro-Ser-GluNH$_2$
X	*P*	51–59	Val-Try-Lys-Pro-Pro-Ser-GluNH$_2$-Val-Thr
XI	*P, C*	60–67	Val-Arg-Phe-Pro-Asp*-Ser-Asp-Phe
XII	*P*	60–66	Val-Arg-Phe-Pro-Asp*-Ser-Asp
XIII	*P*	68–75	Lys-Val-Tyr-Arg-Tyr-Asp*-Ala-Val
XIV	*C*	68–70	Lys-Val-Tyr
XV	*C*	71–72	Arg-Tyr
XVI	*P*	88–94	Asp*-Thr-Arg-AspNH$_2$-Arg-Ileu-Glu*
XVII	*P*	108–117	Asp*-Ala-Thr-Arg-Arg-Val-Asp*-Asp*-Ala-Thr
XVIII	*P*	108–119	Asp*-Ala-Thr-Arg-Arg-Val-Asp*-Asp*-Ala-Thr-Val-Ala
XIX	*P*	120–127	Ileu-Arg-Ser-Ala-Asp*-Ileu-AspNH$_2$-Leu-
XX	*P*	132–137	Ileu-Arg-Gly-Thr-Gly-Ser
XXI	*P*	132–143	Ileu-Arg-Gly-Thr-Gly-Ser-Tyr-AspNH$_2$-Arg-Ser-Ser-Phe
XXII	*P, C*	139–143	AspNH$_2$-Arg-Ser-Ser-Phe

Asp* = Asp or AspNH$_2$; Glu* = Glu or GluNH$_2$

The careful analysis of larger peptide chains furnishes several kinds of information. Proteins have specific functions and their biosynthesis is under genetic control. Therefore we cannot expect a random sequence of amino-acids. The accumulation of Ser in the first 15 and in the last 17 positions is striking. These terminal parts, comprising 20 per cent of the molecule, contain 11 of the 16 Ser residues. Of course, more data on other proteins must be collected before any conclusion can be drawn about regularities in the combinations of individual amino-acids.

Furthermore the results reveal information about the specificity of the proteinases. Trypsin was strictly specific for the basic amino-acids; only the Lys residue in position 53 was resistant, perhaps due to the adjacent Pro, and the Arg residue in position 112 was inhibited. A Lys residue resistant to trypsin was also found in ribonuclease[32]. Chymotrypsin liberated the carboxylic group of Phe, Tyr, Try, and Leu, and less frequently that of GluNH$_2$ (three times) and of Thr (twice). Pepsin reacts rather unspecifically. It frequently affects the carboxylic or the amino group of Phe, Tyr, Leu, and Val. Ileu and GluNH$_2$ were also attacked in a few cases.

Since the ribonucleic acid of tobacco mosaic virus induces the synthesis of the protein a relationship between the sequences of the nucleotides and amino-acids, respectively, must be assumed. The ribonucleic acid contains about 6,000 nucleotides, that is, 40 nucleotides per 1 amino-acid residue in the protein. But are so many nucleotides actually required to bring one amino-acid into the right position? The determination of the entire sequence of 6,000 nucleotides is beyond the limits of our present experimental techniques. However, it may be possible to find certain correlations utilizing the inadequate technique at present available. By treatment with nitrous acid the nucleotide pattern of the ribonucleic acid can be altered *in vitro* and genetically stable mutants are produced[38,39]. The amino-acid sequences of these mutants should be compared with that of the normal strain to find out whether all mutants have undergone an alteration in the protein. If the ribonucleic acid produces other proteins, the genetical change could occur in these and the virus protein remains unaffected. In this case the ratio of nucleotides per amino-acid would be less than 40.

Fig. 1 shows only the primary structure of the tobacco mosaic virus protein. In the virus particles this chain is folded into an ordered secondary structure leading to protein sub-units. These protein sub-units are arranged in a helix which we call the tertiary structure. By denaturation the tertiary and secondary structures are destroyed, but under certain conditions the disordered protein can be re-naturated and re-aggregated to the original tertiary structure[36]. By reconstitution[37] with ribonucleic acid the tertiary structure is stabilized and the length of the protein helix is adapted to the length of the nucleotide chain. The importance of the amino-acid sequence in determining the internal structure of the tobacco mosaic virus particle is therefore evident.

[1] Gierer, A., and Schramm, G., *Z. Naturforschung*, **11**,*b*, 138 (1956); *Nature*, **177**, 702 (1956).

[2] Fraenkel-Conrat, H., *J. Amer. Chem. Soc.*, **78**, 882 (1956). Fraenkel-Conrat, H., Singer, B., and Williams, R. C., *Biochim. Biophys. Acta*, **25**, 87 (1957).

[3] For literature, see Schuster, H., in Chargaff, "The Nucleic Acids", 3 (in the press).

[4] Colter, J. S., "Prog. in Med. Virol.", 1, 1 (1958).

[5] Stanley, W. M., *Physiol. Rev.*, **19**, 524 (1939).

[6] Schramm, G., and Muller, H., *Naturwiss.*, **28**, 223 (1940).

[7] Schramm, G., *Naturwiss.*, **31**, 94 (1943); *Z. Naturforschung*, **2**,*b*, 112 (1947).

[8] Schramm, G., Schumacher, G., and Zillig, W., *Z. Naturforschung*, **10**,*b*, 481 (1955).

[9] Anderer, F. A., *Z. Naturforschung*, **14**,*b*, 24 (1959).

[10] Ansevin, A. T., and Lauffer, M. A., *Nature*, **183**, 1601 (1959).

[11] Wittmann, H. G., *Experientia*, **15**, 174 (1959).

[12] Schramm, G., and Zillig, W., *Z. Naturforschung*, **10**,*b*, 493 (1955).

[13] Schramm, G., *Z. Naturforschung*, **3**,*b*, 320 (1948). Schramm, G., and Braunitzer, G., *ibid.*, **5**,*b*, 297 (1950).

[14] Knight, C. A., *J. Biol. Chem.*, **171**, 297 (1947).

[15] Spackman, D. H., Stein, W. H., and Moore, S., *Fed. Proc.*, **15**, 358 (1956); *Anal. Chem.*, **30**, 1190 (1958).

[16] Hirs, C. H. W., Stein, W. H., and Moore, S., Symposium on Protein Structure, Paris, 1957, ed. by Neuberger (Methuen and Co., London, 1958).

[17] Rudloff, V., and Braunitzer, G., *Z. physiologische Chem.* (in the press). Braunitzer, G., Liebold, B., Hilse, K., and Rudloff, V., *Angewandte Chem.*, **71**, 376 (1959).

[18] Harris, J. I., and Knight, C. A., *Nature*, **170**, 613 (1952); *J. Biol. Chem.*, **214**, 215 (1955).

[19] Braunitzer, G., *Z. Naturforschung*, **9**,*b*, 675 (1954).

[20] Braunitzer, G., *Naturwiss.*, **42**, 371 (1955).

[21] Niu, C. I., and Fraenkel-Conrat, H., *Biochim. Biophys. Acta*, **16**, 597 (1955).

[22] Niu, C. I., and Fraenkel-Conrat, H., *Arch. Biochem. Biophys.* **59**, 538 (1955).

[23] Fraenkel-Conrat, H., and Singer, B., *J. Amer. Chem. Soc.*, **76**, 180 (1954).

[24] Schramm, G., and Braunitzer, G., *Z. Naturforschung*, **8**,*b*, 61 (1953). Braunitzer, G., *Biochim. Biophys. Acta*, **19**, 574 (1956).

[25] Anderer, F. A., *Z. Naturforschung*, **14**,*b*, 363 (1959).

[26] Narita, K., *Biochim. Biophys. Acta*, **28**, 184 (1958); *Fed. Proc.*, **17**, 281 (1958).

[27] Ramachandran, L. K., and Gish, D. T., *J. Amer. Chem. Soc.*, **81**, 884 (1959). Gish, D. T., *Biochim. Biophys. Acta*, **35**, 557 (1959). Gish, D. T., Ramachandran, L. K., and Stanley, W. M., *Arch. Biochem. Biophys.*, **78**, 453 (1959). Ramachandran, L. K., and Witkop, B., *J. Amer. Chem. Soc.*, **81**, 4028 (1959).

[28] Wittmann, H. G., and Braunitzer, G., *Virology*, **9**, 726 (1959).

[29] Franklin, R. E., *Nature*, **177**, 928 (1956).

[30] Wittmann, H. G. (in the press).

[31] Anderer, F. A., Weber, E., and Uhlig, H., *Z. Naturforschung*, **15**,*b*, 79 (1960).

[32] Justisz, M., and Ritschard, M., *Biochim. Biophys. Acta*, **17**, 548 (1955).

[33] Uhlig, H., Diplomarbeit, Tubingen (1957).

[34] Fraenkel-Conrat, H., and Ramachandran, L. K., in "Advances in Protein Chemistry", **14**, 175 (1959).

[35] Hirs, C. H. W., Moore, S., and Stein, W. H., *J. Biol. Chem.*, **219**, 623 (1956).

[36] Anderer, F. A., *Z. Naturforschung*, **14**,*b*, 642 (1959).

[37] Fraenkel-Conrat, H., and Singer, B., *Biochim. Biophys. Acta*, **24**, 540 (1957).

[38] Schuster, H., and Schramm, G., *Z. Naturforschung*, **13**,*b*, 697 (1958).

[39] Gierer, A., and Mundry, K. W., *Nature*, **182**, 1457 (1958).

RADIOACTIVE FALLOUT DURING 1959

By W. ANDERSON, R. E. BENTLEY, L. K. BURTON, J. O. CROOKALL
and C. A. GREATOREX

Physics Department, Institute of Cancer Research:
Royal Cancer Hospital, London

THE suspension of nuclear weapons testing from November 1958 until February 1960 has provided a useful period during which measurements of the relative abundance of different radionuclides in fallout material may be used to obtain some indication of the average age of this material and its atmospheric history. Further interest attaches to this period, for, as shown recently[1], the concentration of strontium-90 in rain falling over Great Britain rose sharply during the first half of 1959 to values substantially higher than those found for previous years. We have made measurements of the radiostrontium content of rain-water, sampled throughout 1959, and have also studied the variations in the concentration of certain short-lived fission products present in surface air during the same period. The results of these investigations are presented here and are discussed briefly in relation to current theories on the transport of fission products in the atmosphere.

Rain-water samples were collected at a site near Leatherhead, Surrey, using a polythene funnel and collecting bottle (funnel area for early samples, 325 sq. cm., and latterly, 1,320 sq. cm.). Radiostrontium determinations were made following well-established methods[2]. Samples of atmospheric dust were collected from surface air (of the order of 10^7 l.) at our laboratory at Sutton, Surrey, using a large two-stage electrostatic precipitator developed originally for

Table 1. PRINCIPAL NUCLIDES 1 YR. AFTER FISSION SHOWING THEIR MAIN MODES OF DECAY*

Nuclide	Half-life of: Parent	Half-life of: Daughter	Maximum β-energy for principal mode of decay (MeV.)	Principal γ lines: Energy (MeV.)	Principal γ lines: Transitions per 100 disintegrations	Disintegrations/min./10^{10} fissions† after 1 yr. for ^{235}U (thermal)	^{238}U (fast)	^{239}Pu (thermal)
^{137}Cs ^{137m}Ba	30 yr.	 2·6 m.	0·5	 0·66	 83	25	25	20
^{90}Sr ^{90}Y	28 yr.	 64 h.	0·6 2·2			20	10	‡
^{147}Pm	2·6 yr.		0·2			90	‡	110
^{106}Ru ^{106}Rh	370 d.	 30 s.	0·04 3·5	 0·51 0·62	 21 10	20	140	250
^{144}Ce ^{144}Pr	285 d.	 17 m.	0·3 3·0	0·13	~ 5	350	320	350
^{95}Zr	65 d.		0·4	0·76 0·72	49 49	90	80	85
^{95}Nb		35 d.	0·2	0·77	100	180	160	170
^{91}Y	58 d.		1·5			60	‡	30
^{89}Sr	53 d.		1·5			30	20	10
^{103}Ru	40 d.		0·2	0·50 0·61	90 7	30	70	60

* Based on information cited in refs. 6, 7 and 8.

† Except in the case of (zirconium-95 + niobium-95), it may be assumed that equal amounts of parent and daughter nuclides are present at equilibrium. The figures shown opposite nuclide pairs give the values for the parent only.

‡ Information not available.

air-cleansing purposes[3] (air-flow, 3,800 l./min.; efficiency of precipitation for methylene blue particles, 0·5μ mass median diameter, 80 per cent). These samples were studied by γ-scintillation spectrometry using a 100-channel analyser[4].

Samples collected during May–September 1959, that is, more than six months after the last reported nuclear weapons test in 1958, showed three prominent photopeaks. These peaks were at about 0·14, 0·50 and 0·75 MeV., which correspond to the γ-energies of cerium-144, (ruthenium-103 + rhodium-106) and (zirconium-95 + niobium-95) respectively. These are the main γ-emitting nuclides to be expected in a 6–18-month old mixture of fission products (Table 1). We have therefore assumed that these were the nuclides measured. A number of checks on the decay of their activity at various times after collection provided further confirmation of the validity of this assumption. The activities presented in Table 4 were computed from the areas under the photopeaks, using an experimentally determined calibration and making due allowance for the known branching ratios of the nuclides (Table 1, column 6). An estimate of the separate contributions of ruthenium-103 and rhodium-106 to the 0·51-MeV. peak was derived from two sets of measurements, one made shortly after collection and the other after a period covering several life-times of ruthenium-103.

Table 2. QUARTERLY CONCENTRATION (10^{-12} CURIE/LITRE) OF STRONTIUM-90 IN RAIN, 1959

Quarter:	1st	2nd	3rd	4th
Activity:	13·3	15·8	4·6	1·0

The average concentrations of strontium-90 found by us in rain-water collected over quarterly periods during 1959 are shown in Table 2. The values for the first two quarters are similar in magnitude to those reported recently[1], being approximately three times the average values found in the same periods of the previous four years[4]. The marked reduction of activity in the third and fourth quarters is illustrated in detail by monthly values from May onwards. These are plotted on a logarithmic scale against time in Fig. 1 (upper curve, μμc./l.).

It is well established[5] that, for long-range fallout of nuclear debris injected originally into the stratosphere, the principal mechanism of deposition is wash-out in rain-water after entry into the troposphere. The amount deposited by dry turbulent deposition is on the average only about 3 per cent of the total. In consequence, measurements of the specific activity of strontium-90 in rain, for average rainfall conditions, provide a useful guide to the

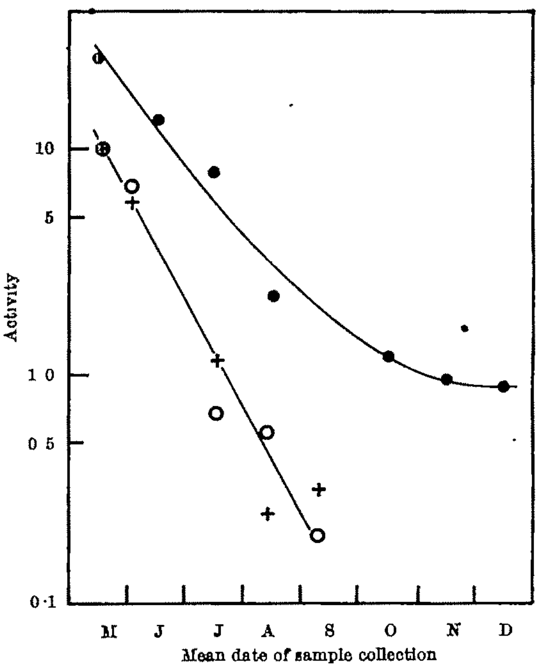


Fig. 1. Fission products in rain-water and air, 1959. ●, strontium-90 in rain; ○, rhodium-106 in air; + (zirconium-95 + niobium-95) in air

variations of activity in the lower atmosphere. It should be noted that the present monthly values for strontium-90 (Fig. 1) will include different fractional contributions from the dry deposition process, depending on the extent of departure from average conditions. Thus, from the known rainfall, and following the previous findings of Stewart *et al.*[5], it appears that for both May and June, which had comparatively low rainfalls, a dry deposition contribution of about 20 per cent should be allowed, compared with about 5 per cent for the other months, which had near average conditions. With due allowance for this factor, the results indicate that the concentration of strontium-90 in the lower atmosphere at the end of 1959 had fallen to one-twentieth of that present in May of the same year. Since the amount of radioactive decay of strontium-90 during this time would be negligible, the rapid fall in activity is clearly due to meteorological factors.

Table 3. STRONTIUM-89/STRONTIUM-90 RATIOS IN RAIN, 1959

Month:	May	June	July	August	Sept.	Oct.
^{89}Sr/^{90}Sr*	7·3	5·5	2·6	2·7	—	< 1·0

* ^{89}Sr ($T_{1/2}$ = 51 days) values calculated to mid-month.

The strontium-89/strontium-90 ratios of the rain-water (Table 3) provide a measure of the age of the strontium-90 being deposited during the summer of 1959. These ratios may be compared with the maximum values to be expected on the assumptions of (1) a strontium-89/strontium-90 ratio between 150 and 200 at the time of fission[6,7] and (2) an absence of weapons testing since November 1958. This comparison leads to the conclusion that on the average 70–85 per cent of the strontium-90 deposited during May–August 1959 was derived from fission processes which occurred during the autumn of 1958.

The results obtained for the concentrations of rhodium-106 and (zirconium-95 + niobium-95) in surface air are shown in Table 4. Compared with strontium-90, these radionuclides are short-lived, and during the period of the investigation a substantial radioactive decay of the atmospheric reservoir of these activities must have occurred. Using the known half-lives of these nuclides, the values in Table 4 may be re-scaled to eliminate the effect of the radioactive decay which occurred after the date of the first sample (May 17, 1959). The values adjusted in this way have been plotted on a logarithmic scale in arbitrary units against time (Fig. 1, lower curve). The two sets of results (rhodium-106 and zirconium-95 + niobium-95) have been normalized after equating the values for the first sample.

It is useful to compare the two curves plotted in Fig. 1, since both reflect changes in the radioactive particle content of the lower atmosphere. It should be noted, first of all, that our measurements relate to the atmosphere at a single site. However, since a prolonged period for atmospheric mixing elapsed between the last reported test in 1958 and the start of the present investigation, it is clear that the results represent conditions in the atmosphere over a comparatively wide area. This conclusion is underlined by the results of Stewart *et al.*[9] on the spread of nuclear dust clouds which were formed in the lower atmosphere from low-yield explosions. These workers showed that the lateral spread was virtually complete after a few weeks. Thereafter, apparently as the result of removal by deposition, the specific nuclear dust content of the air decreased exponentially, the 'half-life' for this process being approximately 22 days.

Table 4. CONCENTRATIONS (10^{-17} CURIE/LITRE) OF RHODIUM-106 AND (ZIRCONIUM-95 + NIOBIUM-95) IN AIR

Mean date of collection	Period of collection (days)	Rhodium-106*	(Zirconium-95 + niobium-95)
17. 5.59	4	17·0	180
2. 6.59	11	11·3	88
16. 7.59	16	1·02	11
12. 8.59	13	0·79	1·8
8. 9.59	11	0·25	1·7
31.12.59	21	0·26	0·25

* The ratio ruthenium-103/rhodium-106 for the sample at 17.5.59 was estimated to be 0·96.

Looking at Fig. 1, it will be seen that the values plotted for rhodium-106 and (zirconium-95 + niobium-95) lie fairly close to a straight line. This indicates that the concentration in air of fallout particles, which contained these nuclides, decreased exponentially during May–September 1959. The slope of the line shows that the 'half-life' of the removal process was approximately 20 days. The close similarity of this figure to that noted above for the removal of nuclear dust distributed in the lower atmosphere indicates that during June–September 1959 there were no substantial additions of relatively short-lived fission products to the lower atmosphere, either from a stratospheric reservoir, or from fresh weapons tests.

It will also be seen from Fig. 1 that the trend of the values of strontium-90 plotted for May–August 1959, is similar to that for the shorter-lived materials. The slope of the curve until August suggests a 'half-life' for removal of strontium-90 of between 30 and 40 days. Thereafter, the apparent rate of removal becomes greatly reduced and approaches zero at the end of the year. This is a clear indication that at the end of 1959 strontium-90 levels were being maintained by material from a stratospheric reservoir.

Taken together, the various lines of evidence presented above lead to the picture that about 75 per cent of the fallout of strontium-90 during the summer of 1959 was derived from a tropospheric reservoir built up during the early months of the year from material injected into the upper atmosphere in the autumn of 1958. Towards the end of 1959 it appears that the strontium-90 levels were then maintained largely by material descending from the stratosphere.

The average age of the strontium-90 in the stratospheric reservoir is a question of some interest. A comparison of the current trend of levels of relatively short-lived fission products with that of strontium-90 throws light on this question. It should be noted that the estimation of rhodium-106 in air was complicated at the end of 1959 by the fact that beryllium-7 produced by cosmic rays (γ line, 0·48 MeV.) was present in the air at about the same concentration as the fission-product nuclide (results in preparation). The values presented for rhodium-106 and (zirconium-95 + niobium-95) at December 1959 (Table 4) have been estimated by γ-spectrometry with due allowance for the effect of beryllium-7 on the rhodium-106 photopeak. After correction for radioactive decay, these December values suggest that the lower curve of Fig. 1 should be continued approximately parallel to the upper curve. This indicates that a large proportion of the fallout at the end of 1959 originated in fission processes which occurred during 1958.

During the years 1955–58 the trend of strontium-90 concentration in rain falling over Great Britain has shown fairly regular seasonal fluctuations, with maxima in the spring and minima in the autumn, the ratio of maximum to minimum being on the average 4 (ref. 1). These fluctuations have been interpreted by Stewart[5] as representing a seasonal variation in the rate of descent of stratospheric air, carrying long-lived fission products, into the troposphere. Martell[10] has advanced an alternative explanation suggesting that each maximum has been due to a rapid descent of activity in the spring from tests conducted at high latitudes in the autumn of the preceding year, the minimum values representing levels due to a more or less steady leak from a relatively persistent stratospheric reservoir. The results obtained by us for 1959 are clearly consistent with Martell's suggestion. It should be noted, however, that the strontium-90 maximum occurring in 1959 was notably higher than in previous years, and that the ratios strontium-89/strontium-90 do not exclude the possible occurrence of older stratospheric material at levels corresponding in magnitude to previous maxima. Consequently, it is not clear whether the increase in the maximum value for 1959, compared with previous maxima, reflects simply a quantitative difference, or whether two different upward fluctuations have been superimposed. In the latter case, it might be expected that the levels of activity would show a rise early in 1960. In this connexion it is interesting to record that the value found by us for the concentration of strontium-90 in rain collected during January 1960 was 1·7 μμc./l., which is approximately twice the value for December 1959. A preliminary analysis of our early 1960 dust samples also indicates an upward trend of rhodium-106 concentration in the air.

It may be useful to note that the nuclear test conducted on February 13, 1960, was carried out at a period when the activity already being deposited was apparently increasing. It is clear, therefore, that any upward trend in total atmospheric activity appearing after mid-February 1960 would not necessarily indicate a rise due to recent weapons testing. The effect of the French test (February 13) at the present site was to produce a pronounced, but transitory, rise of activity, comprising mainly short-lived fission products[11].

We wish to thank our colleague, Mr. R. P. Parker, for valuable information on the relative abundance of rhodium-106 and beryllium-7 in recent dust samples.

We are indebted to Prof. W. V. Mayneord, director of the Physics Department, Institute of Cancer Research: Royal Cancer Hospital, for his guidance and encouragement throughout this work.

[1] Crooks, R. N., Osmond, R. G. D., Owers, M. J., and Fisher, E. M. R., Atomic Energy Research Establishment, Harwell, *R.*3094 (1959).

[2] Mayneord, W. V., Anderson, W., Bentley, R. E., Burton, L. K., Crookall, J. O., and Trott, N. G., *Nature*, **182**, 1478 (1958).

[3] Layne, D. A., *J. Roy. Sanitary Inst.*, **75**, 171 (1955).

[4] Stewart, N. G., Osmond, R. G. D., Crooks, R. N., Fisher, E. M. R., and Owers, M. J., Atomic Energy Research Establishment, Harwell, *HP/R* 2790 (1959).

[5] Stewart, N. G., Osmond, R. G. D., Crooks, R. N., and Fisher, E. M. R., Atomic Energy Research Establishment, Harwell, *HP/R* 2354 (1957).

[6] Katcoff, S., *Nucleonics*, **16** (4), 78 (1958).

[7] Low, K., and Björnstedt, R., *Arkiv for Fysik*, **13**, 85 (1957).

[8] Strominger, D., Hollander, J. M., and Seaborg, G. T., *Rev. Mod. Phys.*, **30**, 585 (1958).

[9] Stewart, N. G., Crooks, R. N., and Fisher, E. M. R., Atomic Energy Research Establishment, Harwell, *HP/R* 2017 (1957).

[10] Martell, E. A., *Science*, **129**, 1197 (1959).

[11] Anderson, W., Bentley, R. E., Burton, L. K., and Greatorex, C. A., *Nature*, **186**, 223 (1960).

DENSITY OF THE UPPER ATMOSPHERE AND ITS DEPENDENCE ON THE SUN, AS REVEALED BY SATELLITE ORBITS

By D. G. KING-HELE and MRS. D. M. C. WALKER

Royal Aircraft Establishment, Farnborough

IN previous articles in *Nature*[1-3] on upper-air density, a method of finding density from changes in the orbits of artificial satellites was presented, values of average density were obtained from fifteen satellites launched before September 1959, and the variation of density with latitude and season was discussed. The present article extends these results, giving revised values for air density at heights between 180 and 700 km. deduced from twenty-one satellites at dates up to March 1960, and describes two significant new features of the upper atmosphere which have now become apparent.

Method of Analysis

A satellite moving in an elliptic orbit encounters most air drag when it is closest to the Earth, and so the air density in this region, at heights near that of perigee, can be determined from the rate of contraction of the orbit, if the mass, size and shape of the satellite are known.

The method of analysis adopted here is the same as before[3]. The air density ρ is assumed to vary exponentially with height y, so that

$$\rho = \text{const.} \times \exp(-y/H) \qquad (1)$$

where H is a constant, the value of which is not known exactly[3]. It can then be shown[1] that, if H^* is the best estimate of H, the air density ρ^*, say, at a height $\tfrac{1}{2}H^*$ above perigee height is given in terms of the rate of change of orbital period, $\mathrm{d}T/\mathrm{d}t$, by the equation:

$$\rho^* = -\frac{0{\cdot}158}{\delta}\frac{\mathrm{d}T}{\mathrm{d}t}\sqrt{\frac{e}{aH^*}}\left\{1 - 2e - \frac{H^*}{8ae} + 0\left(e^2, \frac{H^2}{a^2e^2}\right)\right\} \qquad (2)$$

where a is the semi-major axis of the orbit, e its eccentricity, and δ a drag parameter, discussed in the next paragraph. If $0{\cdot}02 < e < 0{\cdot}15$, as for most satellites, and if, as is almost certain, H^* does not differ from the true value of H by a factor of more than 1·5, the maximum error in equation (2) is less than 5 per cent. If e is increased to 0·2, the maximum error rises to 10 per cent. If $e < 0{\cdot}02$,

Table 1. VALUES OF $\delta = FSC/m$ FOR SATELLITES 1957α–1959λ

Satellite		Mass m (kgm.)	m/SC_D (kgm./sq. m.)	δ (sq. m./kgm).
Sputnik 1	1957α2	83·6	110	0·0088
Sputnik 1 rocket	1957α1	—	68	0·015
Sputnik 2	1957β	—	62	0·015
Explorer 1	1958α	14·0	23	0·039
Vanguard 1	1958β2	1·47	23	0·040
Vanguard 1 rocket	1958β1	22·7	18	0·050
Explorer 3	1958γ	14·1	23	0·039
Sputnik 3	1958δ2	1,327	210	0·0046
Sputnik 3 rocket	1958δ1	—	63	0·015
Explorer 4	1958ε	17·5	29	0·032
Atlas	1958ζ	3,960	28	0·032
Vanguard 2	1959α1	9·75	20	0·044
Vanguard 2 rocket	1959α2	22·7	18	0·050
Discoverer 2	1959γ	635	48	0·021
Discoverer 5	1959ε1	635	48	0·021
Discoverer 5 capsule	1959ε2	136	120	0·0081
Discoverer 6	1959ζ	635	48	0·021
Vanguard 3	1959η	45·4	26	0·035
Explorer 7	1959ι1	41·5	45	0·021
Explorer 7 rocket	1959ι2	5·9	19	0·048
Discoverer 7	1959κ	635	48	0·021
Discoverer 8	1959λ	635	48	0·021

equation (2) is replaced by a more generalized formula[2] in terms of Bessel functions.

The parameter δ in equation (2) denotes the quantity FSC_D/m, where F is a factor which allows for rotation of the atmosphere and lies between 0·9 and 1, S is the effective cross-sectional area of the satellite perpendicular to the direction of motion, C_D is a drag coefficient the value of which normally lies between 2 and 2·3, and m is the mass of the satellite. The value of S is, as before[2], calculated on the assumption that each satellite has rotated about an axis of maximum moment of inertia, which may, however, have any direction in space, so that S is taken as the mean of the values in the two extreme forms of motion—travelling like an aeroplane propeller, and tumbling end-over-end. The value of C_D is, in accordance with the results of Cook[4] for free-molecule flow with diffuse reflexion, taken as 2·2 for the spherical and nearly cylindrical satellites, and 2·15 for the conical *Sputnik* 3. Values of δ for *Sputnik* 2 and the rockets of *Sputniks* 1 and 3, for which m and S are unknown, are found by comparison with *Sputniks* 1 and 2, as explained previously[1].

Table 1 lists the values of δ thus obtained for all the satellites launched before March 1960 and having known orbits, apart from *Explorer* 6 (1959δ) and *Lunik* 3 (1959θ), to which the theory is not applicable, since e is much greater than 0·2. The values for the *Discoverers* refer to the period after the ejection of their capsules. The error (standard deviation) in the tabulated values of δ is estimated to be rather less than 10 per cent.

Day-to-Night Variations in Density

At heights of 200–300 km. the density probably does not depart from its average value by more than 10 per cent as a result of day-to-night variation[2,3], but at heights above 400 km. this day-to-night variation becomes increasingly important. For *Vanguard* 1, which has a perigee height of about 650 km., the perigee point first entered the Earth's shadow about July 1959, and at about the same time the slope of the period-versus-time curve was greatly reduced. This effect was noted by Jacchia[5] and further examined by Martin and Priester[9,10]. Since then, five other satellites with perigee heights between 550 and 650 km. have exhibited a similar effect, as Fig. 1 strikingly demonstrates. Fig. 1 shows the change in the orbital period during the life-times of the satellites *Vanguard* 1, *Vanguard* 2 and *Explorer* 7, and their rockets (1958β2 and 1, 1959α1 and 2, and 1959ι1 and 2: perigee heights 650, 560 and 560 km., respectively). Each curve is drawn as a full line when perigee is in sunlight, and as a broken line when perigee is in the Earth's shadow. For all six satellites the slope of the period-versus-time curves shows a gradual change from a maximum value in day-time to a minimum value at night; with the three satellites for which well-defined maximum and minimum slopes are available, the values differ by a factor of about 8. This shows that the drag acting on the satellites, and hence probably the air density, is much greater by day than by night at these altitudes. For *Explorer* 1 (perigee height 350 km.) a similar but much smaller variation has been noted[8].

Results

Fig. 2 shows the values of air density obtained by applying the method of analysis already described to twenty-one of the satellites listed in Table 1. The required orbital elements are based on the Table of Artificial Satellites issued by the Royal Aircraft Establishment, Farnborough. In this table values for the *Sputniks* are from British observations and theory[7]; those for the American satellites are compiled from data issued by the U.S. prediction centres, and from theory. Values of H^* for use in equation (2) are taken from a smoothed version of the values of H previously recommended[2]. At heights below 300 km. no attempt is made to separate day-time and night-time values of density; but for satellites with perigee higher than 300 km., two values of dT/dt are distinguished, the maximum day-time value and the minimum night-time value. These have for convenience been labelled 'midday' and 'midnight' values in Fig. 2; but they represent rather the average density during the time, usually lasting several weeks, when the satellite's perigee is in the 'early afternoon' position where density appears to be highest[8] (or in the 'after midnight' position where density is least). The resulting values of density are less accurate than those at lower altitudes, with a standard deviation of perhaps ± 20 per cent above 400 km., and the curves are therefore drawn as broken lines in Fig. 2.

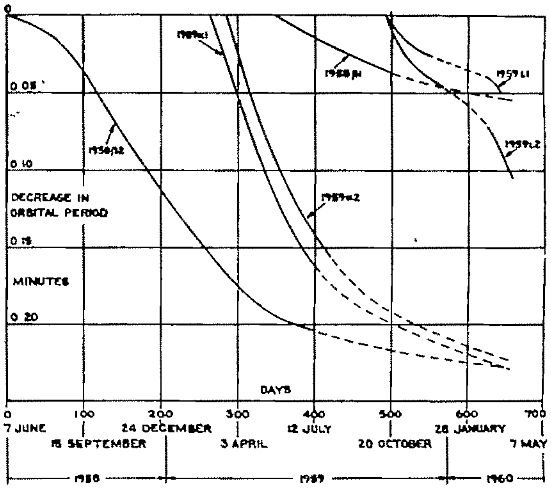


Fig. 1. Decrease in orbital period for *Vanguards* 1 and 2, *Explorer* 7 and their rockets
——— perigee in sunlight; - - - perigee in Earth's shadow

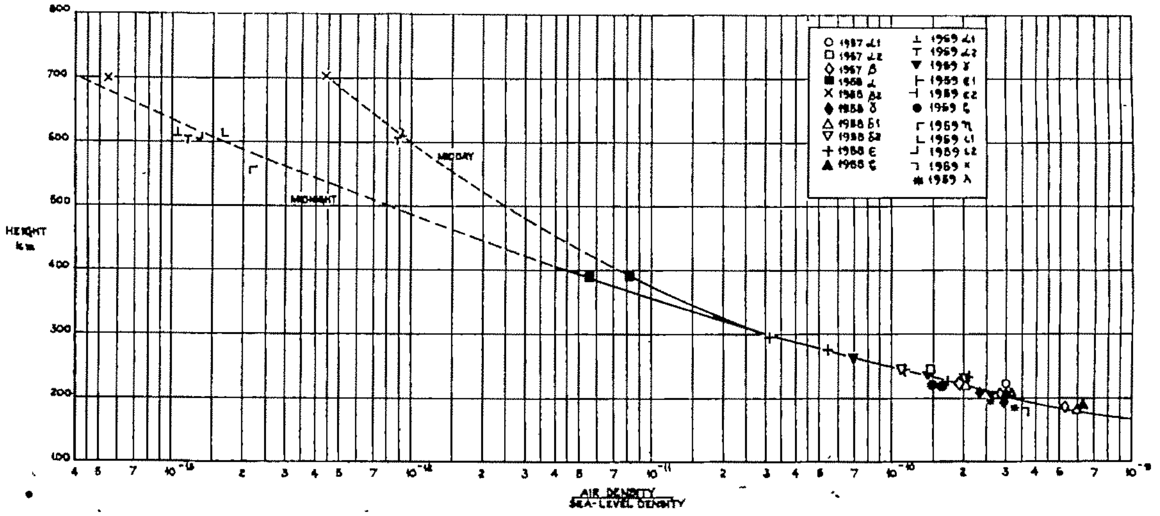


Fig. 2. Density of the upper atmosphere obtained from the orbits of 21 satellites

In discussing the features of interest in Fig. 2, it is best to begin at the lower altitudes. At heights between 180 and 300 km. there are 27 points, referring to satellites of different sizes and shapes, at different seasons, latitudes, etc.: 22 of the points differ from the curve by a factor of less than 1·35 and none by a factor of more than 1·6. This confirms previous evidence[1–3] that the density did not depart from the long-term average for 1957–59 by a factor of more than 1·5 as a result of variations with latitude or season, or from day to night, though there might be variations of larger amplitude during time intervals too short for the orbits to register, that is, less than one day.

A second significant feature of Fig. 2, not apparent at first sight, is a slow variation of density with time at heights of 180–250 km. The 24 points in this region can be divided into two groups, for October 1957–January 1959 (14 points) and for August 1959–March 1960 (10 points), respectively, and the mean curves through each of these groups give densities which are respectively about 10 per cent higher and 10 per cent lower than the curve of Fig. 2. Thus, there has apparently been a small decrease in average density between, say, mid-1958 and the end of 1959, and this explains why the points in Fig. 2 are not so near the average curve as in the corresponding graph of ref. 2. Further evidence of such a decrease in density comes from *Sputnik* 3, which was in orbit from May 1958 until April 1960: the usual methods of predicting life-time have, for this satellite, consistently under-estimated the true life-time. This unexpectedly long life would result from either a general decrease in density or a reduction in the effective cross-sectional area S of the satellite; but the latter possibility can be ruled out because, for *Sputnik* 3, S is little affected by changes in the mode of rotation[4]. The decrease in density appears to confirm the suggestion in a previous article[2] that the average air density is likely to vary in the course of the 11-year sunspot cycle. For it is well known[5–12] that solar disturbances largely control the day-to-day variations in air density at heights of 200–300 km., with the density tending to be high when sunspots are most numerous[13]. It is therefore to be expected that, as indicated by Fig. 2, the average air density will be highest at the sunspot maximum, in 1957–58, and will decrease slowly for a few years thereafter.

For heights between 300 and 700 km. the results in Fig. 2 from the various satellites agree well, and the midday and midnight values are clearly distinguished. The good agreement may be partly fortuitous, since for some of these satellites dT/dt is not well defined, being based on very small changes in period. The density given by the 'midday' curve in Fig. 2 exceeds that on the 'midnight' curve by factors of 1·6, 3, 6 and 11 at heights of 400, 500, 600 and 700 km., respectively. It should be remembered that the density changes gradually between its daytime maximum and night-time minimum, as Fig. 1 shows: the density seems to depend primarily on the zenith distance of the Sun, density being highest when the Sun is nearly overhead[6]. Thus, at heights above 500 km., the density should appear to vary with latitude and season; for example, density would be high by day in the equatorial regions and low near the poles in winter. But it would be misleading to call such effects 'variation with latitude', since such a nomenclature would tacitly attribute to terrestrial geometry an effect whose true source is solar.

At heights of 400–700 km. the major uncertainty in the values of density is, as has been emphasized before[1,2], the role of electrical drag. As a satellite moves through the ionosphere it tends to collect electrical charge, most probably negative charge. The potential to which the satellite becomes raised is not usually known, however, and, even if it were, the magnetohydrodynamic theory of the drag of a charged body in these conditions has not been properly formulated. The potential was estimated by Jastrow and Pearse[14] to be about -10 volts in darkness, while measurements on *Sputnik* 3 indicated potentials between -2 and -6 volts in sunlight[15]. If the potential is of order -10 volts, the theory of Kraus[16] suggests that at heights of 600–700 km. the electrical drag would be less than 10 per cent of the total drag, and would thus scarcely be significant in considering a change of drag by a factor of 8. At present, therefore, it appears most probable that the changes in density indicated in Fig. 2 are real; but, if the potential were much higher than assumed above, the electrical drag might have an important effect.

Another possible source of error is the effect of the radiation pressure P of sunlight. An approximate

Table 2. VALUES OF AIR DENSITY AND H GIVEN BY THE CURVES OF FIG. 2

Height (km.)	Air density / Sea-level density		Density (gm./c.c.)		H (km.)	
180	$5\cdot7\times10^{-10}$		$7\cdot0\times10^{-13}$		30	
190	$4\cdot2\times10^{-10}$		$5\cdot1\times10^{-13}$		36	
200	$3\cdot2\times10^{-10}$		$3\cdot9\times10^{-13}$		43	
210	$2\cdot6\times10^{-10}$		$3\cdot2\times10^{-13}$		47	
220	$2\cdot1\times10^{-10}$		$2\cdot5\times10^{-13}$		44	
230	$1\cdot6\times10^{-10}$		$2\cdot0\times10^{-13}$		42	
240	$1\cdot3\times10^{-10}$		$1\cdot5\times10^{-13}$		41	
250	$9\cdot8\times10^{-11}$		$1\cdot2\times10^{-13}$		40	
260	$7\cdot7\times10^{-11}$		$9\cdot4\times10^{-14}$		41	
270	$5\cdot9\times10^{-11}$		$7\cdot2\times10^{-14}$		42	
280	$4\cdot7\times10^{-11}$		$5\cdot7\times10^{-14}$		44	
290	$3\cdot8\times10^{-11}$		$4\cdot6\times10^{-14}$		47	
300	$3\cdot0\times10^{-11}$		$3\cdot7\times10^{-14}$		50	
	day	night	day	night	day	night
300	$3\cdot0\times10^{-11}$	$3\cdot0\times10^{-11}$	$3\cdot7\times10^{-14}$	$3\cdot7\times10^{-14}$	50	50
350	$1\cdot4\times10^{-11}$	$1\cdot1\times10^{-11}$	$1\cdot7\times10^{-14}$	$1\cdot4\times10^{-14}$	74	53
400	$7\cdot4\times10^{-12}$	$4\cdot5\times10^{-12}$	$9\cdot1\times10^{-15}$	$5\cdot5\times10^{-15}$	83	56
450	$4\cdot2\times10^{-12}$	$1\cdot9\times10^{-12}$	$5\cdot1\times10^{-15}$	$2\cdot3\times10^{-15}$	90	59
500	$2\cdot5\times10^{-12}$	$8\cdot2\times10^{-13}$	$3\cdot1\times10^{-15}$	$1\cdot0\times10^{-15}$	99	62
550	$1\cdot5\times10^{-12}$	$3\cdot6\times10^{-13}$	$1\cdot9\times10^{-15}$	$4\cdot4\times10^{-16}$	109	65
600	$1\cdot0\times10^{-12}$	$1\cdot6\times10^{-13}$	$1\cdot2\times10^{-15}$	$2\cdot0\times10^{-16}$	118	69
650	$6\cdot6\times10^{-13}$	$8\cdot2\times10^{-14}$	$8\cdot1\times10^{-16}$	$1\cdot0\times10^{-16}$	126	73
700	$4\cdot5\times10^{-13}$	$4\cdot2\times10^{-14}$	$5\cdot5\times10^{-16}$	$5\cdot1\times10^{-17}$	133	77

Sea-level density taken as 0·001226 gm./c.c.

analysis suggests that the change per revolution in the orbital period T of a satellite of reflectivity ε is of the order:

$$\frac{3SPT}{mg}(1+\varepsilon)\left(\frac{a}{r_2}-\frac{a}{r_1}\right)$$

where r_1 and r_2 are the distances of the satellite from the Earth's centre when it (1) enters and (2) emerges from the Earth's shadow, and g is the average gravitational acceleration while the satellite is in eclipse. In the long run, this effect will tend to cancel out, since the mean value of the second bracket is zero, though for a satellite with perigee remaining in sunlight for a long time—such as *Vanguard* 1—the effect builds up; even for this satellite, however, the change in the orbital period in six months would be only about 0·001 min., which, as Fig. 1 shows, is less than 10 per cent of the total change, even when the perigee is in darkness. The effect is likely to be important only for an inflated-balloon satellite with a perigee which is arranged to remain in darkness for several years.

To sum up, it appears likely that at heights between 200 and 300 km. the curve of Fig. 2 gives the average density for 1957–60 with a standard deviation of about 10 per cent, though the density has decreased by perhaps 20 per cent between 1958 and 1960. At heights above 400 km. the curves become less accurate, and it should be noted that, by chance, the midday values all refer to early 1959 and the midnight values to late 1959 or early 1960, so that any general decrease in density during this time, to match the decrease at lower altitudes, will have widened the apparent difference between day and night.

The curves of Fig. 2 agree well with the direct measurements of air density made by the manometers in *Sputnik* 3, as reported by Michnevich *et al.*[17]. At heights between 225 and 300 km. the difference is less than 20 per cent; at heights of 300–500 km. the direct measurements fall between the two curves of Fig. 2, within the region which would be expected from the local time of the measurements. Also the density at a height of 430 km., obtained from the expansion of a sodium cloud from a Russian Geophysical Rocket in September 1958 (ref. 18), is within 5 per cent of the midday curve in Fig. 2.

Values from the curves of Fig. 2 are listed in Table 2.

Scale Height and Air Temperature

The values of the coefficient H of equation (1), which is nearly equal to the atmospheric scale height[1], can be found from the slope of the density-versus-height curves of Fig. 2, and values are listed in the last column of Table 2. There is a slight indentation in the curve of Fig. 2 at a height near 210 km., though this is less pronounced than in the corresponding curve in ref. 2, because the scatter of the points is greater. The values of H in Table 2 are subject to maximum errors of about ± 20 per cent between 180 and 300 km. height and to larger errors at greater heights.

The value of air temperature can be deduced[1] from H and the mean molecular weight of the air, M, which is, however, not known exactly. Taking $M = 22$ at 200 km., decreasing to $M = 16$ at 500 km., and constant thereafter, and using the values of H from Table 2, the temperature obtained at a height of 200 km. is about 1,200° K.; at a height of 600 km. the value would be about 1,200° K. in darkness, or about 2,200° K. in sunlight.

Conclusions

The wide variation of density between midnight and midday at heights above 500 km., which had previously been noted for one satellite[5], has now shown itself for five other satellites (see Fig. 1), and the day-time and night-time values revealed by each conform to a consistent pattern (see Fig. 2).

At heights between 180 and 250 km., the average air density seems to have decreased appreciably, by perhaps 20 per cent, between 1958 and 1960. Since it is known that day-to-day variations in air density depend on solar activity, this change is interpreted as the beginning of an 11-year cycle, maximum density occurring at the sunspot maximum in 1957–58. At heights above 250 km. this effect ought to be more prominent.

We are grateful to the United States prediction centres, Project Space Track and the Smithsonian Astrophysical Observatory for supplying many of the values of orbital period used in this article.

[1] King-Hele, D. G., *Nature*, **183**, 1224 (1959).
[2] King-Hele, D. G., *Nature*, **184**, 1267 (1959).
[3] King-Hele, D. G., and Walker, D. M. C., *Nature*, **185**, 727 (1960).
[4] Cook, G. E., Ministry of Supply Report (1959).
[5] Jacchia, L. G., Smithsonian Astrophys. Obs. Spec. Rpt. No. 29 (1959).
[6] Martin, H. A., and Priester, W., *Nature*, **185**, 600 (1960).
[7] King-Hele, D. G., Cook, G. E., and Walker, D. M. C., Ministry of Aviation Report, 1959.
[8] Nonweiler, T. R., *Nature*, **182**, 468 (1958).
[9] Jacchia, L. G., *Nature*, **183**, 526 (1959).
[10] King-Hele, D. G., and Walker, D. M. C., *Nature*, **183**, 527 (1959).
[11] Priester, W., *Naturwiss.*, **46**, 197 (1959).
[12] Jacchia, L. G., *Nature*, **183**, 1662 (1959).
[13] Paetzold, H. K., *Planet. Space Sci.*, **1**, 115 (1959).
[14] Jastrow, R., and Pearse, C. A., *J. Geophys. Res.*, **62**, 413 (1957).
[15] Krassovsky, V. I., Proc. Ninth Int. Astronautical Congress, Amsterdam, 1958, p. 614 (Springer Verlag, Vienna, 1959).
[16] Kraus, L., paper presented at AGARD Avionics Panel, Copenhagen, October 1958.
[17] Michnevich, V. V., Danilin, B. S., Repnev, A. I., and Sokolov, V. A., *Iskuss. Sputniki Zemli*, No. 3, 84 (1959).
[18] Kurt, V. G., *Priroda*, No. 5, 74 (May 1959).
[19] Priester, W., and Martin, H. A., Bonn University Observatory, Report No. 29 (1960).

OBITUARIES

Prof. J. H. C. Whitehead, F.R.S.

Prof. J. H. C. Whitehead, who died suddenly in Princeton on May 8, was one of our greatest mathematicians. His contributions to topology were both massive and fundamental. He also had an international reputation as a geometer and as an algebraist. In research he went from strength to strength, uniting profound study with ever-growing creativity.

Henry Whitehead, as he was known, was Waynflete professor of pure mathematics in Oxford. He lived in the Otmoor village of Noke where his wife Barbara runs a farm, in which he took the liveliest interest. Their exuberant hospitality brought many and varied friends to Manor Farm, as it had done previously to their house in north Oxford. They shared great zest for life and enjoyed a marriage of surpassing happiness. They have two sons, David and Oliver.

Whitehead was born in India in 1905. His father, Bishop of Madras and brother of the philosopher A. N. Whitehead, sent him to Eton, a school for which he always had the highest regard. He went on to read mathematics at Balliol under H. W. Nicholson. After graduating, he first tried financial work in London but soon decided on a university career.

In 1928 he went to Princeton for three years as a Commonwealth Fellow to study under Oswald Veblen, whose high standards deeply influenced his mathematical thought and style. Together they wrote the important Cambridge Tract, "The Foundations of Differential Geometry", which is now regarded as a classic, and Whitehead also wrote a number of papers on differential geometry, including his Princeton Ph.D. thesis. Although he never lost his interest in geometry, it quickly became dominated by the study of topology, to which he was initiated by Veblen, Alexander and others. This young subject had run into formidable problems which have only recently begun to give way. The attempt to solve these strongly developed Whitehead's conceptual powers and led him towards some of his finest work.

On his return to Oxford as Tutorial Fellow at Balliol, he plunged into college life with huge enjoyment. He was an inspiring and open-hearted teacher, to whom mathematics mattered and the clock did not. He was an entertaining and resourceful talker with a highly independent view of people and affairs. He loved the more sociable kinds of sport, perhaps cricket most of all. In the Alps he did some fine climbs with Alexander, such as the Zmutt ridge of the Matterhorn and the Grand Charmoz, and he was also a good skier.

Following his marriage in 1934 Whitehead began to publish those pioneer studies which have made him famous. These were mostly on topological subjects, but there are also papers dealing with Lie algebras and free groups. By the beginning of the Second World War he was already concentrating on homotopy theory more than classical topology, and this remained his main interest until two years ago. The fifty papers he wrote on this subject have had great influence on its development and contain some of its most important theorems and ideas.

During the War, Whitehead worked for the Admiralty and the Foreign Office, but his research still continued. He was elected to the Royal Society and then, at the end of the War, he was chosen to succeed Dixon as Waynflete professor at Oxford. This made him a Fellow of Magdalen, where he continued to enjoy many aspects of college life. He never lacked students to inspire with his great knowledge and love of mathematics. Always generous with time and ideas, he managed to be encouraging while at the same time maintaining the highest standards. Students came to him from all over the world. To him is largely due the quality of the work which many of them have since done.

At Oxford Whitehead did much to foster the new Mathematical Institute, with its friendly atmosphere and spirit of hard work. He helped to found the very successful series of British Mathematical Colloquia. Through this and through the London Mathematical Society the invigorating effect of his personality was felt far outside Oxford. He valued international contacts and kept in close touch throughout with topologists in the United States, France, Poland, the U.S.S.R. and elsewhere.

Last year he felt ready to return, with vastly increased powers, to those problems which had challenged him as a student. Accordingly, he went on sabbatical leave to the United States, and it was there in Princeton that he died. I. M. James

Dr. C. S. Gum

On April 28, Dr. Colin Stanley Gum, one of Australia's outstanding younger generation astronomers, was killed in a skiing accident at Zermatt, Switzerland. He had just been appointed to the post of senior lecturer in astrophysics in the University of Sydney, and his visit to Europe was in connexion with plans for the installation of a reflecting telescope by the University.

Colin Gum was born in 1924. He graduated with honours in physics at the University of Adelaide in 1949 and proceeded to Mount Stromlo Observatory, where, in 1955, he obtained his Ph.D. degree in astronomy, the first given by the Australian National University. After a short period on the staff of the University of Adelaide, he joined the Commonwealth Scientific and Industrial Research Organization Radiophysics Laboratory in 1956, and in 1959 he was awarded a Carnegie fellowship to the Mount Wilson and Palomar Observatories, where he was working immediately prior to the fatal trip to Europe.

His work alternated between radio and optical astronomy but was consistently concerned with interstellar matter. His main contribution in the optical field was a major survey of hydrogen emission regions in the southern sky. In the Radiophysics Laboratory he studied the distribution in the Galaxy of interstellar hydrogen, using 21-cm. radio observations. Through this work he became a key member of the International Astronomical Union Commission which set up a new system of galactic co-ordinates in 1958, primarily on the basis of such information. At Mount Wilson and Palomar he had begun to work on interstellar polarization in external galaxies.

His death is deeply regretted by his colleagues in Australia, both radio and optical, and is a very serious loss to Australian science.

J. L. Pawsey

NEWS and VIEWS

Queen's Birthday Honours List

The following names of scientists and others associated with scientific work appear in the Queen's Birthday honours list:

K.C.B.: Frank C. Francis, director and principal librarian, British Museum.

K.B.E.: Dr. Robert Cockburn, chief scientist, Ministry of Aviation.

Knights: Dr. Robert S. Aitken, vice-chancellor of the University of Birmingham; Dr. Basil F. J. Schonland, director, Research Group, U.K. Atomic Energy Authority; Dr. Gordon B. B. M. Sutherland, director of the National Physical Laboratory; Dr. Henry G. Thornton, foreign secretary of the Royal Society; Prof. Robert D. Watt, emeritus professor of agriculture in the University of Sydney.

C.B.: Dr. F. M. Lea, director of the Building Research Station, Department of Scientific and Industrial Research; Dr. J. S. McPetrie, director-general of Electronics Research and Development, Ministry of Aviation.

C.M.G.: N. F. Mitchell, president of the Royal Agricultural Society of Victoria; J. H. Parry, principal of University College, Ibadan, Western Region, Nigeria.

C.B.E.: Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, Ltd.; Prof. N. S. Bayliss, professor of chemistry in the University of Western Australia; L. Farrer-Brown, director of the Nuffield Foundation; J. S. Carter, chief alkali inspector, Ministry of Housing and Local Government; A. P. S. Forbes, director of agriculture, Tanganyika; Capt. G. I. D. Hutcheson, for services to the engineering profession in Australia; Prof. T. G. H. Jones, professor of chemistry in the University of Queensland; W. J. Langford, headmaster of Battersea Grammar School; R. B. McConnell, director of geological surveys, British Guiana; K. D. S. MacOwan, director of veterinary services, Kenya; Prof. M. E. L. Mallowan, professor of Western Asiatic archæology, University of London, and director of the British School of Archæology; H. F. Mooney, forestry and soil conservation adviser, Middle East Development Division, Lebanon; Prof. A. W. Scott, professor of chemical engineering, Royal College of Science and Technology, Glasgow, for contributions to the food dehydration industry and services to the Aberdeen research establishment of the Ministry of Agriculture, Fisheries and Food; A. F. M. Smith, director of lands and surveys, Uganda; Dr. R. A. Smith, chief scientific officer, Royal Radar Establishment, Ministry of Aviation; J. C. C. Stewart, deputy managing director, Production Group, U.S. Atomic Energy Authority; Dr. F. R. Tubbs, director of the East Malling Research Station, Maidstone; Dr. E. I. White, keeper of palæontology, British Museum (Natural History).

I.S.O.: P. A. Allison, lately conservator of forests, Western Region, Nigeria; T. Lacey, principal in the Department of Scientific and Industrial Research; E. W. Pratt, senior principal scientific officer, Admiralty.

Atomic Energy Research Establishment Appointments:

Mr. B. S. Smith

Mr. B. S. Smith has been appointed head of the Isotope Research Division of the Atomic Energy Research Establishment. This Division was formed from the Isotopes Division as part of the re-organization of isotope production and application work carried out by the Atomic Energy Authority last year. The Division has recently completed a move from Harwell to the Wantage Research Laboratory, six miles away, which was opened by the Minister for Science, Lord Hailsham, on May 16. Mr. Smith is a graduate of King's College, London, where he was a demonstrator in physics from 1934 until 1939. During the War he worked at the Radar Research and Development Establishment, first on gun-laying radars and later on 'Identification, Friend or Foe Systems'. In 1944 he transferred to the Tube Alloy Project, and went to Canada, where he worked on the instrumentation for the Canadian *NRX* reactor. He returned to Harwell in 1947, and shortly afterwards joined the newly formed Health Physics Division. He became deputy head of the Division in 1954, and head when Dr. W. G. Marley took over the Radiological Protection Division of the Authority's Health and Safety Branch.

Mr. N. G. Stewart

Mr. Smith's place as head of the Health Physics Division will be taken by Mr. N. G. Stewart, who is at present head of the Health and Safety Division at the Dounreay Experimental Reactor Establishment. Mr. Stewart graduated at the University of Aberdeen in 1937, where he gained first-class honours in mathematics and natural philosophy. After a period teaching, he joined the Radar Research and Development Establishment at the beginning of the War, and became leader of the Aerial and Waveguide Systems Section. He joined the Health Physics Division at Harwell in 1948, and became head of the Radiation Measurements Group. He was transferred to Dounreay in 1958.

Chemical Engineering at Nottingham:

Prof. R. Edgeworth Johnstone

Dr. Robert Edgeworth Johnstone, at present assistant technical manager of Springfield Works, United Kingdom Atomic Energy Authority, has been appointed to be the first Lady Trent professor of chemical engineering in the University of Nottingham. The chair has been endowed by Boots Pure Drug Co., Ltd., Nottingham, in recognition of the services rendered to the University by the late Lord Trent and Lady Trent. Dr. Edgeworth Johnstone was educated at Wellington College and the Royal Military Academy, Woolwich, after which he spent two years at the Manchester College of Technology and a further year at University College, London. He graduated with first-class honours in applied chemistry and was awarded the degree of M.Sc. in chemical engineering of the University of London. In 1958, he was awarded the degree of doctor of science. He has had wide experience in Great Britain and abroad of large-scale plant management and development, and after the War was design engineer for important new petrochemical and chemical units in Lancashire and London. For almost ten years he has been with the Ministry of Supply with special responsibility for pilot plant experiments and process studies, and he has published numerous articles on the problems of translating experimental and small-scale production methods into full-scale commercial schemes.

Research in Optical Design at the Imperial College, London

An optical design group is to be set up at the Imperial College of Science and Technology, London, under the direction of Dr. C. G. Wynne, of the Wray Optical Co., Ltd., with the support of a grant for an initial period of seven years of £9,400 a year from the Department of Scientific and Industrial Research. The group, initially employing a staff of four in addition to Dr. Wynne, will be established under Prof. W. D. Wright, professor of technical optics in the College. The scientific programme will be: (1) to develop new methods of lens design, including the use of electronic digital computers, and to give instruction in these methods; (2) to design and construct lens systems of orthodox type but improved performance; of novel types including systems employing aspheric surfaces; and of specialized systems required in very limited numbers but having unusual performance characteristics, such as for space research.

Dr. C. G. Wynne

Dr. Wynne graduated at Exeter College, Oxford, to which he won an open science scholarship in 1930. He joined Messrs. Taylor, Taylor and Hobson, Ltd., where he worked on lens design. In 1943 he became chief lens designer to Messrs. Wray (Optical Works), Ltd., and in 1949 a director of Wray (Developments), Ltd., a subsidiary company which has undertaken a considerable volume of new optical design. In 1955 he became technical director of Wray (Optical Works), Ltd. In 1953 he was awarded a Ph.D. by the University of London. Dr. Wynne is the honorary business secretary of the Physical Society and is the honorary secretary of the newly established Institute of Physics and the Physical Society. He has acted as English language editor of *Optica Acta* since its inception in 1954.

Forest Products Research Laboratory: Mr. A. C. Copisarow

Mr. H. Wooldridge, deputy director, Stations Division, in the Department of Scientific and Industrial Research, has agreed to withdraw his acceptance of the directorship of Forest Products Research (see *Nature*, January 23, p. 212) at the special request of the secretary of the Department, because of the increasing pressure of work at headquarters of the Department. Mr. A. C. Copisarow, at present scientific attaché at Paris, has been appointed director of the Forest Products Research Laboratory in succession to Dr. F. Y. Henderson, who retires in October. Mr. Copisarow graduated in 1942 in the honours school of geology at the University of Manchester. He served in the Royal Navy, for four years on radar duties, and during 1946–54 was with the Joint Intelligence Bureau of the Ministry of Defence. He has published papers on the colloidal chemistry of silica. A former Council of Europe Research Fellow, he has served at the British Embassy in Paris for six years.

The United States Geological Survey: Dr. W. H. Bradley

In appreciation of the work of Dr. 'Bill' Bradley, chief geologist of the United States Geological Survey during 1944–59, the *Americal Journal of Science* has published a 'Festschrift' of 38 papers (*Amer. J. Sci.*, Bradley Volume, 258–A. Pp. 433 + 10 pl.; 1960) ranging over many topics in the Earth sciences. Dr. Bradley joined the U.S. Geological Survey as a 'geologic aid' in 1921, and soon became well known for his distinguished work on the oil shales and other strata of the lacustrine Green River Formation of middle Eocene age. These studies were interrupted by the War, when he was appointed chief of the Military Geology Unit responsible for supplying geological information to the American forces; and immediately afterwards he took over the leadership of the Geologic Division of the U.S. Geological Survey, which expanded under his charge from 400 geologists in 1944 to close on 1,000 in 1955. Recently he relinquished these administrative responsibilities to return to his initial research work. The volume in his honour is a fitting tribute to many years of good management of the largest geological organization in the Western world.

Advisory Committee on Poisonous Substances used in Agriculture and Food Storage

Sir Charles Dodds, Courtauld professor of biochemistry in the University of London, and director of the Courtauld Institute of Biochemistry at the Middlesex Hospital, has been appointed chairman of the inter-departmental Advisory Committee on Poisonous Substances used in Agriculture and Food Storage, in succession to Sir Solly Zuckerman. This Committee was recently reconstituted to include the following five members from outside the Government service; Prof. J. H. Gaddum, director of the Institute of Animal Physiology, Cambridge; Prof. Andrew Wilson, professor of pharmacology, University of Liverpool; Dr. J. Hamence, public analyst and agricultural analyst; Mr. F. H. Garner, principal of the Royal Agricultural College, Cirencester; and Prof. A. R. Clapham, professor of botany, University of Sheffield. The Committee was appointed in March 1954 to keep under review all risks that may arise from the use of toxic substances on agricultural products and in the storage of food, and to make recommendations to the Ministers concerned.

National Reference Library of Science and Invention

Answering a question regarding progress with the proposed National Reference Library of Science and Invention in the House of Lords on May 31, the Minister for Science said it is proposed to house this Library in a new Patent Office building to be erected on the South Bank, London. The terms of a lease of the site are now being settled between the Ministry of Works and the London County Council, and it is hoped to start building in the spring of 1963 with the view of completion by the end of 1965. Lord Hailsham had stated on July 30, 1958, that the Library would be built up and expanded from the existing Patent Office Library. He now said that it has been decided that it would be in the long-term interest of learning and of the completeness of the national collections of scientific literature for the National

Reference Library of Science and Invention to be formed as part of the British Museum Library, although housed as a separate unit. Scientific publications at present in the British Museum Library would be incorporated in the new Library. Care would be taken to safeguard the interest and convenience of those who use the present Patent Office Library, and they would be represented on an Advisory Committee to be set up when the new Library is brought into operation. Viscount de L'Isle welcomed this decision on behalf of the Trustees of the British Museum, and said that it would in due course make available to students and research workers the existing scientific resources of both the Patent Office and of the British Museum scientific collections in a compendious way and with the minimum of duplication.

State Scholarships and Commonwealth Co-operation

In the House of Lords on June 1, Lord Tweedsmuir asked the Government whether it would consider permitting up to 100 of the 2,000 State scholarships annually awarded in Britain to be tenable at Canadian or other Commonwealth universities if the recipient so elected. Lord Hailsham, replying for the Government, said that the Government would consider the matter in the light of the recommendations of the Anderson Committee. Asked by Lord Dalton to accelerate consideration of this question in view of the opportunities which Canadian and Australian universities can offer, Lord Hailsham agreed that it is a separate question from most of the contents of the Anderson Report, but thought that consultation with the Commonwealth Governments would be necessary before he could reply. Lord Casey suggested that the success of the proposal would depend on reciprocity between Commonwealth countries and the United Kingdom, and that into this consideration of cost and of available places would enter.

Preservation of North Devon Countryside

An area of the North Devon countryside about 66 square miles in extent is to be protected by the confirmation by the Minister of Housing and Local Government of an order made by the National Parks Commission. The area includes the whole of the Hartland Peninsula and such places as Clovelly, Braunton Burrows, Croyde, Woolacombe and Combe Martin, near the western edge of the Exmoor National Park. The order, which is made by the National Parks Commission under the National Parks and Access to the Countryside Act, 1949, designates these parts of North Devon as "Areas of Outstanding Natural Beauty", not as a National Park. The responsibility for preserving and enhancing the natural beauty of the landscape rests with the local planning authority, Devon County Council. Government grants can be made at the rate of 75 per cent towards the cost of treating derelict land, tree planting and preservation, and removing disfigurements.

Nature Conservation in Africa

Answering questions about Nature conservation in the Colonial territories in the House of Commons on June 2, the Secretary of State for the Colonies, Mr. Iain Macleod, welcomed the opportunity to reaffirm the Government's concern for wild life in Africa. Wild life conservation measures are, he said, continuously under review in the East and Central African territories, and in the past decade much has been done to establish and consolidate national parks and reserves. More use could be made of technical knowledge in developing the wild-life reserves, and the voluntary co-operation of the African populations is essential. The International Union for the Conservation of Nature, in consultation with other international agencies, is exploring the possibility of convening next year in Africa a conference on conservation. Mr. Macleod said that in a few weeks he would be able to study a detailed report by Dr. E. B. Worthington on his recent visit to Africa and the need for further help.

Journal of Child Psychology and Psychiatry

A new journal which will be generally welcomed has been issued by the Association of Child Psychology and Psychiatry. It is the *Journal of Child Psychology and Psychiatry and Allied Disciplines*, and is published under a distinguished editorial board of international authorities. The joint editors consist of a research psychologist, psychiatric social worker and a well-known physician in child-psychiatry, Dr. Emanuel Miller, while the corresponding editors are Prof. Milton Senn, Department of Pediatrics, Yale University, and P. H. Mursen, Department of Psychology, University of California. The *Journal* is attractively produced and the first issue (Vol. 1, No. 1 (January 1960). Pp. 98. Published quarterly. Subscription rates: To members of the Association of Child Psychology and Psychiatry 63*s*. per annum, inclusive of membership. To private individuals 105*s*. (15 dollars) per annum. To libraries and institutions 140*s*. (20 dollars) per volume. London and New York: Pergamon Press, 1960) contains articles which are refreshingly free from the jargon so beloved by students of human behaviour. The standard is set in the first article by Dr. Miller, who traces the origins of child-psychiatry, while Prof. Leo. Karner (Johns Hopkins University) shows that behaviour symptoms do not always indicate psychopathology; the clarity and brevity of his writing has much to commend itself to his fellow-American psychiatrists. Other articles deal with the effects of early deprivation and separation on children, manic-depressive psychosis in childhood, a gap in the structure of general psychology and a description of the training provided in child-psychotherapy at the Tavistock Clinic. Provided that the new journal can maintain this standard and keep itself free from psychiatric expertize, it could prove as useful to teachers and intelligent parents as to the professional child-psychiatrist and psychologist for whom it is intended.

Pavlov Journal of Higher Nervous Activity

This journal has been added to the list of Russian journals which are being published in English translation. By arrangement with the Soviet authorities, 'rush' copies of the original journal and its illustrations are to be made available, so that the delay in publication of the translation can be made as short as possible. The first issue of the 1959 volume contains 18 original communications, together with a short review of work carried out in the United States of America during the years 1954–57 on conditioned reflexes in animals. There is an obituary of the eminent Russian physiologist, L. A. Orbeli (Vol. 9, No. 1. Translated from the Russian. Pp. 140. Published bi-monthly. Approximately 1,000 pages per volume. Annual subscription 210*s*.; 30 dollars. London and New York: Pergamon Press, 1960).

Medical and Biological Compilation

THE second edition of "Current Indexing and Abstracting Periodicals in the Medical and Biological Sciences" attempts to provide an annotated list of all the most important indexing and abstracting periodicals in medicine and the allied sciences published currently throughout the world, and the number of titles has been increased from 142 in the first (1953) edition to 310 (World Health Organization. Library News, Vol. 12, Supplement 2. Pp. 85. Geneva: World Health Organization, 1959). In general annual publications containing review articles are excluded, but the yearbook series, containing the abstracts, are included. Periodicals are listed alphabetically by title, with the name and address of the publisher and/or responsible organization, first year of publication, current subscription price, year and volume number of the first volume in the World Health Organization holding, frequency of publication, number of periodicals regularly scrutinized and of abstracts or title entries published annually.

Transvaal Museum

THIS active museum publishes both a *Bulletin* and *Annals*. The former for January 1960, No. 4, includes some notes on mammal specimens as museum material and the collecting expedition of Colonel Jack Scott to Somalia. A short article also describes the bird-life at Sandwich Harbour. The April issue of the *Annals* (14, Part 1; 1960) contains an important key to the genera of South African freshwater and estuarine gastropods, observations on the locomotion of the South African adder, *Bitis peringueyi*, and on the early post-natal development of multi-mammate mice. The dibatag, *Ammodorcas clarkei*, is also dealt with in an important illustrated paper by Mr. J. Meester.

Psychiatric Services and Architecture

A BOOKLET published by the World Health Organization attempts an analysis, not only of the planning and management of psychiatric hospitals, but also of the structure and function of other psychiatric services such as out-patients' departments, psychiatric wards in general hospitals, rehabilitation facilities, and other mental health services (Public Health Papers, No. 1: Psychiatric Services and Architecture. By A. Baker, R. Llewelyn Davies and P. Sivadon. Pp. 59. Geneva: World Health Organization; London: H.M. Stationery Office, 1959. 2 Swiss francs; 3*s*. 6*d*.). It is the joint work of two psychiatrists and an architect who has specialized in hospital architecture, but it also takes account of the comments and suggestions of twenty-nine other psychiatrists and four architects from other countries. It represents an international approach to the problem of how psychiatric services can best be organized in the interests of the patients and be given suitable architectural expression. The types of buildings proposed are very different from the gloomy, prison-like mansions which until recently were regarded in many parts of the world as the only appropriate places in which to incarcerate mental patients; the approach to the patient is based upon the desire to re-integrate him into society with all possible speed, and to provide him with surroundings that will contribute to that end.

Roe Deer

Two of Britain's native deer, the red and the roe, have been known to inhabit the country since prehistoric times. The roe is now more widely distributed in England than the red, but, in Scotland, the red deer is the more widespread species. There are few, if any, in Wales, and none in Ireland. Because there are no predatory animals to keep these deer in reasonable numbers, the burden of doing this rests on the owners of the land on which they live. As the planted forests grow taller the problem of control will increase, and it is important that game-keepers and foresters should be familiar with their habits. To help them, the Forestry Commission has produced another of its attractive illustrated booklets, on the roe deer, which would be equally useful for natural history lessons in schools (Leaflet No. 45: The Roe Deer. Pp. 16. (London: H.M. Stationery Office, 1960.) 1*s*. 6*d*. net). It describes not only methods of control but also how these attractive animals may be stalked, the terms of venery, the calls of the roe, and, not least attractive, a suggested method of cooking roast haunch of roe.

A New British Transistorized Computer

THROUGH the joint enterprise of the General Electric Company and International Computers and Tabulators, Ltd., 149 Park Lane, London, W.1, a new, fully transistorized, automatic digital computer, the 1301, has been produced. This machine has characteristics which place it in the front rank of the large British computers which are available at the present time. It has storage, both on magnetic cores and on drums, the former in units of 400 words; the latter in units of 12,000 words; magnetic tape transports and a high-speed line-at-a-time printer are also available. The arithmetical speeds of the machine are such that addition and like operations take about 25 μsec., and multiplication about eight times as much. These fast operating speeds are achieved with the remarkably low pulse-operating time of 1 Mc./s.; this is apparently due to the unusual feature of the machine, namely, that it operates in serio-parallel decimal code, each decimal digit being represented by signals on four lines in parallel and each computer word consisting of twelve decimal digits. Probably the most surprising feature of the machine is its low power consumption, which the makers state to be only 4 kW. In common with most recently produced machines, a comprehensive range of sub-routines and automatic programming facilities is also available. Because it is built with magnetic tape as a standard and planned-for ancillary, this machine is more attractive than many of the British machines of the immediate past, in which the later addition of magnetic tape has only been achieved by considerable alterations.

Rock Pressure and Earthquakes

WHEREAS the virgin pressure of the fluids in rock formations at depth can be measured readily, the pressure in the solid rock itself could not, until recently, be measured directly. In practical problems concerned with mining and deep drilling it has been customary to assume that the pressure is satisfactorily defined by the weight of overburden. A method of direct measurement has been developed in Sweden which shows that this assumption is too simple. The method and results are described by Nils Hast in a recent issue of *Sveriges Geologiska Undersökning* (Ser. C, No. 560: The Measurement of Rock Pressure in Mines. By Nils Hast. Pp. 183. Stockholm: Sveriges Geologiska Undersökning, 1958).

The principle is to pre-stress a small stress-measuring cell situated in a hole drilled some distance into the rock, and then to cut away a portion of the surrounding rock by drilling an annular hole co-axial with and enclosing the first. The stress in the core of rock containing the cell is thus removed, and the difference between the original and final load measured by the cell gives the absolute value of the stress acting in the rock at the measuring point. The cell measures stress in one direction only; by using three boreholes the stress ellipsoid may be determined.

This method was first tried in 1951 in the Grängesberg iron mines, and has since been improved and applied to other mines. It has been found to be of great value in investigating the stability of roofs, walls and pillars, and the use of block caving as an efficient means of ore extraction. Besides their immediate practical value, however, the measurements promise to throw new light on the dynamics of the Earth's crust. In all cases where rock pressures have been measured in Sweden there has been found a pronounced excess of the horizontal component, usually 1·5–3·5 times the amount accounted for by the weight of overburden. These large horizontal stresses are ascribed by Hast to secular movements in the crust. Since many earthquakes are believed to be due to the sudden failure of parts of the crust following a steady accumulation of stress, it is further suggested that periodic measurements of rock pressure in earthquake regions might disclose the stage reached in the preliminary build-up, leading to the possibility of earthquake prediction.

The Wellcome Trust: Grant to the Massachusetts General Hospital, Boston

The Wellcome Trustees have made a grant of £50,000 to the Massachusetts General Hospital, Boston, for the establishment of a Henry S. Wellcome research chair in medical science. The professor will be chosen by a special committee of the Massachusetts General Hospital, Harvard University, and the Massachusetts Institute of Technology, from a number of workers who have already achieved a high scientific reputation for their researches. The appointment will be made for ten years. This is the largest single grant to be made by the Wellcome Trustees to a medical research centre in the United States. In 1956 they made a grant of nearly £25,000 to the University of Pennsylvania to provide a Wellcome associate research professorship of anesthesiology for five years, and earlier in the present year they made a grant of £15,000 to construct a laboratory for cardiovascular research within the Department of Medicine at Johns Hopkins Hospital, Baltimore.

The Waverley Gold Medal Competition

The Scientific Advisory Board of *Research* has decided to continue the Waverley Gold Medal essay competition, and this year will be the eighth year in succession in which it is offered. The Waverley Gold Medal, named after the late Lord Waverley, together with £100 will be awarded for the best essay of about 3,000 words describing a new scientific project or practical development, giving an outline of the background, the experimental results and the potential application of the project or process in industry. A second prize of £50 will be awarded, and also a special prize of £50 for the best entry from a competitor under the age of thirty on July 31. Further information can be obtained from the Editor of *Research*, 4/5 Bell Yard, London, W.C.2. The last date of entry is July 31.

Teratology Society

Following the fourth Teratology Conference, which was held at the Memorial Sloan-Kettering Cancer Center in New York City and attended by 76 scientists from Canada, England, France, Germany and the United States, the Teratology Society was formed. One of the main purposes of the Society is to hold regular meetings at which investigations concerned with etiology and morphogenesis of congenital malformation can be presented and discussed. The following officers were elected: *President*, Dr. Josef Warkany (Cincinnati); *President-elect*, Dr. James G. Wilson (Gainesville); *Secretary-Treasurer*, Dr. Marjorie M. Nelson (San Francisco); *Recorder*, Dr. Sidney Q. Cohlan (New York); *Council*, Dr. F. Clarke Fraser (Montreal), Dr. David L. Gunberg (Portland) and Dr. M. Lois Murphy (New York). The National Foundation assisted in the formation of the Society with advice and financial aid. Further information concerning the society can be obtained from Dr. Marjorie M. Nelson, Department of Anatomy, School of Medicine, University of California, San Francisco, 22.

The Agricultural Society of India

The following have been elected members of the new Executive Council for 1960 of the Agricultural Society of India: *President*, Dr. J. N. Mukherjee; *Vice-president*, Sri Bimal Chandra Sinha; *Editor*, Dr. P. K. Sen; *Secretary-treasurer*, Sri. R. M. Datta; *Other members*, Dr. N. R. Dhar, Dr. J. C. Sen Gupta, Dr. B. C. Kundu, Dr. H. K. Nandi, Dr. M. C. Das, Dr. S. K. Mukherjee, Dr. T. M. Das, Dr. U. N. Chatterjee, Dr. D. N. Roy Choudhury, Sri R. S. Roy, Sri T. K. Bose.

University News:

Birmingham

Dr. S. Mandelstam, assistant research physicist, Department of Physics, University of California, has been appointed to the newly established chair of mathematical physics within the Department of Mathematical Physics from October 1. The following lectureships are also announced: Dr. R. W. Whitworth (physics), Dr. A. B. Robbins (physics), Dr. J. R. Majer (chemistry), Dr. E. H. Creaser (senior lecturer in microbiology), Dr. F. W. J. Teale (biochemistry), and Dr. D. G. Walker (biochemistry). Research fellowships are as follows: A. M. Hoare (pure mathematics), J. S. Lilley (nuclear physics), B. Cockayne (William Gibbins Research Fellow in the Department of Physical Metallurgy) and E. N. Corlett, senior Research Fellow in the Department of Engineering Production).

Bristol

Appointments to lectureships are as follows: Dr. P. G. Drazin (mathematics), Dr. A. E. Scott (chemistry), Mr. J. K. Whitaker (mathematical economics). Mr. K. F. H. Murrell has been appointed a Research Fellow in the Department of Psychology. Dr. D. H. Perkins has been elected reader in physics.

Durham

The following appointments to lectureships are announced: Dr. O. E. W. R. Kurth (senior lecturer in mathematics), Mr. D. J. Bellamy (botany), Dr. R. D. Chambers (chemistry), Dr. D. P. Hendry (psychology), Dr. D. M. Hirst (geochemistry), Dr. M. J. Morant (applied physics).

London

DR. W. KLYNE, reader in biochemistry at the Postgraduate Medical School of London, has been appointed to the University chair of chemistry tenable at Westfield College; and Dr. R. E. O. Williams, deputy director of the Central Public Health Laboratory, Colindale, has been appointed to the University chair of bacteriology tenable at St. Mary's Hospital Medical School. Appointments to readerships are as follows: Dr. J. H. Green (physiology), tenable at Middlesex Hospital Medical School; Dr. H. J. J. Blackwood (oral anatomy) at the Royal Dental Hospital of London School of Dental Surgery; J. C. de C. Henderson (reinforced concrete structures), tenable at the Imperial College of Science and Technology; A. J. Buller (physiology), tenable at King's College).

The Night Sky in July

FULL moon occurs on July 8d. 19h. 37m. U.T., and new moon on July 23d. 18h. 31m. The following conjunctions with the Moon take place: July 7d. 12h., Jupiter 5° S.; July 8d. 18h., Saturn 4° S.; July 17d. 17h., Mars 3° N.; July 19d. 10h., Aldebaran 0·4° S. Mercury and Venus are too close to the Sun for observation. Mars rises at 0h. 30m., 0h. 00m. and 23h. 25m. at the beginning, middle and end of the month, respectively; its stellar magnitude is $+0·9$ and its distance from the Earth on July 15 is 137 million miles. Mars is now prominent in the eastern sky before sunrise. Jupiter sets at 3h. 05m., 2h. 05m. and 0h. 55m. on July 1, 15 and 31, respectively. It is near the boundary between Sagittarius and Ophiuchus, its stellar magnitude is $-2·1$ and its distance from the Earth in the middle of the month is 400 million miles. Saturn is also in Sagittarius, setting shortly after sunrise at the beginning of the month, and at 3h. 30m. and 2h. 20m. on July 15 and 31, respectively. Its stellar magnitude is $+0·3$, and it is in opposition on July 7, when its distance from the Earth is 840 million miles. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: July 3d. 21h. 44·0m., κ Vir. (*D*); July 19d. 10h. 20·3m., Aldebaran (*D*); July 19d. 11h. 34·1m., Aldebaran (*R*). *D* and *R* denote disappearance and reappearance, respectively. The Earth is at aphelion on July 2, its distance from the Sun being 94·6 million miles.

Announcements

THE Council of the National Institute of Industrial Psychology has awarded the Vernon Prize for 1960 to Dr. R. B. Buzzard of the Industrial Psychology Research Group of the Medical Research Council. Dr. Buzzard has been engaged for ten years in research into attendance and absence from work, and has made an exceptional contribution to knowledge in this difficult field.

THE Department of Mathematics and Natural Science of the Bavarian Academy of Science, Munich, in celebration of its two hundredth Jubilee, is offering a prize of 8,000 D.M. for the best essay on "Die Rückkoppelung als Urprinzip der Lebensvorgänge". The competition is open to persons with a doctorate or other recognized qualifications. The essay is to be written in the German language and presented by August 1, 1961. Further information can be obtained from Prof. R. Sauer, Bayerische Akademie der Wissenschaften, Munchen 22, Marstall-Platz 8.

THE eleventh International Congress of Entomology is to be held in Vienna during August 17–25. Further information can be obtained from Dr. Max Beier, General Secretary, P.A. Natural History Museum, Vienna 1, Burgring 7.

THE annual conference of the Institute of Sewage Purification will be held at Scarborough, during June 21–24. Further information can be obtained from the Secretary of the Institute at Maple Lodge, Maple Cross, Rickmansworth, Herts.

THE Photoelectric Spectrometry Group is organizing a meeting on "Spectrofluorimetry" at the Inorganic Chemistry Department, South Parks Road, Oxford, on July 8. Further information can be obtained from K. A. Macdonald, Unicam Instruments, Ltd., Arbury Works, Cambridge.

THE Danish Atomic Energy Commission is organizing an international summer course on "Plasma Physics" at its Research Establishment, Riso, during August 1–12. Further information can be obtained from the Danish Atomic Energy Commission, Research Establishment, Riso, Roskilde.

THE tenth General Assembly and nineteenth International Congress of the International Geographical Union are to be held in Stockholm during August 6–13. Further information can be obtained from the Assistant Secretary of the Geographical Association, Park Branch Library, Duke Street, Sheffield 2.

A JOINT meeting of the Challenger Society and representatives from the Marine Laboratories (Development Commissioners' Scheme) has been convened at the Zoological Laboratory, Downing Street, Cambridge, during June 23–24. Further information can be obtained from Dr. R. Bainbridge, Zoological Laboratory, Downing Street, Cambridge.

THE third Australasian Conference on "Radiation Biology" is to be held at the University of Sydney during August 15–18. Further information can be obtained from Dr. Peter Ilbery, Department of Preventive Medicine, University of Sydney, N.S.W.

THE eighth International Symposium on "Combustion" is to be held at the California Institute of Technology, Pasadena, during August 29–September 2. Further information can be obtained from the Office of Industrial Associates, California Institute of Technology, Pasadena, California.

THE twenty-first International Geological Congress will be held in Copenhagen at the Mineralogical-Geological Museum of the University during August 15–25. The Congress is being organized jointly by Denmark, Finland, Iceland, Norway and Sweden. Further information can be obtained from the General Secretary, International Geological Congress, Mineralogisk Museum, Øster Voldgade, Copenhagen K.

THE tenth annual meeting of holders of Nobel Prizes will be held in Lindau during July 4–8. Among those present who are to speak are Prof. H. A. Krebs (Oxford), Prof. F. Sanger (Cambridge), Prof. G. Domack (Wuppertal-Elberfeld), Prof. C. Heymans (Ghent), Prof. W. P. Murphy (Brookline), Prof. A. Butenandt (Munich), Prof. R. Kuhn (Heidelberg), Prof. A. I. Virtanen (Helsinki), Prof. H. Dam (Copenhagen), Prof. W. R. Hess (Zurich), Prof. Hans von Euler-Chelpin (Stockholm), Prof. G. von Hevesy (Stockholm) and Dr. P. H. Müller (Basle). Further information can be obtained from the Sekretariat der Tagungen der Nobelpreistrager, Lindau (B), Postfach 11.

MINOR ELEMENTS IN NUTRITION

THE 132nd meeting of the Nutrition Society (58th of the Scottish Group) was held in the Hannah Dairy Research Institute, Kirkhill, Ayr, on April 30. It took the form of a symposium on "Minor Elements in Nutrition".

In his introductory remarks the chairman, Dr. D. P. Cuthbertson (Rowett Research Institute, Aberdeen), observed that during the past thirty years a steadily increasing number of mineral elements had been found as permanent constituents of plant and animal tissues. The biological functions of mineral elements present in relatively large amounts, the so-called 'major elements', were well defined, but the role of many of the minor elements in tissues was still, as yet, unknown. This might arise partly from the technical difficulties associated with estimating trace amounts of such elements; but with the increased use of modern techniques it is expected that some at least of these minor elements with an unknown function will be found to have an essential physiological role in the tissues.

For the purposes of this symposium, a minor element was defined as a metal generally belonging to the transitional group of the Periodic Table (iodine, fluorine and selenium being exceptions) which is present in the organism in concentrations of not more than 1 in 20,000, or 50 p.p.m., and serves therein an essential function as an oxygen carrier or in some enzyme system, hormone or vitamin.

The first paper, on "Trace Elements in Scottish Soils", was given by Dr. R. L. Mitchell (Macaulay Institute for Soil Research, Aberdeen). Dr. Mitchell pointed out that the realization of the importance of trace elements in animal nutrition had led to a requirement for maps or other means of ascertaining the probable trace element status of the soils of any locality. In contrast to regions with extensive areas of soils derived from uniform parent material such as the great continental plains, where the trace element status of the soil can often be related directly to pedological factors and can be readily mapped on small-scale maps, conditions in Scotland are much more complex and such generalization is impossible.

Scotland is an area of complex geology in which the parent rocks contain highly variable amounts of the biologically important trace elements, and several periods of glaciation have produced surface drift which further complicates the picture.

Dr. Mitchell then discussed the distribution of trace elements in soils and soil parent materials. Trace elements are located in major rock-forming minerals as a result of substitution for major elements of similar ionic radius in the crystal lattice. Elements of biological importance such as cobalt and copper tend to be concentrated in argillaceous sediments along with molybdenum and selenium. Sandstones and derived sandy soils often have low trace-element contents. The trace-element content of soils can be predicted from the parent material. Unlike the concentrations of major minerals, those of minor minerals can differ widely by a hundred or even a thousand times from soil to soil. A semiquantitative estimate of trace-mineral content or even the nature of the parent material will usually suffice for an assessment of soil status. The availability of trace elements is influenced by rate of weathering of soil minerals and pedological factors affecting the rate of weathering.

Uptake of available minerals by the plant is affected by agricultural practices such as liming, which alters the soil *p*H, and drainage. Under Scottish conditions drainage is the factor most influencing the mobilization of trace elements. With poor drainage there is a larger soil concentration of trace elements, and herbage contents of more than 10 p.p.m. molybdenum have been recorded under such conditions. Certain areas of Aberdeenshire are almost completely infertile owing to poor drainage and the accumulation of excessive quantities of extractable nickel in the soil.

Trace-element uptake by animals on herbage is related not only to soil factors such as those mentioned above but also to seasonal changes in plant composition, variation in the relative amounts of different species in the sward throughout the season, stage of maturity of the crop and climatic factors affecting growth.

In the second paper, Dr. E. C. Owen of the Hannah Dairy Research Institute, Ayr, discussed the "Biochemical Function of Some of the Minor Elements". Dr. Owen confined his remarks to cobalt, zinc, vanadium and manganese. As an essential part of vitamin B_{12}, cobalt is essential for non-ruminants to prevent anæmia and to ensure optimal growth on food of vegetable origin. Vitamin B_{12} can be synthesized by ruminants providing they are supplied with sufficient dietary cobalt. In addition, both ruminants and non-ruminants probably need cobalt in ionic form for the activity of a number of enzymes. After describing typical symptoms of cobalt deficiency in animals, Dr. Owen pointed out that people eating only food of vegetable origin run a special hazard in regard to vitamin B_{12} deficiency in that a high intake of folic acid from greenstuff raises the requirement for vitamin B_{12}. The distribution of vitamin B_{12} in Nature is consistent with a general belief that only bacteria can synthesize it from cobalt salts.

Zinc is a constituent of the carbonic anhydrase of bovine erythrocytes and certain organs of the body and of plant tissues. Carbonic anhydrase is inhibited by sulphonamide, but apparently not through the zinc of its molecule. Studies on the skin disease of pigs called parakeratosis show that high dietary calcium aggravates the condition probably by causing a more rapid turnover of zinc and thus raising the requirement. It is claimed that the effects of excess calcium can be nullified by adding citric or acetic acids to the ration.

It is of interest that pigs suffering from parakeratosis show more variable alkaline phosphatase activity than control pigs and that zinc has been suggested as a specific activator of alkaline phosphatase. Other enzyme systems associated with zinc are alcohol dehydrogenase of yeast and equine liver, glutamic dehydrogenase of bovine liver and lactic dehydrogenase of rabbit skeletal muscle. Dr. Owen thought that the turnover of zinc may be of more importance than the actual concentration in tissues.

In the third paper, Dr. C. F. Mills (Rowett Research Institute, Aberdeen) described "Comparative Studies of Copper, Molybdenum and Sulphur Metabolism in the Ruminant and the Rat". Dr. Mills pointed out that elevated levels of molybdenum and sulphate in the diet of the sheep gave rise to depletion of copper stores and the appearance of symptoms of copper deficiency. The mechanism of action of molybdenum and sulphate under these conditions is unknown. Studies with the rat have shown that high dietary molybdenum contents lead to reduced growth-rate, failure of hæmoglobin synthesis, and production of skeletal abnormalities. That this indicated an interference with normal copper metabolism was shown by increasing dietary copper levels and thus preventing the deleterious effects. It has further been shown that high dietary levels of molybdenum cause accumulation of copper in the liver of the rat. This is in marked contrast to the experience with sheep, where a *depletion* of tissue copper reserves usually occurs.

Excess dietary sulphate also has a contrasting effect when fed in high-molybdenum/low-copper diets. In sheep, increase in dietary sulphate precipitates a rapid decline in liver copper levels, but in the rat it prevents the abnormal accumulation of copper in the liver and improves the growth-rate, hæmoglobin development and skeletal development. In both rat and sheep, adding sulphate to the diet led to an increased output of urinary molybdenum and a fall in tissue molybdenum levels.

These marked species differences led to an investigation of the fate of sulphate in the digestive tract. In the ruminant, sulphide is formed rapidly by micro-organisms, and experiments on feeding molybdenum, sulphide and copper to rats in semi-synthetic diets were carried out. It was found that the sulphide oxidizing system of the rat liver was markedly depressed by feeding molybdate. This suggested that the detoxication of sulphide may be restricted in tissues high in molybdenum.

Among other enzyme systems found to be influenced by high dietary levels of molybdenum are alkaline phosphatase and liver cytochrome oxidase. In connexion with the latter, it is interesting to note that liver cytochrome oxidase activity may be drastically reduced in the copper-deficient rat.

Comparable work is in progress feeding sheep on diets enriched with molybdenum and sulphate. It would appear that the presence of molybdenum increases the rate of reduction of sulphate to sulphide in the rumen. The presence of molybdenum and sulphate depressed the content of soluble copper in the rumen and abomasum. These results might indicate the formation of insoluble copper sulphide, a poor source of copper for sheep.

However, the true significance of the increased sulphide levels in the rumen of sheep following ingestion of molybdenum, in relation to changes in soluble copper concentration, are not yet clear, and in current work to study this aspect the possibility of more extensive effects of molybdenum on sulphur metabolism in the digestive tract is being considered.

In his paper on "Selenium in Animal Health", Mr. G. A. M. Sharman (Veterinary Investigation Service, North of Scotland College of Agriculture, Aberdeen) observed that selenium was a relatively scarce element which was hard to estimate chemically. The lowest soil concentrations are expected in light soils derived from Old Red Sandstone, carboniferous sandstone rocks or certain granites. Concentrations of 0·05 p.p.m. or less might be expected in such soils and might well give rise to deficiency states in grazing animals. Relatively higher values are found in sedimentary rocks, certain shales having values as large as 0·25–1·2 p.p.m. There are certain areas in western Canada and the United States, Mexico, Colombia, Ireland, Israel and Australia where soils containing even higher contents of selenium are to be found, and because the vegetation is high in selenium there is a problem of toxicity among grazing animals. On such seleniferous soils plants absorb very little or a great deal of selenium from the soil depending on the species. Some plant species contain as much as a thousand times more selenium on the dry basis than the soil on which it was grown.

Selenium is the only element known to be absorbed by plants in sufficient amount to cause death from acute poisoning when eaten. For farm animals, dietary concentrations above 10 p.p.m. would appear to be lethal and for chicks a level of 1 p.p.m. produced definite changes in blood constituents. Ingestion of sub-lethal amounts of selenium for long periods leads to its accumulation in hair and hide. Chemical estimation in hair is therefore a guide to selenium status. Cattle from seleniferous areas had hair with selenium content ranging from 10 to 25 p.p.m. compared with the normal 1–4 p.p.m.

It has been shown recently that in rats, chicks and certain farm animals, symptoms of vitamin E deficiency may be alleviated by feeding traces of selenium, and in some cases selenium appears to be essential. New York workers have shown that rations containing 1·1 p.p.m. selenium fed to pregnant ewes prevented white muscle disease in lambs, whereas rations containing 0·01–0·08 p.p.m. did not. Similar experiences have been reported from elsewhere.

Enzootic muscular dystrophy in calves in the north of Scotland was cured by daily dosing with 0·25 mgm. selenium as selenate, or by weekly dosing with 200 mgm. α-tocopherol.

Mr. Sharman emphasized that selenium should not be added to commercial mineral mixtures for farm animals because of the small margin of safety between essential and toxic levels.

In the final paper, on "Adventitious Metals in Processed Foods", Miss E. M. Chatt (British Food Industries Research Association, Leatherhead, Surrey) directed attention to the rapid advances in food production, processing and technology which had taken place this century. She pointed out that increased production of flesh foods led to increased production of crops, giving rise to increased hazard from pests, which had to be controlled by chemical sprays or dusting. Some of these methods of chemical control give rise to contamination with toxic metals which can persist and be carried over into the finished product. Adventitious metals may be present therefore in many raw materials before they arrive at a factory for processing, and in the factory further contamination is liable to occur. In the case of canned foods, contamination also occurs by absorption of tin and iron during storage.

In drawing up recommendations for limits of traces of metals in foods the Food Standards Committee of the Ministry of Agriculture, Fisheries and Food is guided by what is judged to be good commercial practice. All paint in factories should be lead-free and of the rust-resisting variety. Condensation should be avoided by suitable factory design. Equipment should preferably be made from metals not readily subject to abrasion, such as stainless steel. Miss Chatt gave many examples of ways of avoiding contamination, including methods of inspection and the manufacture and lacquering of cans, and also gave a comprehensive list of the commoner metallic contaminants sometimes encountered in foods—arsenic, lead, copper, zinc, iron, nickel, mercury and antimony.

J. Davidson

NITROGEN IN TROPICAL AGRICULTURE

A SYMPOSIUM on nitrogen in tropical agriculture was held in Brisbane during February 23–24. It was organized by the Commonwealth Scientific and Industrial Research Organization at the Cunningham Laboratory, the headquarters of the Division of Tropical Pastures. Although the majority of the papers were by officers of the Organization, several other organizations concerned with research in agricultural and pastoral industries in tropical Australia also contributed.

In his foreword to the conference proceedings, Dr. J. G. Davies (chief of the Division of Tropical Pastures) described the objective of the symposium as "to review existing information on the role of nitrogen in the agriculture of the tropics and sub-tropics, with emphasis on those aspects which are relevant to the problems of northern Australia and Queensland in particular".

The symposium was highly successful on two counts: it brought together under ready reference a number of reviews on topics of the utmost importance to the future development of tropical agriculture, and equally significant, the papers and discussions demonstrated many serious gaps in information on the role of nitrogen in the tropics and showed where further research is required.

Four papers in Session 1 (general problems of nitrogen economy) dealt with the processes by which nitrogen is gained and lost by the soil/plant system and with the nitrogen economics of natural plant communities and the grazing ruminant animal. D. O. Norris and E. F. Henzell, who considered the processes by which nitrogen is added to the soil/plant system, emphasized the widespread nature and importance of nitrogen deficiency in limiting pasture and crop production in the tropics and concluded that, despite the difficulty of estimating the efficiency of fixation, there was evidence that tropical legumes, under favourable conditions, were equal if not superior to temperate legumes as nitrogen fixers. A. E. Martin and G. W. Skyring dealt with losses of nitrogen from the soil/plant system, listing leaching, crops, erosion, fire and volatilization as factors involved. They considered that some of the losses due to leaching, and most of the losses of gaseous nitrogen reported in the literature, were exaggerated, and suggested that the standard analytical techniques were likely to give lower gains and higher losses of nitrogen than were, in fact, experienced. J. E. Coaldrake emphasized the much slower turnover of nitrogen in natural communities compared with pastures, and joined with Norris and Henzell in pointing out that important accretions of nitrogen came from non-legumes. In reviewing the nitrogen intake and excretion of grazing animals, I. W. McDonald discussed the varied requirements of different classes of ruminant animal, stressing that they retained, on average, only 15 per cent of ingested nitrogen. Discussion topics included the possible importance of free-living nitrogen-fixing organisms in the nitrogen economy of the tropics and the need to ascertain the nitrogen requirements of ruminant animals in tropical environments.

Session 2 (soil nitrogen) consisted of three papers on nitrogen status and nitrogen transformations in soil. G. D. Hubble and A. E. Martin described the nitrogen status of Queensland soils and noted similar modal nitrogen contents in soils from northern and southern Australia (both of which were less than for East African soils); it was apparent that the total nitrogen of surface soils in Queensland was more highly correlated with total phosphate than with annual rainfall. G. W. Skyring and Barbara J. Carey described the microbial species involved in nitrification and denitrification, their physiology and biochemistry and techniques of isolating and culturing them. Although denitrification occurred in apparently well-aerated soil, no denitrification was detectable in cultures containing measurable quantities of oxygen. Nitrogen transformations in soil were considered by A. E. Martin, who referred to recent tracer work with nitrogen-15 in the United States and Sweden which had shown that mineralization and immobilization of nitrogen were simultaneous processes; only net effects had hitherto been measured. He noted that, while ammonia was important, nitrate was not necessary to the microbial cycle. Important topics in discussion were the factors promoting and inhibiting nitrate formation, the carbon/nitrogen ratio and its indication of soil nitrogen availability, and methods of determining the availability of soil nitrogen. Instances were quoted where, although 80 per cent of the nitrogen present in the original rain forest vegetation remained in the soil, nitrogen shortage was still severely limiting pasture growth.

Session 3 (nitrogen fixation) contained two papers. D. O. Norris, in his review of the biology of nitrogen fixation, showed that the classical temperate legume/rhizobium symbiosis was atypical of the Leguminosae as a whole, which were essentially of tropical origin; he also emphasized the wide range of plants and bacteria involved in fixation. C. S. Andrew considered the growth of legumes in acid soils and used this criterion as a measure of symbiotic efficiency. The use of plants other than conventional herbaceous legumes, for example, blue-green algae or nodulating non-legumes, to build up nitrogen in the system was discussed. The mechanism by which phosphate stimulated nodulation also received attention.

Two papers in Session 4 (plant nitrogen) dealt with the pathways and processes of nitrogen metabolism in plants. Protein synthesis was the main theme of M. P. Hegarty's paper on nitrogen uptake and transformations. He reviewed the evidence pointing to ammonia as a key intermediate and described the primary synthesis of amino-acids and their subsequent elaboration. Interference with amino-acid metabolism caused by mineral deficiency was described by R. G. Coleman. He showed that mineral deficiency was frequently associated with disruption of enzyme activity; amino-acids may accumulate, and symptoms of deficiency result. Discussion emphasized the complexity of mineral imbalance which could affect the level of other nitrogen compounds, for example, purines and pyrimidines, as well as amino-acids. The comparative insensitivity of ruminant animals to changes in the proportions of nitrogen compounds in their diet was attributed to the profound modifications brought about by microbial metabolism in the rumen.

Session 5 (nitrogen for crops) contained five papers. I. F. Phipps described the manufacture and use of nitrogenous fertilizers, dealing chiefly with Australia, where about 125,000 tons were used annually, mostly in the form of ammonium sulphate, although the popularity of urea was increasing. The papers on nitrogen fertilizing of crops were by L. G. Vallance (sugar), F. Chippendale (tobacco and horticultural crops), W. J. Cartmill (cotton) and S. A. Waring (grain and forage crops). One hundredweight of ammonium sulphate increased the yield of sugar by 25 hundredweight in Australia: the highest commercial application was 5 hundredweight ammonium sulphate per acre. There was considerable disagreement about the effects of different sources of nitrogen on tobacco quality, although the nitrate form was favoured in Queensland. With cotton in Queensland, responses to nitrogen were related to moisture availability; best results had been achieved where nitrogen fertilizer and irrigation were combined. Among possible adverse effects from nitrogen fertilization of grain crops were lodging, excessive nitrogen content in malting barley, and actual yield depression with droughted sorghum. Delegates spoke of the different soil depths exploited by different forage crops, the superiority of slow-acting nitrogenous fertilizers for some crops, and the growing popularity of urea as a source of nitrogen.

Session 6 (nitrogen for pastures) comprised two paper on sources of nitrogen, both including consideration of the influence of the grazing animal. W. W. Bryan considered the three symbioses legume/rhizobium, legume/grass and pasture/herbivore. World information on these relationships was almost wholly confined to temperate conditions; because of the many important differences of the tropical environment, a thorough study of these symbioses in the tropics was needed. Discussion revealed conflicting points of view on the importance and duration of the effects of nitrogen voided by the grazing animal. The need for perennial legumes capable of exploiting an improved soil environment, further information on native tropical pasture legumes as nitrogen donors and fundamental data on the mechanism of legume adaptation to difficult environments was emphasized. In reviewing the use of nitrogen fertilizer on pastures, E. F. Henzell pointed out that the widespread nature of nitrogen deficiency in tropical regions was accentuated by the lack of pasture legumes. There was a number of grass species with a growth potential appreciably greater than temperate grasses when nutrition was adequate. Because of the relatively low returns from pastoral farming and the high cost of nitrogenous fertilizers, insignificant quantities were now used on tropical pastures.

Discussion at the symposium inevitably dwelt on the fact that data applicable to the tropical environment were sadly lacking in such diverse fields as pasture utilization, nitrogen fixation by free-living organisms, soil nitrogen availability and the nitrogen metabolism and requirements of tropical pasture and crop plants. Those participating, most of whom were actively engaged in research on these and related fields, expressed the hope that the symposium would help to focus attention on the important problems of nitrogen in tropical agriculture.

A. G. EYLES

RHEOLOGY IN AUSTRALIA

A SYMPOSIUM on "Visco-Elastic Systems" was held during February 16–18 at the Division of Forest Products, Commonwealth Scientific and Industrial Research Organization, Melbourne. Organized by the host laboratory, the meeting was attended by more than fifty delegates from universities, industrial concerns and research institutes, and it foreshadowed some of the activities of the nascent Australian branch of the British Society of Rheology.

Opening the conference, Dr. F. W. G. White, chairman of the Organization, stressed the need to place industrial activity on the most mature and fundamental scientific basis. He welcomed the move to form a rheological society in Australia, which would provide more opportunity for co-operation on common problems in different scientific fields.

The topics were grouped into six sections. In the first of these, "Structural Interpretation", B. J. Rigby reviewed theories of rate processes, and illustrated the use of the Burte-Halsey theory by its application to the rheological behaviour of wool. R. S. T. Kingston applied rate-process theory to the analysis of time-dependent mechanical behaviour of wood at high stresses. A qualitative change in the flow process was indicated by a stress region where energy constants underwent sudden changes.

H. G. Higgins presented a theoretical account of the behaviour of hydrogen-bonded materials, based on the work of Prof. A. H. Nissan. Chemical substitution of hydroxyl groups in cellulose can confirm the basic assumption that the mechanical response is controlled by the number of hydrogen bonds per unit volume. Dr. N. W. Tschoegl gave an account of his studies on monomolecular cereal protein films. The influence of the substrate on the visco-elastic properties of the film yields much information on the nature of bonding in the film. A. W. McKenzie discussed the influence of inter-fibre bonding in a paper on the tensile stress-strain behaviour. A qualitative change in the orientation of fractures with increased bonding is interpreted as an increase in shear strength relative to tensile strength. R. C. Gifkins, after briefly surveying the subject of deformations in crystals, suggested that apparent viscous relaxation in grain boundaries may be an interaction of dislocations and vacancies, that is, a discontinuous crystalline process.

In the second section, "Heterogeneous Systems", Dr. F. A. Blakey discussed the relative contribution of the cement paste and of the aggregate to the creep of concrete. J. De Yong, in a paper with H. G. Higgins, described draining studies on a pad of cellulose fibres, representing an early stage of paper formation. Compressibility of the porous medium complicates both the Kozeny and the drag equations. L. Dintenfass presented a rheological classification of suspensions, separating the properties of the solid and the liquid phases. He correlated colloidal structural properties such as sedimentation volume with the flow-curves of paints and other systems.

In the following section, "Hygroplasticity", several papers were devoted to wood and one to wool. Dr. G. N. Christensen described the effect of rheological properties on sorption. He had observed that the rate of water sorption by thin layers of wood is inconsistent with diffusion control, and suggested it might be dependent on the relaxation of swelling stresses. Two important practical effects arising on drying wood, namely, 'collapse' and 'set', formed the subject of a paper by Dr. W. G. Kauman, who correlated macroscopic observations with the molecular processes in the cell wall. M. Feughelman discussed the effect of humidity on stress relaxation in wool, and suggested a model in which hydrogen bonds break in the presence of 'mobile' water. L. D. Armstrong presented experimental evidence on the great increase in creep of wood when changes in moisture content take place while the material is loaded. The influence of changes in moisture content was also observed by J. W. Gottstein, who used strips of wood veneer held at constant deformation and subjected to humidity cycles.

The fourth section was concerned with "Specific Materials". Dr. F. A. Blakey reviewed factors influencing the creep of gypsum plaster, and again emphasized the effect of free moisture content on the stress-strain-time relations. Various practical requirements of glazing compounds were discussed by E. R. Ballantyne, who compared the properties of oil-based and rubber-based compounds. C. Massey described tests on several thermoplastics with reference to their suitability for model structural analysis.

In a section on "Instruments", Dr. B. I. Aldrich, in a joint paper with E. L. Newman, described a Couette viscometer designed for testing syrup during fractionation; it accommodates a wide range of shear stresses and has close temperature control. K. G. Martin described a micro-viscometer and discussed factors in its operation.

"Continuum Theory" was the subject of the last section. Dr. P. U. A. Grossman discussed Prof. K. Weissenberg's ideas leading from an assumed restriction on stress directions for a given strain history to observable phenomena, such as cross-stresses.

A policy session was held, at which the possibility of future co-operation in the field of rheology was discussed. In New South Wales the branch of the Society of Rheology has already held several meetings and has arranged a full programme of activities for the current year, including lecture courses on rheology. Plans were discussed for broadening the interest in this field, and for holding future meetings both at the local and national level.

P. U. A. Grossman

GAS CHROMATOGRAPHY

The Gas Chromatography Discussion Group of the Institute of Petroleum Hydrocarbon Research Group held its annual general meeting in conjunction with an informal symposium at the Brunel College of Technology, Acton, London, W.3, on April 22. The secretary, Mr. D. H. Desty, reported that the Group had had another successful year in which it consolidated its position following the rapid expansion of the past few years. Interest in the Group's activities has been well maintained and its status in the field is now well recognized on an international basis.

The abstracting service organized by the Group has made rapid progress, and more than 100 British and foreign journals are abstracted regularly by a team of 25 abstractors. The inaugural volume of "Gas Chromatography Abstracts", 1958, was published by Butterworths, London, on May 5, and has largely been the work of Mr. C. E. H. Knapman, the editor of the Group's editorial committee. This volume provides abstracts and, more particularly, a detailed subject index for 1,468 papers in this field published up to January 1, 1959. Succeeding volumes will appear annually.

Dr. A. T. James and Dr. D. Ambrose have taken part in the preparation by an international committee of preliminary recommendations on the nomenclature and presentation of gas chromatographic data, which were presented to the Analytical Section of the International Union of Pure and Applied Chemistry in September, 1959. These have now been approved in the International Union for publication. The Group's financial position is very sound, and its financial year has been adjusted to coincide with that of the Institute of Petroleum Hydrocarbon Research Group (that is, to the end of September). No change in the annual fee (1 guinea), which is now primarily intended to cover the cost of publications issued by the Group, is therefore necessary.

The informal symposium which followed the annual general meeting was organized and introduced by Dr. J. A. Skellon of Brunel College of Technology, who commented on the active research interests of the College in the field of gas chromatography. The first paper, and perhaps the highlight of the meeting, was that by Dr. J. H. Purnell on the modification of solid supports. Dr. Purnell described measurements, made in his laboratory, of the adsorptive properties of 'Celite' and brick dust which show that whereas 'Celite' has the lower adsorption, brick dust has the more reproducible properties. These experiments were made with the view of studying treatments of the support which might reduce adsorption and minimize tailing of peaks. One promising method of treatment is the use of hexamethyldisilazane, which reacts with hydroxyl groups. Its practical application is simple and the treated support is unwettable and has reduced adsorption. Although chromatograms obtained on the treated support are improved, a further improvement is obtained if 0·1 per cent polyethylene glycol is added to the column with the stationary phase. One disturbing fact is that treatment of the support in this way has a slight effect on values of the specific retention volume even when the columns contain as much as 20 per cent of stationary phase.

The other contributions to the meeting concerned the study of pyrolysis products. Dr. J. Girling described studies on the identification of the primary products of the pyrolysis of coal, in which field the introduction of gas chromatography has enabled the scale of experiments to be reduced from 20 kgm. to 20 mgm. A 20-mgm. sample is heated to a series of steady temperatures ranging from 50° up to 700° C. and the products of pyrolysis at each temperature are swept into a refrigerated trap. The analytical sample is injected on to the column, containing polyethyleneglycol or squalane, by means of an automatic valve of 0·1 ml. capacity; there was considerable interest in the design of this valve, the fixed sample volume of which is formed by a length of 1-mm. bore nylon tubing between two sections of the tubing which are compressed by cam-operated plungers. Dr. J. Blenkin described the analysis of hydrocarbon elastomers by combined pyrolysis and gas chromatography. It was hoped that elastomers could be identified if the monomers from which they are made could be obtained from them and analysed by gas chromatography: to a large extent this hope has been realized. Samples are pyrolysed by dropping them into a heated silica tube attached to the apparatus, so that the products of pyrolysis are swept into the column and chromatographed; for example, polybutadiene gives a chromatogram of butadiene, natural rubber one of a mixture of isoprene and dipentene. Dr. Lehrle described similar experiments in which the degradation was carried out in stages. A sample is placed in a coil of resistance wire in the form of a basket which is located at the entrance to the column. The temperature of the wire is varied by altering the current passing through it, and within half an hour a series of chromatograms can be obtained corresponding to the degradation of the one sample at each temperature. The series of chromatograms is characteristic and suitable for qualitative and quantitative analysis.

The symposium concluded with a general discussion on sample injection, which was introduced by Dr. Purnell. Most speakers were agreed on the difficulty, if not present impossibility, of injecting representative samples for quantitative analysis which are small enough to be satisfactory with ionization detectors. The lower limit of sample introduction possible with pipettes and syringes is probably about 25 micrograms. Various suggestions—for designs of valves or introduction of the sample in solution—were made, but the simplest proposal for quantitative analysis was made by Dr. A. B. Littlewood, namely, to use a large sample and correspondingly insensitive detector.

D. AMBROSE

MEDICAL RESEARCH IN MALAYA

THE valuable research work being done in the vast field of tropical medicine is well brought out in the annual report of the Institute for Medical Research, Federation of Malaya, for 1958.

The Institute is divided into a number of divisions, each of which is carrying out investigations into diseases which are baffling and wide-spread. In the Pathology Division, for example, a curious type of allergic granuloma, apparently hitherto undescribed and believed to be the result of an auto-immunity reaction, has been investigated for some years. The variations in the behaviour of melanocytes when surrounded by atypical or malignant epidermal cells have also been studied.

A number of important investigations are being made in the Division of Nutrition and Biochemistry. Severe anæmia is one of the main complications of pregnancy in Asian women, and one in eight of the beds available for ante-natal patients in the General Hospital, Kuala Lumpur, is occupied by a patient requiring treatment for anæmia. Premature births, deaths of infants and of mothers were all increased in this group of women.

The relationship of hookworm infection to anæmia was also studied: the greater the degree of anæmia, the higher was the proportion of patients with hookworm infection. The use of radioactive chromium enabled calculations of the daily loss of blood apparently due to hookworms; with heavy infections this could amount to as much as 80 ml. (almost 3 fl. oz.) of blood a day. Other studies were made on the changes in blood volume in chronic anæmia, on the factors influencing response to treatment, and on the reasons for the frequent low levels of vitamin B_{12} to be found in patients with megaloblastic anæmia.

Dietary inquiries made in the homes of a number of the patients indicated that various causes, besides poverty, were responsible for the poor diets which finally resulted in their admission to hospital with nutritional anæmia.

In almost every area where sufficient numbers of 'toddlers', children aged 1–4 years, have been examined, examples of protein malnutrition can be found; this is true even in the heart of Kuala Lumpur. Only a few come to hospital; they must be sought out by home visits and detailed inquiries. As might be expected, the condition is most common in isolated areas where communications are poor and unemployment is prevalent. A detailed investigation was made of kampongs on the Perak River where protein malnutrition is common; the diets there were found to be most unsatisfactory, and well below the recommended allowances.

In the Bacteriology and Serology Division, research activities were directed to the production of vaccines to combat epidemics of cholera and smallpox.

The search for Malayan streptomyces which may produce antibiotics continued, but without success; resistance of bacteria to the commonly used antibiotics is becoming more noticeable.

Resistance to the tubercle bacillus is now reaching the point where it presents a serious problem. Judging by sensitivity tests, about 10 per cent of local strains are completely resistant to streptomycin, about 10 per cent are resistant to *p*-aminosalicylate, and 2 per cent to isoniazid. Partial resistance to one or other of these drugs is found in 30–50 per cent of strains tested.

The Virus Research and Medical Zoology Division continued its work on arthropod-borne and other viruses. Further work was done on the survey of animal reservoirs of leptospirosis, and infected rats were obtained from Maxwell Hill in Perak, from Langkawi Island, and from parts of Trengganu. By contrast, no infections were found in much larger numbers of rats from Selangor coastal region. A new development, still being investigated, was the finding of evidence of frequent infection in one but not another species of water-snake in Kuala Lumpur streams.

Leptospirosis in humans is now recognized as being much more common than had been suspected a few years ago, and the virus laboratory is at present trying to assess the diagnostic value of a relatively simple test, suitable for use in a routine laboratory.

At the request of the World Health Organization, the Entomology Division carried out tests to assess the merits of two types of apparatus in which mosquitoes are held for short periods against surfaces treated with insecticide, and the kill later recorded. The opportunity was taken to include the organo-phosphorus compound, malathion, in these tests: the duration of effectiveness proved to be about three months, which was longer than had been expected. The importance of this finding is that malathion has had to be used to control bed bugs which have developed resistance to the usual residual insecticides, especially dieldrin. Reports of such resistance were received from three rubber estates and a small mental hospital, and malathion is reported to have given satisfactory results.

An incidental result of house-spraying with dieldrin has been the virtual elimination of head-lice in the children living in the sprayed houses. Whereas in unsprayed areas infestation-rates in both boys and girls were 70–90 per cent, no active infestation could be found in the children where spraying had been carried out for one year.

Other work done at the Institute was by the U.S. Army Medical Research Unit, Malaya. The unit investigated two outbreaks of scrub typhus in the Commonwealth Forces in some detail. One in central Perak, near Ipoh, was unusual in that the disease was mild, the Weil–Felix reactions were negative, and cases occurred in forest during the dry season instead of in scrub terrain in the wet season. *Rickettsiae*, however, were isolated in mice inoculated with blood from several patients, and they appear to belong to the scrub typhus group. Cases from the other outbreak in south-east Johore were typical in nature, and Weil–Felix tests were positive.

The report may be obtained from the Director of Medical Research, Federation of Malaya, Kuala Lumpur.

SURFACE TEMPERATURE OF SWEDISH LAKES AND THE ORIGIN OF RAINFALL

By VILHELM IRGENS PETTERSSON*
Bollstavägen 10, Enskede, Sweden

The Dry Summer of 1959

THE accompanying diagrams (Figs. 1–4) give the distribution of rainfall over Sweden as a percentage of the normal in 1959 (published by the Meteorological and Hydrological Institute of Stockholm). They show very clearly that in the summer of 1959 Sweden shared the scarcity of rainfall characterizing the weather over most of north-western Europe, although it varied from place to place. As will be seen, the whole inland area, generally speaking, with its half-dried-out rivers and reduced crops, is framed in by belts of moisture along the coasts and the Norwegian and the Finnish borders, broadening to their maximum in the north.

The period of deficit in rainfall over the major part of Sweden lasted for the five months May–September, according to the monthly surveys of the Meteorological and Hydrological Institute in Stockholm, from which the following data are cited:

May. Total precipitation averaged 87 per cent of normal, with sub-variations of 300 per cent in the north down to 10 per cent in the south.

June. Total precipitation averaged 61 per cent of normal with sub-variations of surplus in the north and deficit in the south with its minimum in the middle south-west.

July. Precipitation in general 72 per cent of normal with a minimum of 10–25 per cent in the northern Baltic coast-land.

August. Precipitation in general 41 per cent of normal; 100 per cent only in limited areas in farthest north and south.

September. Precipitation as total average 53 per cent of normal except along the northern part of the Norwegian border, and in a belt running east–west from south of Lake Vanern to the coast south of Stockholm with a rainfall 100–200 per cent of normal.

Note. In the following, temperatures are in degrees centigrade, distances and depths are in kilometres and metres respectively; surface temperatures were measured 0·5–1·0 m. beneath the surface.

Rainfall South of lat. 59° 30′ N. and Deviations in Temperature from the Average during July–September 1959

In this part of Sweden the landscape is dominated by the two big lakes, Lake Vänern with an area of 5,500 km.^{2}, and Lake Vettern with an area of 1,900 km.^{2}.

July (Fig. 1). The average temperature was 2°–2·5° above normal; precipitation 100 per cent and more only in the south inside a triangular area with its base along the Öresund and farther east to the south point of the island of Öland, reaching up to the south end of Lake Vettern; this lake, together with the north part of Lake Vänern falling inside the contour for 50–75 per cent of rainfall, the south part of Lake Vänern again being inside a region of almost total dryness.

August (Fig. 2). Average temperature was 2°–3° above normal. Precipitation was 10–50 per cent of the average. It was up to normal only in isolated areas, one of them around the south end of Lake Vettern whereas Lake Vänern registered 25 per cent and less.

---

[*] Formerly of the Service Hydrographique in Copenhagen and editor of its *Bulletin Trimestriel*.

September (Fig. 3). Average temperature was 0·5°–1·5° above normal. Precipitation was only 10–50 per cent of the average except inside a broad belt of 100–200 per cent of normal stretching from a region south of Lake Vanern eastwards, covering Lake Vettern and farther east passing the Baltic to the island of Gotland, its southern border touching the north point of the island of Öland.

Probable Cause for Heterogeneous Distribution of Rainfall

A study of the diagrams for July–September gives the impression that the surface of Lake Vettern, in the midst of an almost dried-out inland area, exercises a sort of attraction on the contours encircling areas of increased rainfall (July) in some cases being more or less included therein (August–September); by contrast, the surface of Lake Vánern, its neighbour to the west, is generally speaking, avoided by the contours, and in some cases came partly inside regions of almost total dryness (July–August). In order to explain this difference we have to look into the hydrographical conditions characterizing the two lakes.

Lake Vanern. The surface of this lake is a quadrilateral figure of about 70 km. × 70 km. apart from a peninsula cutting into it from the north-west. Its bottom topography over the major part of its area is more or less a plane from 20–40 m. beneath the surface, and sloping slightly west- and northwards where in isolated places depths up to some 90 m. have been sounded. The water in this shallow basin in periods of intense insolation during the summer months easily attains a surface temperature of 20° and higher, which has been the case for months in the hot summer of 1959. Measurements then undertaken in the middle of July by the Meteorological and Hydrological Institute showed a surface temperature of 19·3°.

Table 1

Stations	(1)	(2)	(3)	(4)
Date (July)	22	20	20	20
Wind	?	N., faint	N., faint	quiet
Air temp. (°C.)	?	16·3°	15·8°	17·0°
Water temp. (°C.)				
(*a*) Surface	18·2°	17·7°	15·25°	12·8°
(*b*) Soundings				
At 54·5 m.	6·7°	—	—	—
At 15 m.	10·8°	—	—	—
At 5 m.	17·3°	—	—	—
Above depths of	55·5 m.	0·80 m.	0·9 m.	2·8 m.

Lake Vettern. This is farther east; its basin was created by a depression in the Earth's crust, forming a groove stretching south-south-west–north-north-east 128 km. in length by some 20 km. in width, up to 30 km. only where the Gota Canal cuts through the

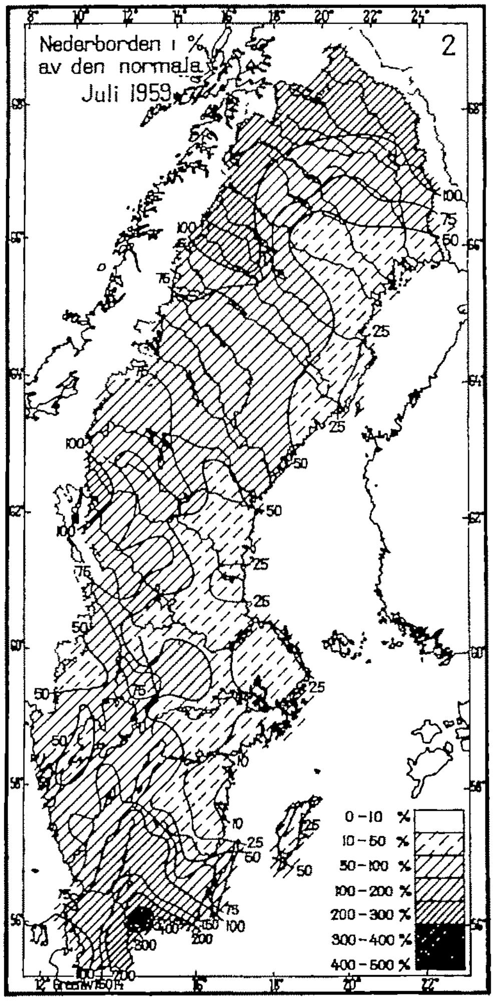


Fig. 1. July

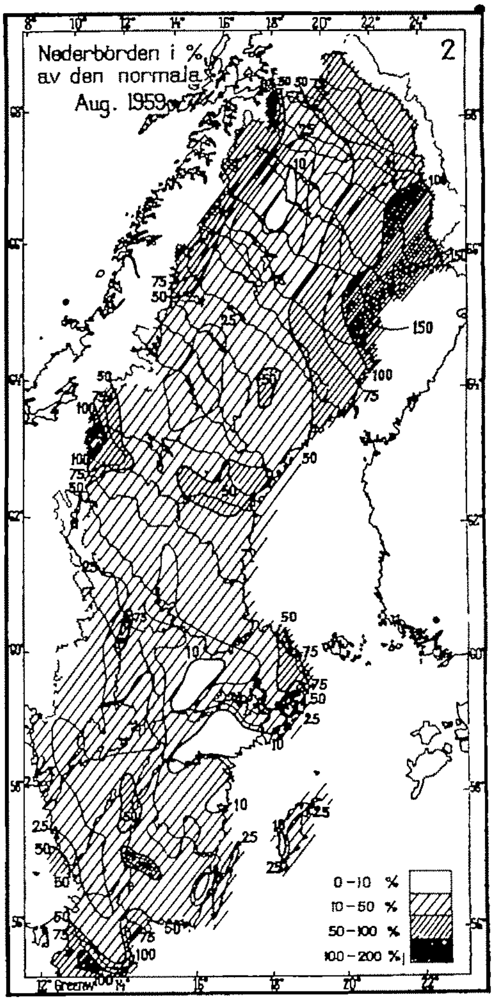


Fig. 2. August

Table 2

1959 Date	July 1	July 11	July 21	August 1	August 11	August 21	September 1	September 11	September 21	November 1	November 11	November 21
Sv. Bj.	10·9°	14·8°	17·0°	18·2°	18·9°	20·3°	11·7°	13·0°	11·3°	8·8°	8·0°	7·1°
Average		14·7°			19·1°			12·0°			7·6°	
Vinga	17·7°	18·4°	19·3°	19·9°	19·1°	18·6°	16·6°	16·5°	15·7°	10·3°	9·9°	7·7°
Average		18·4°			19·3°			16·3°			9·3°	

east border at Motala. Its east and west borders slope down to meet in the bottom of the groove at a depth of some 100 m. running parallel to and some kilometres east of the longitudinal axis of the lake almost from end to end. The water of Lake Vettern is remarkable for its low surface temperature in summer relative to that of Lake Vanern, and also for the perfect clearness of its water, the neighbouring towns taking drinking water by pipe-lines from the Lake. Temperatures were recorded at four points along the borders of Lake Vettern in July 1959 by the Ice Service of the Meteorological and Hydrological Institute. The points of observations were (Table 1); western border: (1) Karlsborg, lat. 53° 30′ N.; (2) Hjo, lat. 53° 15′ N.; southern end of the Lake: (3) Jonköping; eastern border: (4) Gränna, lat. 58° N.

The variations in surface temperature of Lake Vettern in a period of intense insolation giving an average of at least 4° below that of Lake Vänern are caused by a mixing of the sun-heated surface with colder water from the deeper layers, due to a continuous vertical circulation both ways. The prime agent effecting this is the wind by its tangential pressure on the surface layer, particularly since its direction crosses the Lake perpendicular to its longitudinal axis, namely, east–west and vice versa. The water on the surface thus driven away from the windward border towards the lee border, making colder water from beneath rise and mix with the warmer upper layer, effects a reduction in its temperature. In consequence the surface temperature in Lake Vettern as a rule is higher at the lee and lower at the windward border.

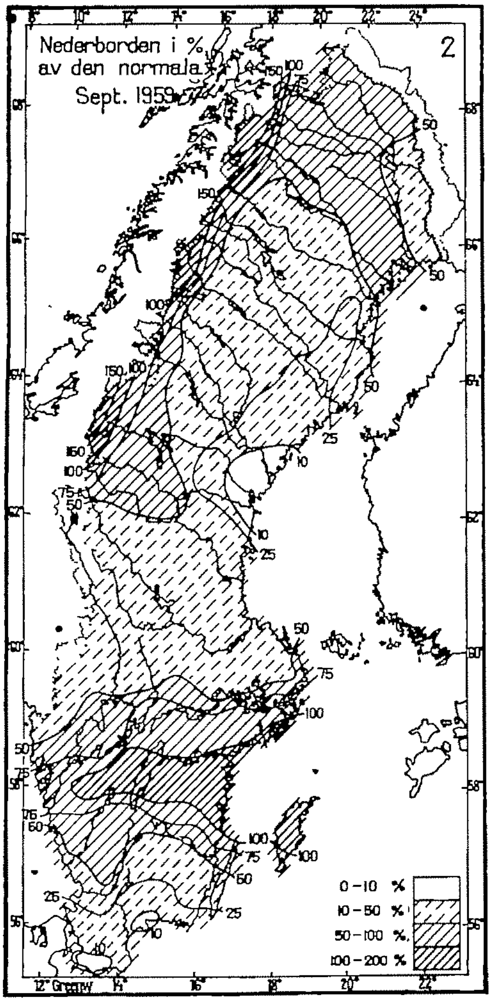


Fig. 3. September

Incidentally, the same phenomenon on a gigantic scale takes place off the west coast of North Africa, where the hot winds from the Sahara always blowing westwards drive the surface layer out from the coast, thereby allowing cold water from the deeper layers to rise to the surface. As a consequence, this part of the North Atlantic has its surface temperature reduced to less than 20° and even to some 16° as far west as the Canaries.

But the tangential pressure on the surface layer, when directed instead more or less parallel to the longitudinal axis of the Lake, namely, north–south or vice versa, drives the water from one end towards the other and makes the water-level rise at the lee and sink at the windward end—which on a reduced scale takes place also in the first case—and gives rise to another phenomenon known as the 'seiches of Lake Vettern'. This phenomenon was studied in the early part of the present century by Dr. F. Bergsten and published by him in a treatise under that title. By bringing the water-level out of balance, the whole bulk of some 80 km.^{3}—some 80 billion tons of water—is set swinging like a gigantic rocking chair on a nodal axis half-way between the ends of the Lake where the movement is nil, increasing to its maximum at either end, the water-level here alternately rising and falling with the same amplitude relative to the horizontal plane. This phenomenon is characteristic especially of oblong lakes and was first studied by Forel in Lake Leman and later by Chrystal and Maclagan-Wedderburn in the Scottish Lochs Earn and Treig. Dr. Bergsten based his work on the methods elaborated by Chrystal and found the seiches of uninodal order in Lake Vettern to have a maximal amplitude of 13 cm. and a frequency, that is, time between oscillations, of 174–180 min.

Variations in barometric pressure have also been found under certain conditions to influence the formation of seiches caused by the winds, for example, when minima pass parallel to its longitudinal axis.

To ascertain the difference in surface temperature between Lake Vettern and the sea areas east and west of southern Sweden swept by the winds before passing over the district of the big lakes, observations from the series registered daily on the Swedish light-vessels *Svenska Bjorn* in the Baltic east of Stockholm and *Vinga* west of Gothenburg for July–September are given in Table 2. The corresponding observations for November are also given, representing a later

Table 3

1959	November										
Date	2	3	4	5	6	9	12	13	17	18	30
Wind	W. 7	S.W. 10	S.W. 6	N. 3	—	S. 4	S.E. 3	S.E. 8	N.E. 10	S.E. 5	E. 5
	Lee border						Windward border				
$T°$ (4 m.)	9°	9°	9°	8°	7°	7°	7°	7°	7°	6°	6°
Sv. Bj.	8·8°						8°			7·1°	
Vinga	10·3°						9·9°			7·7°	

period of another thermal character to be dealt with later.

The cold surface of Lake Vettern, almost 2,000 km.[2] in area and situated in the midst of a depression in the highland plateau of southern Sweden, will in hot summers continuously build up a 'mound' of cooled air, making the warmer winds ascend and unload their moisture as shown by the curves of Figs. 1–3 in accordance with the theory of Vilhelm Bjerknes.

The above data from the Baltic and the Skagerak for August 1959 compared with the average values calculated by the Deutsche Seewarte in Hamburg represent a surplus of 3–4 deg., whereas the surface layer of the Baltic in ordinary summers is cooled by the outflow from the rivers in the north transporting water from the melting snow in the mountains of Sweden and Finland. Its total mass, holding a few parts per thousand of salt from a bottom current entering by the Belts from the Kattegat, like a gigantic river is perpetually moving south to its outflow through the Belts and the Öresund into the Kattegat at a yearly quantity calculated by Witting as about 430 km.[3]. Presumably the total for 1959 will undergo a considerable reduction because of the scarcity of rainfall over the Baltic and the diminished influx from the rivers where the low water-level has made timber-floating almost impossible.

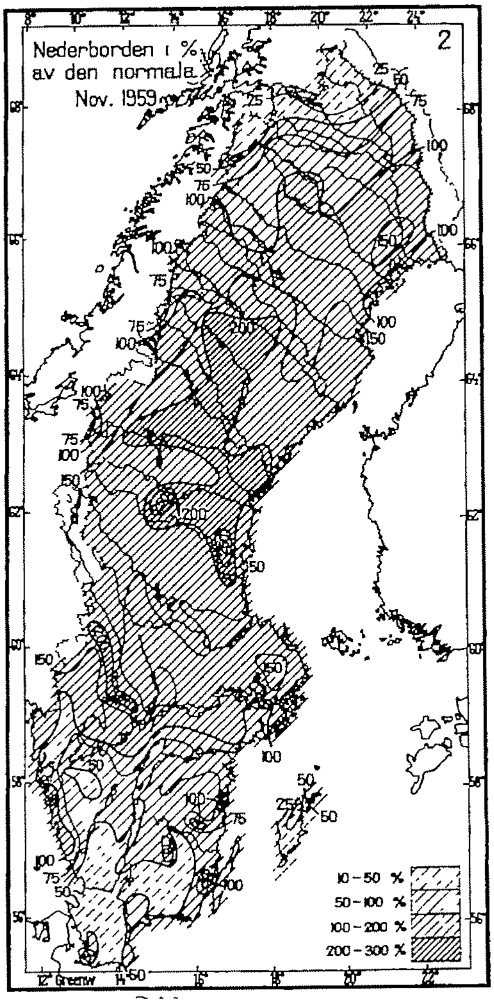


Fig. 4. November

An open question is whether the continuous damming up of river water for bigger and bigger hydro-electric plants for supplying electric power in winter does indeed cause a noteworthy reduction in the summer outflow into the Baltic. This, in periods of intensified insolation, would tend to increase its surface temperature.

The Situation in November 1959

According to the monthly meteorological survey, the average temperature south of lat. 59° 30′ N., steadily sinking from September, still shows an excess above normal of 1–2 deg. Only in isolated places did precipitation amount to normal, in spite of the abundant rainfall of up to 200 per cent and more in middle and northern Sweden north of the curve for 100 per cent rainfall running east-west and including the major part of Lake Vänern in that area, but leaving Lake Vettern south of it in a rainfall area of 75 per cent of the average and extending its southern end into an offshoot from an area of maximal scarcity in the farthest south.

Thus in November, both Lakes seem to have exchanged their former character of attractiveness or the opposite on the curves of increased precipitation. Surface data for Lake Vänern, however, could not be obtained, but by a lucky chance temperatures for Lake Vettern in November have been supplied by courtesy of Chief Engineer G. Wigforss of Motala, being registered at 4 m. beneath the surface at a point 500 m. west of Motala at the eastern border where Mr. Wigforss wanted for a special purpose to ascertain the thermal development.

Table 3 shows the temperatures together with (*a*) the direction and velocity of the wind, because as already mentioned they influence indirectly the variations in surface temperature and (*b*) for comparison also data for the Baltic and the Skagerak.

The reason for accepting data at a depth of 4 m. as representative for the surface is that the direction of the wind is alternately from either border, thus shifting between windward and lee. The temperature of the former being expected to sink and the latter to rise will give a medium value at 4 m. of satisfactory accuracy for the purpose of a comparison with that of the sea surface.

The results indicate that the usual reduction in surface temperature during September has taken place at a slower rate in Lake Vettern than in the sea east and west, resulting in an equilibrium in November. This explains the disappearance of any tendency to start a moisture condensation from the air above or in the vicinity of the Lake, contrary to the situation in the preceding months.

Discussion

The present work indicates an equivalence between the temperature of the sea surface on either side of

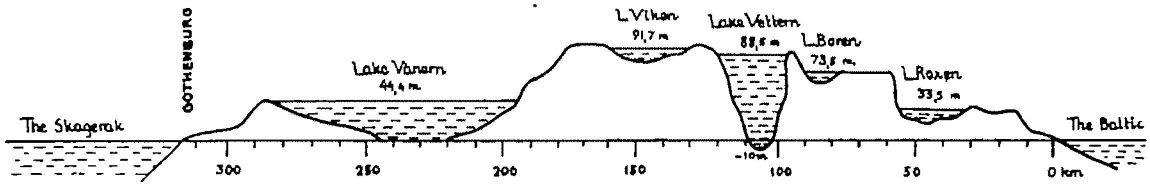


Fig. 5

Sweden in the summer of 1959 and that of the continental and Atlantic winds sweeping it, in contrast to the difference in ordinary years prevailing between the cooler surface of the Baltic and the Skagerak relative to the warmer atmosphere above. Application of the thesis formulated by Otto Pettersson from a climatic point of view leads to the conclusion that this balance in the thermal state explains the scarcity of rainfall over the major part of Sweden during the summer of 1959, the invading winds from south and west not unloading their moisture until attacking the cold wall of the polar front, apparently established farther north than in ordinary years when July statistically holds the year's record in rainfall.

The apparent activating influence by the colder surface of Lake Vettern on condensation of moisture in the air above it during July–September is also in agreement with this thesis, as well as the simultaneous scarcity in rainfall over and in the vicinity of Lake Vänern, then presumably of a temperature equal to that of the sea surface to the east and west. Hence the occurrence of cold and moist summers, at least in south and middle Sweden up to a certain elevation above the sea-level, will be directly related to a difference in surface temperature between the Baltic and the Skagerak and the warmer winds from the south and west, depending on or in connexion with an extension to the south of the polar front, a problem which was attacked from a cosmic point of view by Otto Pettersson in his lecture referred to above.

Fig. 5 gives the profile of a vertical section of southern Sweden following the course of the Göta Canal and cutting the highland plateau between the Baltic and the Skagerak, on its way crossing both Lakes Vettern and Vänern. As will be seen, the surface of the latter is 44·4 m. above the sea surface whereas that of Lake Vettern reaches 88·5 m. above and the deepest part of its bottom groove some 10 m. below, its maximal depth thus amounting to about 100 m. (Lake Vettern, however, is very shallow compared with the biggest Norwegian lake, Lake Mjösa, only 359 km.^{2} in area but with a maximal depth of 443 m., of which no less than 322 m. is below and 121 m. above the surface of the North Sea.) For the exact middle water-level in the respective lakes I am indebted to the directors of the Göta Kanal Co., Ltd., through Colonel B. Klint, Motala.

The significance of hydrography for meteorological forecasting cannot be over-emphasized, provided that the necessary data, especially regarding surface temperature from the actual sea areas, can be provided at a sufficient geographical extension and within the shortest time possible, as is done in reporting of air temperatures on land to the meteorological centres. It is a question of devising a rationalized technique for speedy sampling of the data and bringing them to the forecaster.

BIBLIOGRAPHY

Pettersson, Otto, lecture at the Royal Swedish Agricultural Academy in 1935 regarding condensation of moisture caused by difference in temperature between warm and cold air being mixed together.
Monthly Survey of Weather and Water Supply for May–November 1959 (Meteorological and Hydrological Institute of Stockholm).
Witting, R., "Havsytan, Geoidytan och Landhojningen utmed Baltiska Havet och vid Nordsjon" (Helsingfors, 1918).
Bergsten, F., "The Seiches of Lake Vettern", *Geogr. Ann.*, 1–2 (1926).
Means of T° for the beginning of August: "Atlas der Deutschen Seewarte", 1927.
Bjerknes, V., *Quart. J. Roy. Met. Soc.*, **46** (1920).
Schott, G., "Geographie des Atlantischen Ozeans" (Hamburg, 1920).

CORRELATION BETWEEN COMPOSITION, STRUCTURE, SHAPE AND FUNCTION OF A SALIVARY MUCOPROTEIN

By Dr. ALFRED GOTTSCHALK
Department of Microbiology, John Curtin School of Medical Research, Australian National University, Canberra

MUCOPROTEINS may be defined as conjugated proteins having hexosamine containing oligosaccharides as multiple prosthetic groups. For bovine submaxillary gland mucoprotein, a representative of this class, Hammarsten[1] established in 1888 the presence of a firm chemical linkage between carbohydrate and protein, and he also recognized the strongly acidic character of the compound. In 1901, F. Muller[2] isolated crystalline D-glucosamine hydrochloride from bovine submaxillary gland mucoprotein and demonstrated the presence of acetyl groups in this mucoprotein. During the next fifty years little attention was paid to mucoproteins and scarcely any notice was taken of the important discovery by Blix[3] of a new, though unidentified acidic carbohydrate in bovine submaxillary gland mucoprotein. The situation changed dramatically when Burnet[4] and co-workers showed: (1) that many glandular mucins of human and animal origin, among them the submaxillary gland mucins of ruminants, inhibited hæmagglutination by heat-inactivated influenza virus, (2) that the active principle of the mucin was a mucoprotein and (3) that living influenza virus and an exo-enzyme of *Vibrio cholerae* (*RDE*) destroyed this inhibitory capacity.

The elucidation of the chemical reaction underlying the enzymic inactivation of the inhibitory mucoproteins was initiated when Gottschalk[5] and co-workers isolated a dialysable compound of low molecular weight from the digest of purified inhibitory mucoproteins and purified influenza virus and *RDE*, respectively. The chemical properties of the 'split product' closely resembled those of the acid isolated by Blix[5] from bovine submaxillary gland mucoprotein and termed in 1952 'sialic acid'[6]. By treating bovine submaxillary gland mucoprotein with 5 per cent methanolic hydrochloric acid, Klenk *et al.*[7] obtained the same methoxyneuraminic acid which Klenk had previously prepared from certain brain mucolipids by a similar procedure. Furthermore they isolated from bovine submaxillary gland mucoprotein N-acetylneuraminic acid and on repeating Gottschalk's work identified the crystalline split product as N-acetylneuraminic acid[7].

Concerning the structure of the new sugar acids, Gottschalk[8] proposed in 1955 on the available data a comprehensive scheme with neuraminic acid as the parent structure common to sialic acid, N-acetylneuraminic acid and methoxyneuraminic acid. Neuraminic acid was visualized as an aldolcondensation product of hexosamine and pyruvic acid, N-acetylneuraminic acid as N-acetylated neuraminic acid, sialic acid as N,O-diacetylated neuraminic acid and methoxyneuraminic acid as the methylglycoside of neuraminic acid. By the fusion of pyruvic acid with hexosamine a keto-, deoxy-, hydroxyl- and amino-group become α-, β-, γ- and δ-positioned respectively to the carboxyl group, an alignment favouring cyclization to a pyrrole ring. It was the conversion of the split product to pyrrole-2-carboxylic acid[9] under mildest alkaline conditions which rendered possible the allocation in space of the functional groups, elaborated previously by Blix *et al.*[10] and Klenk *et al.*[7]. The correctness of the scheme was proved by alkaline degradation of N-acetylneuraminic acid to N-acetyl D-glucosamine and pyruvic acid[11] and by the chemical synthesis[12] of N-acetylneuraminic acid from N-acetyl D-glucosamine and oxaloacetate at *p*H 11·0 and 20°. Recently, Comb and Roseman[13] showed that the N-acetylhexosamine fragment of N-acetylneuraminic acid has the steric configuration of N-acetyl D-mannosamine, the ease of the epimerization reaction N-acetyl D-glucosamine $\rightleftharpoons$ N-acetyl D-mannosamine accounting for the synthesis of natural N-acetylneuraminic acid from N-acetyl D-glucosamine and oxaloacetate.

The main sugar components of the homogeneous submaxillary gland mucroproteins are N-acetylgalactosamine and sialic acid (in the new nomenclature[14] the generic name of all N- and O- substituted neuraminic acids). Bovine submaxillary mucoprotein contains equimolecular amounts of sialic acid (22·4 per cent expressed as N-acetylneuraminic acid) and N-acetylgalactosamine besides small quantities of other sugars. In ovine submaxillary gland mucoprotein the total carbohydrate (42 per cent) consists practically only of N-acetylneuraminic acid and N-acetylgalactosamine in the molecular ratio 1 : 1.

In the elucidation of the structure of the carbohydrate group of the submaxillary gland mucoproteins the *Vibrio cholerae* enzyme *RDE* proved to be a valuable tool. The liberation of 70 per cent of the total sialic acid, and of sialic acid only, from bovine submaxillary gland mucoprotein by *RDE* suggested a terminal position of the acid; the reducing power of the sialic acid released from the non-reducing bovine submaxillary gland mucoprotein indicated a glycosidic (ketosidic) linkage of the terminal sialic acid to its partner, thus allowing classification of the enzyme as a glycosidase. The further qualification of *RDE* as an α-O-glycosidase was derived from *RDE* action on sialyl-lactose. The enzyme was named 'neuraminidase'[15].

The prosthetic group of ovine submaxillary gland mucoprotein was readily released by mild alkali treatment. On heating an ovine submaxillary gland mucoprotein solution, adjusted to *p*H 11·5 with barium hydroxide, at 80° for 15 min., 22 per cent of the prosthetic groups were released, and this treatment could be repeated several times yielding further quantities of prosthetic groups. The prosthetic group was identified as α-D-N-acetylneuraminyl (2 → 6) N-acetylgalactosamine by elementary analysis, cleavage into its components by neuraminidase, consumption of 4 moles IO_4^-/mole and by conversion to characteristic derivatives[16].

The prosthetic groups are joined through their reducing ends to the free carboxyl groups of glutamic and aspartic acid residues by a glycosidic ester linkage. This was first indicated by an appreciable drop in *p*H concomitant with the release of prosthetic groups when an ovine submaxillary gland mucoprotein solution with an initial *p*H of 10·5 was heated at 80°. Quantitative determination of the number of prosthetic groups released and of the number of carboxyl groups unmasked were in fair agreement. The presence of a glycosidic ester linkage to aspartyl and glutamyl respectively was conclusively proved by the reduction of one of the carboxyl groups of the dicarboxylic acids when ovine submaxillary gland mucoprotein, after pretreatment first with trypsin and then with phenyl-*iso*thiocyanate, was dissolved in anhydrous tetrahydrofuran and acted upon with lithium boron hydride. This reagent is known to effect a reductive cleavage of ester linkages without appreciable action on amide or peptide bonds[17]. The recovery of total dicarboxylic acids of ovine submaxillary gland mucoprotein after such treatment was only 12 per cent of the normal value (10·7 gm. dicarboxylic acids expressed as glutamic acids), indicating esterification of one of the carboxyl groups of the missing 88 per cent dicarboxylic acids. Again the reductive cleavage was accompanied by the release of prosthetic groups. The extent of reductive cleavage of ovine submaxillary gland mucoprotein is limited by its rather low solubility in tetrahydrofuran, even after fragmentation by trypsin and blocking of the N-terminals by phenyl-*iso*thiocyanate to suppress ionization. The true extent of esterification is indicated by the finding that 84 per cent of the prosthetic groups are removed by heating ovine submaxillary gland mucoprotein at *p*H 11·5 and 80° for 4 hr.; this figure cannot be increased by more severe alkaline conditions. About 16 per cent of the prosthetic groups are linked in an alkali-stable O-glycosidic linkage, probably to serine and/or threonine[18].

The quantitative amino-acid analysis revealed a nearly complete complement of amino-acids; however, the content of aromatic and sulphur-containing amino-acids was low and that of glycine, proline and β-hydroxy-amino-acids high[19].

The susceptibility of ovine submaxillary gland mucoprotein to trypsin action is sterically hindered by the prosthetic groups which are bulky substituents at the side chains of frequently occurring amino-acids (Fig. 1). One out of 6·4 amino-acid residues carries a prosthetic group and one out of 16 amino-acid residues is a lysyl or arginyl residue, that is, 2·5 prosthetic groups/trypsin-susceptible bond. Removal by neuraminidase of the terminal

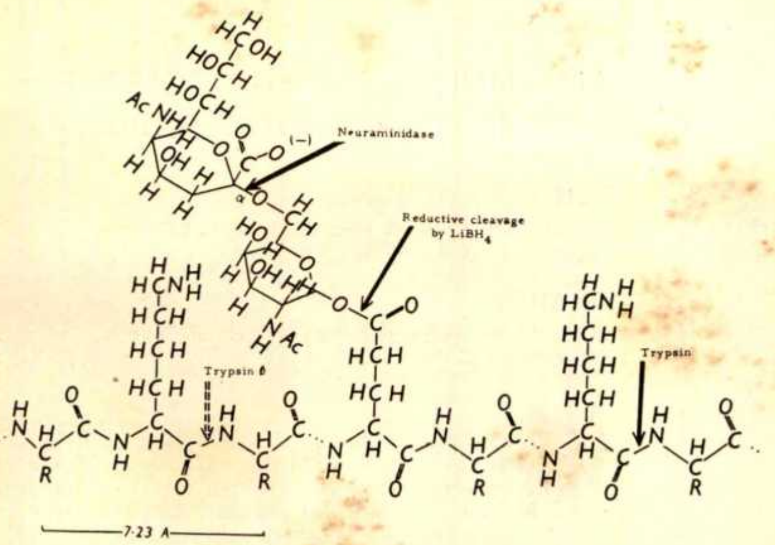


Fig. 1. Diagrammatic segment of ovine submaxillary gland mucoprotein showing: (1) the neuraminidase-susceptible α-ketosidic linkage; (2) the lithium boron hydride-susceptible glycosidic-ester linkage between prosthetic group and the carboxyl of a dicarboxylic acid (here the γ-carboxyl of glutamyl); (3) trypsin-susceptible bonds at the carboxyl of diamino-acids (here lysyl), one accessible to the enzyme, the other sterically hindered by the prosthetic group

N-acetylneuraminic acid units increased by 45 per cent the number of peptide bonds split by trypsin[20].

In the course of these experiments the observation was made that release of N-acetylneuraminic acid by crystalline neuraminidase at pH 6·0 decreased markedly the viscosity of ovine submaxillary gland mucoprotein. Quantitative measurements showed that the reduced viscosity of ovine submaxillary gland mucoprotein at pH 6·1 decreased from 3·13 to 1·33 on treatment with crystalline neuraminidase (free of proteinases). Since N-acetylneuraminic acid like pyruvic acid is a strong acid (pKa = 2·6), this result suggested a dependence of the shape of the molecule on the strongly negative charge of the prosthetic group. To test this suggestion the viscosity of ovine submaxillary gland mucoprotein was measured over a pH range of 7·8–1·8 under comparable conditions of ionic strength. There was little change between pH 7·8 and 4·3 (isoelectric point of ovine submaxillary gland mucoprotein = 4·7); however, the reduced viscosity dropped from 3·50 to 2·50 between pH 4·3 and 1·8, that is, in the pH range of decreasing ionization of N-acetylneuraminic acid. This decrease in viscosity was completely reversible on readjustment of the pH. These results would indicate that the strongly negative charge of the carboxyl groups of N-acetylneuraminic acid is responsible for the extended shape of the mucoprotein. On enzymic removal of N-acetylneuraminic acid at pH 6·0 or on suppression of its ionization the molecule assumes a more compact shape losing thereby its viscous character[21]. Prof. Linus Pauling has suggested to me as a possible structure of ovine submaxillary gland mucoprotein that the protein consists of α-helix segments loosely joined by proline residues. The prosthetic groups would then form a secondary helix around the protein core. It has been shown on models that the average spacing of 6·4 residues offers many possibilities for the formation of hydrogen bonds, in the direction of the helix axis, between adjacent sugar rings. The co-operative effect of the H-bonds and the electrostatic repulsion of the charged carboxyl groups of N-acetylneuraminic acid could preserve a rod-like structure despite the potential flexibility of ovine submaxillary gland mucoprotein at the sites of the proline residues.

In ruminants the submaxillary glands are the main mucus-secreting salivary glands; because of its high mucoprotein content the secretion is very viscous. This secretion together with that of the parotid gland (serous gland) and that of the much smaller sublingual glands (mixed glands) form the saliva. One of the main functions of saliva is to cover the foodstuffs with a lubricant layer of mucus, assisting swallowing and protecting teeth and the lining cells of the mucosa against injury. Of all the substances synthesized by the organism mucoproteins, because of their high viscosity, are especially suited for the functions of lubrication and protection. It seems to be of interest that by such a rather simple expedient as the attachment of strongly negatively charged, multiple disaccharides to the side-chains of the protein core a high degree of viscosity is imparted to the molecule. The wide distribution of neuraminic acid among the viscous epithelial secretions of the respiratory, intestinal and uro-genital tracts may well reflect one, at least, of the physiological functions of this acid. If this concept proves to be true, Nature was wise to incorporate into neuraminic acid the strongest stable organic acid produced in the metabolism of the animal cell.

I am indebted to Dr. G. L. Ada, of the Walter and Eliza Hall Institute, Melbourne, for a generous supply of crystalline neuraminidase.

This work was supported by a personal grant from the National Health and Medical Research Council of Australia.

[1] Hammarsten, O., *Z. physiol. Chem.*, **12**, 163 (1888).
[2] Müller, F., *Z. Biol.*, **42**, 468 (1901).
[3] Blix, G., *Z. physiol. Chem.*, **240**, 43 (1936).
[4] For summary, see Burnet, F. M., *Physiol. Rev.*, **31**, 131 (1951).
[5] Gottschalk, A., and Lind, P. E., *Nature*, **164**, 232 (1949). Gottschalk, A., *ibid.*, **167**, 845 (1951).
[6] Odin, L., *Nature*, **170**, 663 (1952).
[7] For summary, see Klenk, E., *Angew. Chem.*, **68**, 349 (1956).
[8] Gottschalk, A., *Nature*, **176**, 881 (1955).
[9] Gottschalk, A., *Nature*, **174**, 652 (1954); *Biochem. J.*, **61**, 298 (1955).
[10] Blix, G., Lindberg, E., Odin, L., and Werner, I., *Nature*, **175**, 340 (1955).
[11] Kuhn, R., and Brossmer, R., *Chem. Ber.*, **89**, 2471 (1956).
[12] Cornforth, J. W., Firth, M. E., and Gottschalk, A., *Biochem. J.*, **68**, 57 (1958).
[13] Comb, D. G., and Roseman, S., *J. Amer. Chem. Soc.*, **80**, 497 (1958).
[14] Blix, G., Gottschalk, A., and Klenk, E., *Nature*, **179**, 1088 (1957).
[15] For review, see Gottschalk, A., "The Chemistry and Biology of Sialic Acids and Related Substances", 98 (Cambridge University Press, 1960).
[16] Graham, E. R. B., and Gottschalk, A., *Biochim. Biophys. Acta*, **38**, 513 (1960).
[17] Chibnall, A. C., and Rees, M. W., *Biochem. J.*, **68**, 105 (1958).
[18] Gottschalk, A., and Murphy, W. H., *Biochim. Biophys. Acta* (in the press).
[19] Gottschalk, A., and Simmonds, D. H., *Biochim. Biophys. Acta* (in the press).
[20] Gottschalk, A., and Fazekas de St. Groth, S., *Biochim. Biophys. Acta* (in the press).
[21] Gottschalk, A., and Thomas, M. A. W., *Biochim. Biophys. Acta* (in the press).

ULTRA-STRUCTURE OF HUMAN AMNION AND ITS POSSIBLE RELATION TO THE CIRCULATION OF AMNIOTIC FLUID

By Dr. GORDON L. BOURNE
Department of Obstetrics and Gynaecology, St. Bartholomew's Hospital, London, E.C.1
AND
Dr. DENNIS LACY
Department of Zoology and Comparative Anatomy, St. Bartholomew's Hospital Medical College, University of London, E.C.1

THERE is no doubt that some circulation of amniotic fluid occurs between the human fœtus and mother. According to Plentl[1], from work carried out by the use of deuterium, the exchange is about 450 ml. per hr. at term. Plentl has also demonstrated differential rates of transfer of sodium and potassium ions. The turn-over of sodium in the amniotic fluid is believed to occur at about seven times the rate that potassium is replaced. There is no definite information to show either how such large amounts of fluid are conveyed from the fœtus to the mother, or to account for the passage of various ions at different rates. In an attempt to throw further light on these problems we have been investigating the fine structure of the human amnion at term.

An account of the fine structure of the epithelial layer has been published by Lanzavecchia and Morano[2]. This work was carried out at moderate resolution and relates primarily to changes occurring during development.

Amnion was obtained from patients delivered by Cæsarean section at term. The amniotic membrane was dissected from the chorion, and portions of the placental and peripheral amnion were selected for examination.

Small pieces of the membrane were fixed for 2 hr. in osmium tetroxide solution buffered to *p*H 7·3 (ref. 3). The tissue was then rinsed briefly in distilled water, dehydrated in gradually increasing concentrations of ethanol and finally embedded in a 1 : 3 mixture of *n*-methyl and *n*-butyl methacrylate. Sections were cut with a glass knife and mounted on copper grids previously covered with a thin carbon film. The material was examined in a Siemen's Elmiskop 1*a* generally operated at 60 kV. Micrographs were obtained at initial magnifications varying from × 1,000 to × 40,000. The following is a brief account of the main results so far obtained.

Epithelial Layer. This consisted of a single layer of cells the height of which varied from about 1μ to 25μ. At moderate magnification (Fig. 1) the cells appeared to be covered by a single membrane which, on the surface next to the amniotic fluid, was evaginated to form many short processes or microvilli. Along the lateral aspect, the two membranes of adjacent cells delimited a series of irregularly shaped vacuoles (Fig. 1). Some of these vacuoles simply appeared to extend into adjacent ones ; others were connected by fine channels (about 170 Å. internal diameter) formed by the close apposition of the two cell membranes. While the majority of these vacuoles were located in the regions between adjacent cells (that is, were hollowed out in the sides of the cells) a few were seen lying deeper in the cytoplasm. Projecting into some of the vacuoles were a variable number of microvilli, generally less per unit area than seen on the upper surface of the cells. In the basal region the cell membrane was irregular in outline and delimited irregularly shaped vacuoles of various sizes. The appearance of this region, therefore, was similar to that seen along the sides of the cells (Fig. 2). Some micrographs showed that the cell membrane in the basal region was thickened at intervals.

The vacuoles in the lower parts of the cells were generally filled with a substance of moderate density

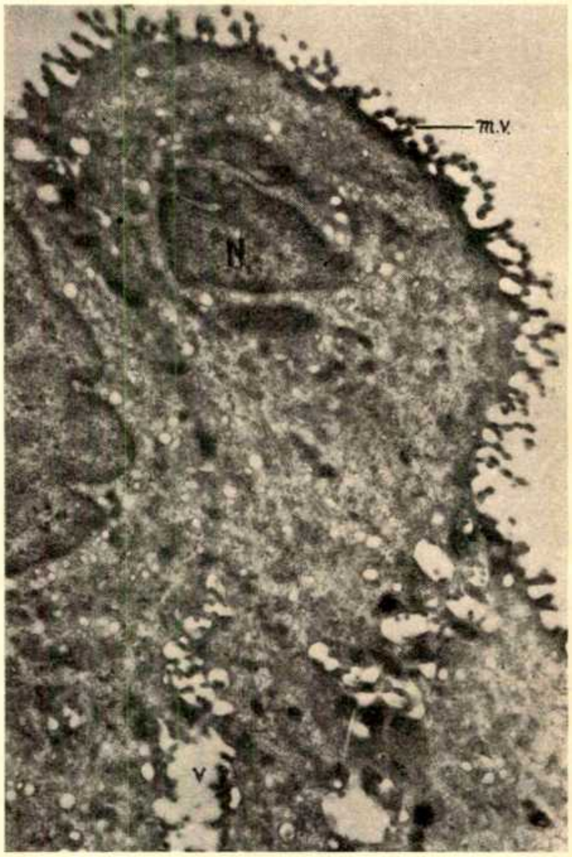


Fig. 1. Micrograph showing the general appearance of the upper part of amniotic epithelial cells. *m.v.*, microvilli ; *N*, nucleus ; *v*, system of intercellular vacuoles. (×10,000)

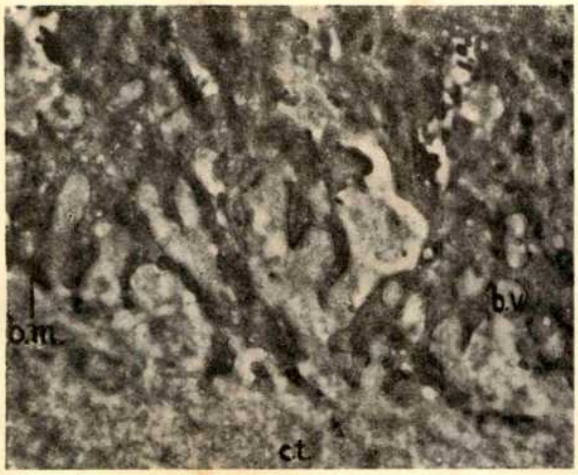


Fig. 2. Micrograph showing the general appearance of part of the basal region of an amniotic epithelial cell. *b.m.*, basement membrane; *b.v.*, basal vacuole; *c.t.*, connective tissue. (×10,000)

which was continuous with, and similar in appearance to, the material forming the basement membrane (Fig. 2). In a few micrographs we observed a similar substance in vacuoles in the upper parts of the cells which communicated with the amniotic fluid. In the majority of our micrographs, however, vacuoles in the upper parts of the cells lacked demonstrable contents.

The cytoplasm of the epithelial cells appeared very dense and granular (Fig. 1). Mitochondria were extremely scarce and when seen were usually in the form of small spheroidal bodies about 0·3μ in diameter. A Golgi apparatus has so far not been observed; if present it was presumably small and inconspicuous. In some cells we observed about two or three (per section) dense bodies each about 1μ in diameter. The nucleus was a large, dense object located close to the upper surface. It was irregular in outline and sometimes fenestrated (Fig. 1).

Various parts of the cells were examined at high magnification and resolution. This revealed that the microvilli were bordered by two closely applied membranes, each about 30 Å. thick. Within the microvilli were many fine rods which, due to the presence of a 'clear' medulla and dense cortex, were canal-like in appearance. The external and internal diameters of these canal-like elements varied; the maximum diameters recorded were 150 Å. (external) and 70 Å. (internal). When seen in cross-section these elements simply appeared to be placed closely together. Rarely, however, elements of similar composition were seen which exhibited the 9 + 2 arrangement found in cilia and flagella[4]. This suggests that occasional cilia existed alongside the microvilli. However, the possibility cannot be ruled out that the 9 + 2 pattern may occur in some microvilli, perhaps during some stage in their development. The canal-like elements penetrated into the cytoplasm to a depth ranging from about 0·25μ to 0·5μ. Due mainly to this there appeared to be a thin layer of particularly dense cytoplasm immediately beneath the microvilli in cells examined at lower magnification (Fig. 1).

When studied at high resolution and magnification, comparatively large areas of the cytoplasm were seen to contain numerous paired parallel lines and circular elements (Fig. 3). These observations are interpreted as showing the presence of membranes arranged mainly in the form of fine canals with some occurring as parallel sheets. The membranes were each about 60 Å. thick, the distance between them (canal lumen) was about 100 Å. Examination of representative parts of the cell surface, where it bordered the lateral and basal system of vacuoles referred to above, revealed many circular apertures (about 75–100 Å. internal diameter) which communicated with the intracellular channels and canals. The evidence suggests, therefore, that amniotic epithelial cells contain an extensive system of canals and channels which communicate directly with the extracellular 'space'. Further details of this system, such as its relationship with the upper surface of the cell and microvilli, are now being studied.

Basement Membrane. This consisted of a thin layer, usually about 0·1μ thick, of a moderately dense substance which penetrated into the vacuolar-like indentations of the cell membrane. At high resolution it was seen to consist of fibrils (each about 200 Å. in diameter) embedded in a material of closely matching density.

Connective Tissue Layer. This relatively deep layer (0·05 mm.–0·5 mm. thick) consisted mainly of fibrils, each about 300 Å. thick and exhibiting faint transverse striations with a periodicity of about 600 Å. The fibrils were branched, the angle of branching usually being about 90°. They were arranged in bundles (not bounded by a membrane) lying in various planes (Fig. 4). Thus in any region a great number of parallel fibrils lay next to a comparable number of similar elements sectioned transversely or obliquely. Such an arrangement accounts for the appearance of a network of fibres in light microscopi-

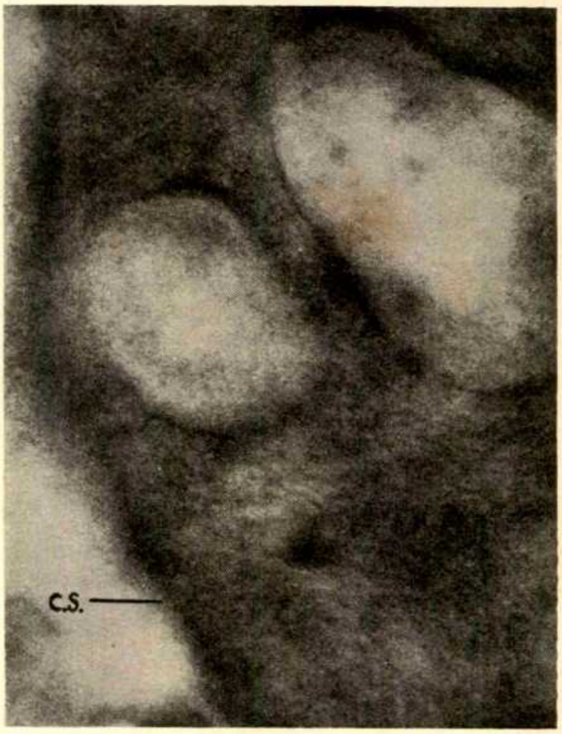


Fig. 3. Micrograph of the numerous membranes found in various regions of the cytoplasm of amniotic epithelial cells. The membranes are believed to be arranged mainly in the form of canals with some occurring as parallel sheets. Along the cell surface (*c.s.*) are many small circles suggestive of pores. (×100,000)

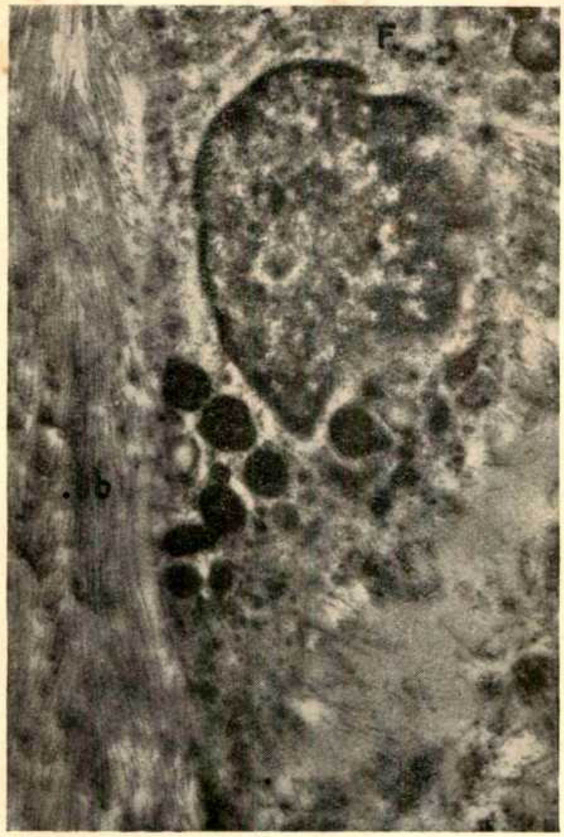


Fig. 4. Micrograph of part of the connective tissue layer showing a fibroblast (*F*) and bundles of fibrils (*b*). Along the lower right-hand side of the cell connective tissue fibrils can be seen partly embedded in cytoplasm. (×9,000)

cal preparations[5]. The morphological evidence, therefore, suggests that the fibrils were reticular fibrils. Typically, in the deeper parts of this layer the fibres had a wavy appearance ; this was probably due to some contraction.

Cells were comparatively scarce and were located in an intermediate zone and in the deeper parts of the layer (fibroblast and spongy layers described by Bourne[5]). These cells were of two kinds : fibroblasts and macrophages. As far as could be determined from individual sections, the fibroblasts in the intermediate zone formed a diffuse network. Parts of the cell surface appeared not to be covered by a membrane. Where this occurred were many connective tissue fibrils projecting from the cell cytoplasm into the extracellular 'space' (Fig. 4). There seemed little doubt that the fibroblasts were actively synthesizing new fibres. The fine structure of these cells varied, either because the cells were of different ages or in different physiological states. Most of them, however, contained an irregularly shaped, dense nucleus (sometimes elongated), a moderately well-developed endoplasmic reticulum (lamelliform and tubular in appearance), mitochondria, Golgi apparatus, groups of fine filaments and several small dense spheroidal bodies. The last-named were possibly glycogen granules[6]. Also present in most cells was a single large mass of material which almost totally occupied the region of the cell in which it was located. This material was bordered by membranes of the endoplasmic reticulum. When examined at high resolution, it was seen to consist of an almost 'clear' matrix within which was a network of greater density. In some cells the network consisted of fibrils (each about 300 Å. in diameter) embedded in a homogeneous ground substance. In other cells the fibrils were scarce or absent and within the ground substance were many small vesicles (each about 500 Å. in diameter). These observations seem to show quite definitely that some connective tissue fibrils were being formed intracellularly.

In the deeper part of the connective tissue layer were elongated cells. The ends of these cells were closely applied and this, together with the fact that the cells followed the wavy course of the connective tissue fibres, made them appear to be articulated. The general appearance of these cells was different from that shown by the cells in the intermediate zone. It seems likely, however, that they were fibroblasts.

The only other cells observed were macrophages. These were very scarce and scattered throughout the connective tissue layer. Within these cells were inclusions which, from evidence obtained by the use of Perl's[7] test for iron (on sections examined under the light microscope), probably contained hæmosiderin.

So far as can be determined on a purely morphological basis, it seems likely that some of the amniotic fluid which passes from the fœtus to the mother, and the accompanying differential rate of turn-over of various ions, may be brought about by the amnion. As a working hypothesis it may be conjectured that the fluid enters the amnion via (*a*) the opening between adjacent cells, where it passes into the lateral system of vacuoles and (*b*) the upper surface, the area of which is greatly increased by the presence of microvilli. Within the cells the fluid presumably enters the complex system of fine canals and channels. The fine canals and channels communicate with the lateral and basal vacuoles and hence with the extracellular space ; this results in an enormous increase in surface area. Within the vacuoles there is presumably some mixing of any solution which may have entered via the two principal pathways. Assuming that some ions travel more readily along one route than the other, then this could offer an explanation (although much over-simplified) of the differential rate of turnover of different ions. Having passed through the epithelium the fluid must permeate the connective tissue layer. Since this layer consists mainly of a network of fibres there is no objection to this on morphological grounds.

Experiments are being carried out to examine the validity of the above hypothesis. This part of our work is at an early stage. However, 30 min. after the injection of colloidal gold in the amniotic fluid a few small particles of gold have been observed in the connective tissue layer, either scattered along the length of some of the fibrils or around small processes of the fibroblasts.

The above work was undertaken during the tenure of a Lawrence Research Scholarship of St. Bartholomew's Hospital held by one of us (G. L. B.).

[1] Plentl, A. A., in "Gestation: The Origin of Amniotic Fluid", ed. C. A. Villee (Josiah Macy, Jr. Foundation, New York, 1957).

[2] Lanzavecchia, G., and Morano, E., *Arch. ital. Anat. Embryol.*, **64**, 74 (1959).

[3] Palade, G. E., *J. Exp. Med.*, **95**, 285 (1952).

[4] Bradfield, J. R. G., *Symposia Soc. Exp. Biol.*, **9**, 306 (1955).

[5] Bourne, G. L., *Amer. J. Obstet. Gynec.* (in the press).

[6] Jackson, S. F., *Proc. Roy. Soc.*, B., **144**, 556 (1956).

[7] Pearse, A. G. E., "Histochemistry, Theoretical and Applied" (Churchill, London, 1953).

LETTERS TO THE EDITORS

GEOPHYSICS

Regular Micropulsations of the Earth's Field at the Equator

THE diurnal variation of occurrence of regular pulsations, *pc*, of the Earth's magnetic field has been studied by many workers and it has been found, in all the cases reported, that the phenomenon is predominantly a day-time one. Typical of the results of magnetic measurements are those obtained in Germany by Angenheister[1], for periods of 30–60 sec., which have a maximum frequency of occurrence at 10–12 hr. L.M.T. The measurements of Earth currents, obtained in the U.S.S.R. by Mme. Troitskaya[2], are representative of that experimental approach and they show a maximum frequency of occurrence around 11–13 hr. L.M.T. Most of the results reported have been confined to mid-latitude stations.

At the symposium on "Rapid Variations of the Earth's Field" held at Utrecht in September 1959, I gave a brief report of an analysis of records of Earth currents obtained at Legon, Ghana (lat. 5° 38′, N., long. 0° 11′ W.). This analysis indicated that, at this station, regular pulsations of Earth currents occur during the night as well as during the day and, in fact, that the maximum frequency of occurrence for the whole day is at approximately 18–20 hr. G.M.T. The diurnal variation of frequency of occurrence of regular pulsations, *pc*, for all days, is shown in Fig. 1*a*, which was the result of an analysis of records of Earth currents obtained between October 1957 and December 1958. More recently, analysis of magnetic records obtained from an induction magnetometer, recording d*H*/d*t* at the same station, has shown a similar night-time occurrence of regular pulsations, in addition to the day-time occurrence normally expected. The results of this analysis, which was made for the months of May, June and July 1958, are given in Fig. 1*b*, together with the results obtained from records of Earth currents for the same 3 months. Both graphs show three maxima, occurring at 6 hr., 12 hr. and 20 hr., and in each case the night-time maximum is the greatest. In fact, there is approximately a 50 per cent chance that regular pulsations will occur between 19 and 21 hr. It is probable that the difference in level of frequencies of occurrence in the two cases is due partly to the different sensitivities of the telluric and magnetic recording systems, and partly to the fact that the Earth-current records and magnetic records were examined by the same observer at different times. A separate study has also been made of the degree of subjectivity in the examination of records for the occurrence of these regular pulsations, by having three observers independently analyse the same records. In all cases, the results gave rise to graphs of very similar form to that in Fig. 1*a*, but the mean value of frequency of occurrence differed from one observer to another, a factor which

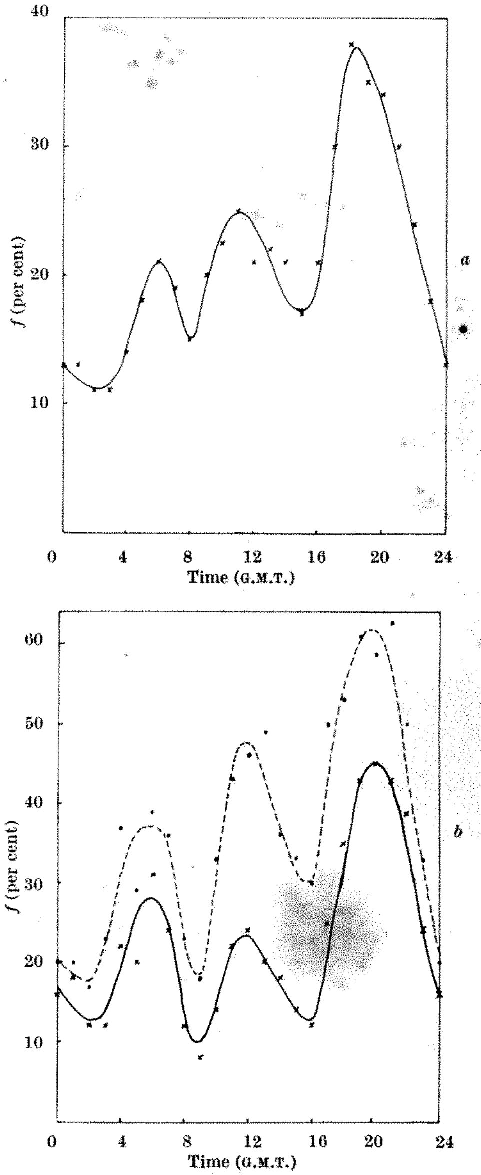


Fig. 1. Diurnal variation of frequency of occurrence, *f*, of regular pulsations at Legon. (*a*) Telluric pulsations for October 1957–December 1958; (*b*) telluric and magnetic pulsations for May–July 1958. Telluric, ———; magnetic, - - - - -

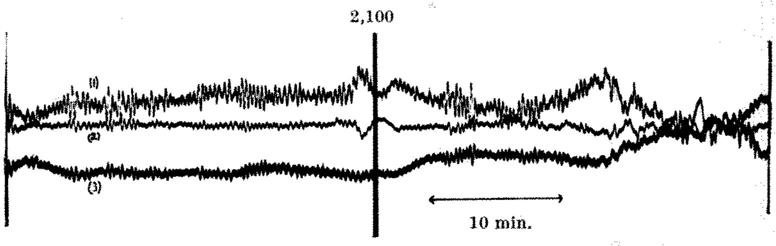


Fig. 2. Example of night pulsations at Legon on both telluric and magnetic traces: May 27, 1958, 2030–2130 hr. (1) E.-W. telluric current; (2) d*H*/d*t*; (3) N.-S. telluric current

was not of primary importance in the present study.

This analysis of both telluric and magnetic records and the independent examination of records by three observers confirms the existence of regular pulsations, *pc*, during night-time as well as during the day, in the equatorial region. An example of these night-time pulsations, on both Earth-current and magnetic traces, is given in Fig. 2.

The Earth-current results have been further analysed to give the diurnal variation of occurrence of regular pulsations for quiet days only and for different seasons of the year and the results compared with a similar study of results from Tamanrasett (long. 22° 48′ N., lat. 5° 31′ E.). Two of the main deductions which may be made from this investigation, which will be reported more fully elsewhere, are : (1) that the frequency of occurrence of regular pulsations at night is greater at Legon than at Tamanrasset ; and (2) that, for quiet days, in the interval 0–14 hr., the frequency of occurrence of regular pulsations at Legon is almost the same as that at Tamanrasset. In both cases there is good agreement in this time interval, with the occurrence of the phenomenon at other stations.

ROSEMARY HUTTON

Department of Physics,
University College of Ghana.

[1] Angenheister, Von G., *Gerlands Beitr. Z. Geophys.*, **64**, 108 (1954).

[2] Troitskaya, V. A., *Priroda*, **5**, 81 (1955).

Structure of the Upper Mantle as derived from the Travel Times of Seismic *P* and *S* Waves

IN a recent investigation[1] I found the travel times of the seismic *P* waves (longitudinal waves) up to an epicentral distance of about 22° to conform with a structure below the Mohorovičić discontinuity that consists of an upper layer extending to a depth of about 220 km. in which the velocity is about 8·1 km./sec., increasing slightly with depth, and a lower layer in which there is a considerable increase of velocity with depth ; at the boundary of the two layers there is an abrupt increase of velocity to about 8·4 km./sec. A discontinuous increase of velocity has to be assumed because the amplitudes of the waves refracted in the lower layer, observable as first arrivals from an epicentral distance of about 15°, increase gradually with epicentral distance, and at the lower end of their time-distance curve there is no focal point at which the amplitudes are very large.

The transverse *S* waves in the same distance-range are less well observed in most regions. In north-eastern America, however, good observations are obtained, and it is found that the S_d waves travelling in the uppermost part of the mantle have a velocity of about 6·5 km./sec., increasing slightly with depth[2]. They are not observed beyond about 14° epicentral distance and the *S* phases observed at greater distances are delayed. This is explainable on the assumption that there is a low-velocity layer extending from a depth of about 150 km. to the discontinuity surface at 220 km. depth. At this surface there is, as for *P*, a sudden increase of velocity and of velocity gradient.

In Europe the S_d phase of shallow shocks is so poorly observed that it was not found possible to construct a time-curve for it directly from observations. The Jeffreys–Bullen time-curve was derived from the S_d travel-times for deep-focus shocks. In a few shallow earthquakes, however, I now find the S_d phase well enough observed to be able to show that the travel times are very nearly the same as in north-eastern America.

In shallow shocks the observations of *S* at distances up to about 20° are complicated by the fact that two phases, a first small phase and a second larger one, appear at intervals ranging from a few seconds at the greater distances to 20 sec. or more at the smaller distances, and one or the other of the two phases may seem to be *S*. The first phase, which may be small enough to escape detection or may be missing, is the S_d phase. The travel times of the later phases scatter a great deal and it was not previously found possible to indicate a structure that would account for them. It appears now, however, that a structure similar to the one adopted for north-eastern America will give rise to phases having travel-times in fair agreement with those of the late *S* phases observed. From an epicentral distance of about 9° onwards they are explainable as reflexions on, and refractions in, the layer below 220 km. depth, their delay against S_d being due to the presence of a low-velocity layer. At epicentral distances smaller than 9°, second mode surface waves seem to be responsible for the late phases.

In earthquakes having their foci at intermediate depth late *S* phases also occur. The *S* phases of six Rumanian earthquakes having a common focus at 130 km. depth were examined and found to be in agreement with those calculated on the assumptions here indicated.

The travel-times of *P* were found to be consistent with a structure that had no low-velocity layer, and although it is physically possible for the velocity of *S* to decrease while that of *P* does not, yet it seems more likely that the *P* velocities are somewhat affected in the layer in which the *S* velocities are low. The velocity distribution for *P* waves was therefore altered so as to include a layer of slightly smaller velocity extending from 150 to 220 km. depth, and it was found possible to do this without altering the travel-times appreciably.

Dr. Mark Landisman of the Lamont Geological Observatory has given kind assistance in the present research, calculating travel times on the Columbia University *I.B.M.* 650 calculator.

I. LEHMANN

Kastelsvej 26,
Copenhagen.

[1] Lehmann, I., *Ann. de Geophys.*, **15**, 93 (1959).

[2] Lehmann, I., *Annali di Geofisica*, **8**, 351 (1955).

PHYSICS

Adsorption of Helium on Carbons : Influence on Measurement of Density

THE magnitude of the adsorption of helium on solids is of interest not only theoretically, but also because of its relevance to the determination of the density of solids when helium is used as the dilatometric fluid ; in such determinations the adsorption of helium is assumed to be so small as to be negligible. We have found that this assumption is not invariably correct.

In the determination of a gas/solid adsorption isotherm by use of the conventional volumetric

Table 1. Helium Adsorption Coefficients and Densities

Source of carbon	Ref. No.	Ash (per cent)	*K* (at 298° K. 10^{-4} ml./gm./cm. mercury)	Observed density (gm./ml.)	Corrected density (gm./ml.)
(*A*) Activated charcoals prepared from :					
Nutshell	260	3·8	7·3	2·256	1·984
Nutshell	373	5·1	6·7	2·157	1·925
Coal	372	11·1	4·1	2·145	1·999
Coal	374	6·7	4·5	2·028	1·885
Anthracite	Run 77	3·2	3·7	1·932	1·824
Anthracite	Run 78	3·8	5·2	1·994	1·829
Anthracite	Run 79	5·1	5·8	2·050	1·869
Anthracite	Run 80	6·9	6·6	2·111	1·892
Wood	403	14·0	6·4	2·395	2·125
Graphite (finely ground)	429	2·0	~7*	—	—
(*B*) Carbonized coconut shell (no activation)	310	2·5	0	1·541	1·541
Anthracite (per cent C = 93·8)	418	3·3	0	1·510	1·510
Bituminous coal (per cent C = 82·4)	346	1·25	0	1·332	1·332
Carbon black	289	0·1	0	~2·00	~2·00

* Difficult to outgas completely ; pumped at 630° K. for 1 week.

adsorption apparatus, the dead-space within the apparatus is assessed by application of the gas laws to the pressure/volume data for a given amount of helium enclosed in the apparatus. Should the adsorption isotherm of helium on the solid be linear—as is very probable—the adsorption of helium will remain undetected during the assessment of the dead space of the apparatus ; conversely, the adsorption isotherm of helium on a solid cannot be determined by conventional means. For the measurements reported here, the effect of temperature on adsorption has been employed by measuring the apparent dead-space of a conventional volumetric adsorption apparatus, the temperature of the bulb containing the adsorbent being changed after each determination. The occurrence of appreciable adsorption is shown by an increase in the apparent dead-space as the temperature of the adsorbent is lowered. Our investigations have embraced various forms of carbon as the adsorbent, and the temperature of the adsorbent has been varied over the range 77–580° K. All adsorbents (with one exception) were out-gassed at 630° K. for at least 24 hr. before adsorption measurements were made, and reproducible results were obtained with both ascending and descending temperatures.

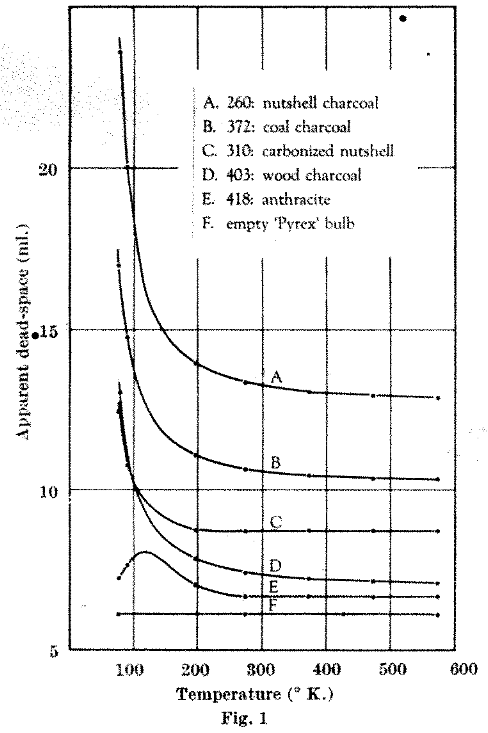


Fig. 1

Several typical sets of results are shown in Fig. 1, which is a graph of the apparent dead-space as a function of temperature. In all cases the value of the apparent dead-space became constant, or nearly so, at the higher temperatures, and the value observed at 580° K. has been taken as the true dead-space for the purpose of calculating minimum values for the adsorption of helium at lower temperatures. With all the forms of carbon examined (see Table 1) adsorption at 77° and 90° K. was readily observed and measured. At 273° K. adsorption was small and varied in extent with the type of carbon. Since our present concern lies with the influence of this adsorption on density measurements, the adsorption at 298° K. (a common temperature of operation in such determinations) is recorded in Table 1 as the slope of the linear adsorption isotherm (ml. standard temperature and pressure per cm. mercury pressure per gm. adsorbent).

On the basis of these results two groups of carbon may be differentiated.

(*A*) Carbons which absorb appreciable quantities of helium at room temperature. All the activated carbons come into this group. Results so far indicate adsorption proportional to surface area ; if the latter is assessed from determinations of the heat of wetting in methanol, an approximate guide to the extent of adsorption at 298° K. on a given carbon is given by the proportionality constant $2 \cdot 1 \times 10^{-5}$ ml. helium per cm. mercury per cal. Adsorption at room temperature was also observed on a finely divided graphite (nitrogen, Brunauer–Emmett–Teller area, 625 m.^{2}/gm.).

(*B*) Carbons for which no adsorption at 298° K. has been detected. The following carbons are found in this group : an anthracite ($C = 93 \cdot 8$ per cent dry ash-free) ; a free-burning bituminous coal ($C = 82 \cdot 4$ per cent dry ash-free) (because of the continued evolution of gases with increasing temperature, the coal was outgassed at 430° K., and the dead-space measured at 398° K. was taken as the true dead-space) ; carbonized coconut shell (unactivated) ; a carbon black (particle size 190 Å., from electron micrographs).

Both the anthracite and the coal gave evidence of restricted adsorption at 77° K. (ref. 1). For group *A* carbons the effect of these small adsorptions on the measured density is most marked. The densities of the carbons as measured by the method of helium displacement at 298° K. are given in Table 1; in the last column are the densities corrected for the observed adsorption of helium.

The reason for the difference in behaviour of the two groups of carbons is not immediately apparent. Both groups contain carbons of comparable specific area; no correlation with ash content is discernible. It appears possible that very small capillaries accessible only to helium may be present in group *A* carbons; some support is given to this explanation by density measurements using methanol as the dilatometric fluid, though this interpretation is dependent on the value assigned by Franklin[2] to the correction for adsorption of methanol.

F. A. P. MAGGS
P. H. SCHWABE
J. H. WILLIAMS

War Department,
Chemical Defence Experimental Establishment,
Porton, Wiltshire.

April 5.

---

[1] Maggs, F. A. P., *Nature*, **169**, 269 and 793 (1952); *Research*, **6**, *S*, 13 (1953).

[2] Franklin, R. E., *Trans. Farad. Soc.*, **45**, 274 (1949).

A Self-supporting Metal Fresnel Zone-plate to focus Extreme Ultra-violet and Soft X-Rays

IN the wave-length region between 10 Å. and 1000 Å., ordinary lenses and mirrors fail as image-forming devices because the transmissivity and reflectivity of materials are very low. In this region diffraction offers a means of bending rays and focusing them.

We have produced a Fresnel zone-plate consisting of 19 metal zones held together by thin radial struts so that the transparent zones are empty. This permits soft X-rays and ultra-violet radiation to pass through and be focused. The device has been tested with visible light and ultra-violet light down to 2537 Å. It behaves as expected in terms of speed and resolution, leading to the belief that it should focus well even at wave-lengths less than 100 Å.

The zone-plate has a central circle of diameter 0·04 cm., an outer circle of diameter 0·26 cm., and is about 10 microns thick. The narrowest gold band has a width of 20 microns. It was made by the Buckbee Mears Company of St. Paul, Minnesota, by techniques that are an outgrowth of the lithographic art.

The zone-plate was better than the optimum pin-hole by a factor of 6 in resolution and 40 in speed. Pictures of fine-mesh screens showed that its resolution compared favourably with that of a simple plano-convex lens of similar aperture and focal length. The lens was about 20 times faster than the zone-plate in visible light, but at 1000 Å. the zone-plate would have been much faster than a lens of any known material. Tests made at 6700, 4358 and 2537 Å. showed that the resolution improved, as would be expected from the Rayleigh criterion, auguring well for resolution at 100 Å.

Means are being considered for integrating the information from a bank of many zone-plates, so as to increase the speed of the system, possibly by some television-type scanning and integrating device.

We may gain some idea of possible future uses of a zone-plate X-ray telescope in an orbiting satellite above the Earth's absorbing atmosphere by considering the results of an experiment at 2537 Å. and extrapolating. At 2537 Å. the angular resolution was close to the theoretical value of $1 \cdot 2 \times 10^{-4}$ radian and held over a field of at least $1 \cdot 75 \times 10^{-2}$ radian, which is 2·0 times the angle subtended by the Sun's disk at the Earth.

A detailed paper on this investigation is being submitted to the *Journal of the Optical Society of America*.

ALBERT V. BAEZ

Smithsonian Astrophysical Observatory,
Cambridge, Massachusetts.

Interpretation of Intensity Distributions in the N_2 Lyman–Birge–Hopfield and CO Fourth Positive Band Systems

IN much of the early spectroscopic literature the photographic density (measured or estimated by eye) of spectral features is reported, in addition to wavelengths, as an aid to identification. In many molecular band systems in the vacuum ultra-violet region (which are becoming of increasing interest in astrophysics and plasma physics and the intensities of which, *in emission*, are relatively difficult to measure) the early data on photographic blackening are still the only experimental information on band intensities available.

Until reliable measurements of intensities have been made, it is therefore worth while to inquire into what quantitative conclusions, if any, may be drawn from the plate blackenings.

A simple method was developed some years ago[1,2] by which a test of quantitative significance is first applied to the blackening data, after which quantitative conclusions may be drawn from analysis of those data which are retained as meaningful. This method has now been applied to blackening data reported for the $N_2(a^1\Pi_g - X^1\Sigma_g^+)$ Lyman–Birge–Hopfield and the $CO(A^1\Pi - X^1\Sigma^+)$ Fourth Positive band systems which are comparable transitions of isoelectronic molecules and lie in the vacuum ultra-violet region between about 1250 Å. and 1850 Å.

It has been shown[1], for molecular band systems, that the plate blackening B_λ is related (*a*) to the emulsion response parameters: contrast γ_λ and inertia $I_{0\lambda}$; (*b*) to the molecular parameters: wavelength $\lambda_{v',''}$, Franck–Condon factor $q_{v'v''}$, electronic transition moment $R_e(r)$, and *r*-centroid $\bar{r}_{v'v''}$; and (*c*) to the population $N_{v'}$ in the vibrational level v' by:

$$B_\lambda = \gamma_\lambda\,[\text{constant} - \log I_{0\lambda} + \log N_{v'} + \log q_{v'v''} - 4 \log \lambda_{v'v''} + 2 \log R_e(\bar{r}_{v'v''})] \quad \cdot \quad (1)$$

The test of quantitative significance is to plot B_λ against $\log q_{v'v''} - 4 \log \lambda_{v'v''}$ for each v'' progression (v' = constant). Meaningful data fall on straight lines of roughly equal slope γ^λ for each progression. Aberrant B_λ values are rejected. The relation between $\log R_e(r)$ and $\bar{r}_{v'v''}$ may then be found by plotting $B_\lambda/\gamma_\lambda + 4 \log \lambda_{v'v''} - \log q_{v'v''}$ against $\bar{r}_{v'v''}$ (or $\lambda_{v'v''}$, as $\bar{r}_{v'v''}$ and $\lambda_{v'v''}$ are monotonically related[3]) for each progression. The segments, one for each progression, will be displaced in relative ordinate by amounts depending upon the influence of $N_{v'}$, from which the distribution of $N_{v'}$ with v' can be found. Objective rescaling of the segments leads to a graph of $2 \log R_e(r)$ + a constant versus $\bar{r}_{v'v''}$ (or $\lambda_{v'v''}$) for the entire band system.

This procedure has been carried through for the blackening B_λ and wave-lengths $\lambda_{v'v''}$ reported by Headrick and Fox[4] for the CO Fourth Positive system and by Birge and Hopfield[5] for the N_2 Lyman–Birge–Hopfield system. Franck–Condon factors were available for each system[6,7] as were r-centroids[3,8]. In the graphs actually made, however, it was sufficient to plot $B_\lambda/\gamma_\lambda + 4 \log \lambda_{v'v''} - \log q_{v'v''}$ versus $\lambda_{v'v''}$. Data were found to be meaningful for 19 bands of six progressions ($v' = 0$–5) for the Lyman–Birge–Hopfield system, and for 11 bands of four progressions ($v' = 0, 1, 3, 4$) of the CO Fourth Positive system. In both cases the graph of $B_\lambda/\gamma_\lambda + 4 \log \lambda_{v'v''} - \log q_{v'v''}$ versus $\lambda_{v'v''}$ was parallel to the $\lambda_{v'v''}$ axis, which is good evidence that $R_e(r)$ must be almost independent of r, and thus constant, for each system.

It may therefore be concluded that for these two bands systems the ($v'v''$) array of relative vibrational transition probability:

$$p_{v'v''} = \bar{R}_e^2(r_{v'v''})q_{v'v''} \tag{2}$$

which, influences, the intensity $I_{v'v''}$ in emission of the $v'v''$ band through:

$$I_{v'v''} \propto N_{v'} p_{v'v''}/\lambda^4{}_{v'v''} \tag{3}$$

is probably, therefore, well represented in each case by the respective Franck–Condon factor $q_{v'v''}$ array.

R. W. NICHOLLS*

National Bureau of Standards,
Washington 25, D.C.
Jan. 11.

---

* Temporarily on leave of absence from the University of Western Ontario, London, Canada.

[1] Nicholls, R. W., *Can. J. Phys.*, **32**, 722 (1954).

[2] Nicholls, R. W., "The Airglow and the Aurorae", edit. by Armstrong, E., and Dalgarno, A., 302 (Pergamon Press, London, 1956).

[3] Nicholls, R. W., and Jarmain, W. R., *Proc. Phys. Soc.*, A, **69**, 253 (1956).

[4] Headrick, L. B., and Fox, G. W., *Phys. Rev.*, **35**, 1033 (1930).

[5] Birge, R. T., and Hopfield, J. J., *Astrophys. J.*, **68**, 257 (1928).

[6] Jarmain, W. R., Fraser, P. A., and Nicholls, R. W., *Astrophys. J.*, **122**, 55 (1955).

[7] Jarmain, W. R., Ebisuzaki, R., and Nicholls, R. W., *Can. J. Phys.*, **38**, 510 (1960).

[8] Nicholls, R. W., Robinson, D., Parkinson, W. H., and Jarmain, W. R., *Proc. Phys. Soc.*, A, **69**, 713 (1956).

Millimetre Waves from Mercury Arc Harmonic Generator

THE use of very small mercury arcs for the purpose of harmonic generation from a microwave input at 2·5 Gc./s. has already been described[1]. I wish now to report the preliminary results obtained with a driving frequency of 35 Gc./s.

For operation at this high frequency, the arc was formed between a vertical tungsten wire 'anode' mounted parallel to the electric vector of the microwave field across a Q-band wave-guide of stainless steel, a mercury pool cathode forming the lower surface of the wave-guide. Harmonics generated by the arc were collected by means of a smaller wave-guide protruding perpendicularly through the side wall of the Q-band guide. The whole device was filled with argon gas at 20 atmospheres pressure, mica windows permitting the entry and exit of microwave power. The level of the mercury surface could be varied by tilting, and the length of the arc was thus adjusted to be less than 0·5 mm.

The 35 Gc./s. drive was supplied by a continuous-wave klystron supplying about 1 watt into the discharge, an 8-volt d.c. supply connected across the arc causing a noticeable increase in efficiency of harmonic production. The combined rectified current was about 100 m.amp.

The highest harmonic found so far is the sixth, corresponding to a frequency of 210 Gc./s. and a wave-length of 1·43 mm., the receiver being a Golay infra-red detector. It has not yet been possible to 'match' the arc to the output circuit, so that the power reaching the detector at 210 Gc./s. is quite small (rather less than 10^{-8} watt); but if an efficient coupling can be devised it should be possible to extract up to a hundred times this power from the discharge. The power in the fourth harmonic (2·15 mm. wave-length) is about 15 db. greater than that in the sixth.

The work described here forms part of the research programme of the National Physical Laboratory, and this communication is published by permission of the Director of the Laboratory.

K. D. FROOME

Standards Division,
National Physical Laboratory,
Teddington, Middlesex.

---

[1] Froome, K. D., *Nature*, **184**, 808 (1959).

METALLURGY

Crystal Growths and the Corrosion of Iron

THE effect of climate on the corrosion of iron has been the subject of many studies. Hudson[1] and more recently Copson[2] have summarized studies on the rate of corrosion of ingot iron in dry and moist climates and in industrial and marine atmospheres. Ingot iron in the dry atmosphere of Khartoum, Egypt, corroded at a rate of 28 millionths of an inch a year while a specimen in the wet country atmosphere of Llanwrtyd Wells, England, corroded at a rate of 1888 millionths of an inch a year.

Critical laboratory studies by Vernon[3,4] on the effect of humidity on the corrosion of iron led to the generalization known as the "Principle of Critical Humidity". For iron, at 25° C., the rate of corrosion increases rapidly for humidities above 65 per cent. Dry oxidation is assumed to change to a rapid electrochemical attack. Local electrochemical action is assumed to occur between local anode and cathode areas through an invisible adsorbed film of water.

This model of localized electrochemical action is the basis of present-day interpretation of wet corrosion. For pure single-phase metals the sites for local cathodes and anodes have not been identified. Part of the difficulty is that liquid-phase corrosion reactions on iron are complex since hydrated oxides are often formed and the corroding metal may be removed from the reaction site.

Gulbransen and Copan[5] proposed that localized chemical reactivity in corrosion processes could be studied in gas phase reactions at elevated temperatures using more nearly ideal reaction conditions and pure metals. Since localized corrosion processes may be the result of dislocations and other defects which occur on an atomic scale, it is necessary to use high-resolution electron microscope methods.

To show the effect of water vapour on the corrosion of iron, we exposed annealed pure zone-refined iron wires to oxygen, water vapour and several gas mixtures of water vapour and oxygen. The 0·0225 cm. wires were treated in a special reactor system at 450° C. for 48 hr. For these conditions electrochemical action and solution of the corrosion product in a liquid phase are eliminated. The complex

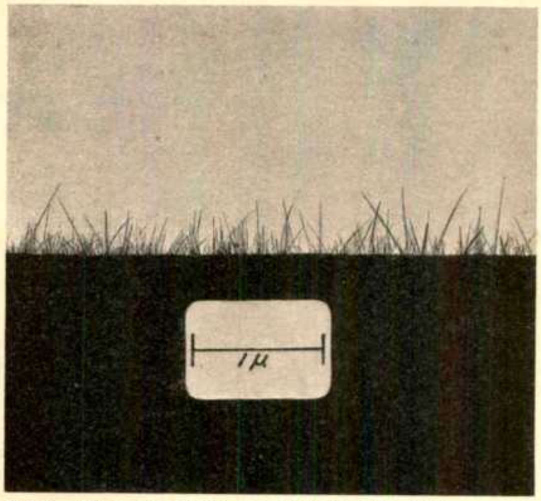


Fig. 1. Effect of moisture on crystal habits of the corrosion products formed on iron after reaction at 450° C. for 48 hr. in dry oxygen

hydrated oxides also are not stable. Electron microscope and electron diffraction studies were made of the edge of the wire specimen after reaction.

Figs. 1 and 2 shows two electron transmission micrographs of the crystal habits of the localized corrosion products. Fig. 1 shows small oxide whiskers were formed when iron was treated with dry oxygen of dew point − 79° C. These whiskers were 150–200 Å. in diameter and grew to an average height of about 8000 Å. Electron diffraction analyses showed the whiskers to be only α-Fe_2O_3. These whiskers were formed in addition to the normal oxide film. Fig. 1 suggests that the nucleation sites on the metal or on the oxide were 150–200 Å. in diameter. Since the diameter was constant along the length of the whisker, we conclude that the length of the nucleation sites remained constant as the whisker grew. The area of the nucleation site appeared to be independent of time or the extent of oxidation.

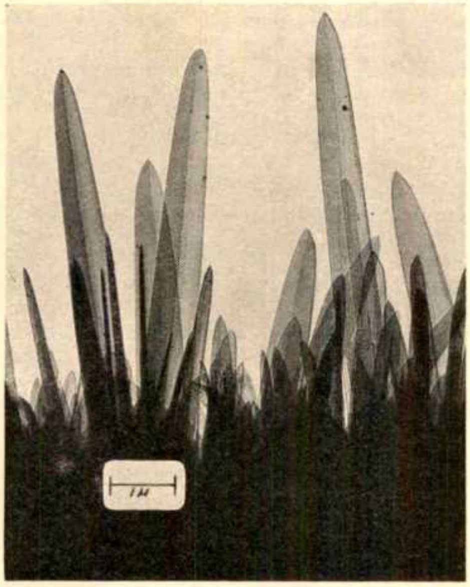


Fig. 2. Effect of moisture on crystal habits of the corrosion products formed on iron after reaction at 450° C. for 48 hr. in 10 per cent water plus 90 per cent oxygen

Fig. 2 shows the crystal habits formed when iron reacts with a 10 per cent water vapour + 90 per cent argon mixture at 450° C. for 48 hr. Many thin blade-shaped platelets were formed. These were 100–200 Å. thick, up to 8000 Å. long, and up to 70,000 Å. high. Electron diffraction analyses showed these platelets to be only α-Fe_2O_3. The surface density was estimated to be about 10^8/cm.^{2}.

The shape of the oxide platelets suggests that the site for reaction enlarges as the reaction proceeds, whereas in the iron–oxygen reaction the site remains of constant area. The constant thickness of the platelets suggests that the width of the nucleating area remains constant. One explanation for the effect of water vapour is that hydrogen ions from the water vapour act to enlarge the area for reaction.

After 48 hr. of reaction the site areas are fifty times the areas observed for the dry oxygen reaction. The total amount of oxide in the form of localized corrosion products for the water vapour reaction is about four hundred times that formed in the dry oxygen reaction.

These experiments made at 450° C. may help to explain the unique effect of water vapour on the corrosion of iron at ambient temperatures. Certain differences of course exist. The corrosion-rate will be slower, hydrated oxides may form instead of α-Fe_2O_3, the corrosion product may dissolve in the liquid phase, and electrochemical action may be present. The important factor which has not been foreseen in earlier studies is the accelerating effect of water vapour itself on localized corrosion in the absence of electrochemical action.

EARL A. GULBRANSEN
THOMAS P. COPAN
Westinghouse Research Laboratories,
Pittsburgh 35, Pennsylvania.

[1] Hudson, J. C., "Corrosion of Iron and Steel", 93 (Chapman and Hall, 1940).

[2] Copson, H. R., *Corrosion*, 533 (October 1959).

[3] Vernon, W. H. J., *Trans. Farad. Soc.*, **23**, 166 (1927).

[4] Vernon, W. H. J., *Trans. Farad. Soc.*, **27**, 264 (1931).

[5] Gulbransen, E. A., and Copan, T. P., "Physical Metallurgy of Stress Corrosion Fracture", 155 (Interscience Pub., New York, 1960).

ENGINEERING

Tensile Behaviour of Pyrolytic Graphite at 2,750° C.

ENGINEERING stress–strain curves have been obtained at temperatures of 1,650–2,750° C. for a pyrolytic graphite which had been heated to 2,870° C. Changes in the crystal structure as determined by X-ray diffraction and changes in the microstructure caused by the heating and straining have been observed.

According to the manufacturer (Raytheon Manufacturing Company) the polycrystalline material tested was deposited at 2,100° C. on a substrate of synthetic graphite by decomposition of a methane–hydrogen mixture. The as-deposited material had a density-range of 2·19–2·21 gm./c.c. and, as shown in Fig. 1, had a 'block-like' structure of conical elements called 'growth cones'. From the surface appearance of the specimen blanks it was possible to divide them into four classes according to the size of the visible 'growth cones'. All specimens were heated in argon to 2,870° C., held for 5 min., and cooled to room temperature prior to testing.

The details of the testing method and equipment used have been described previously[1,2]. All specimens

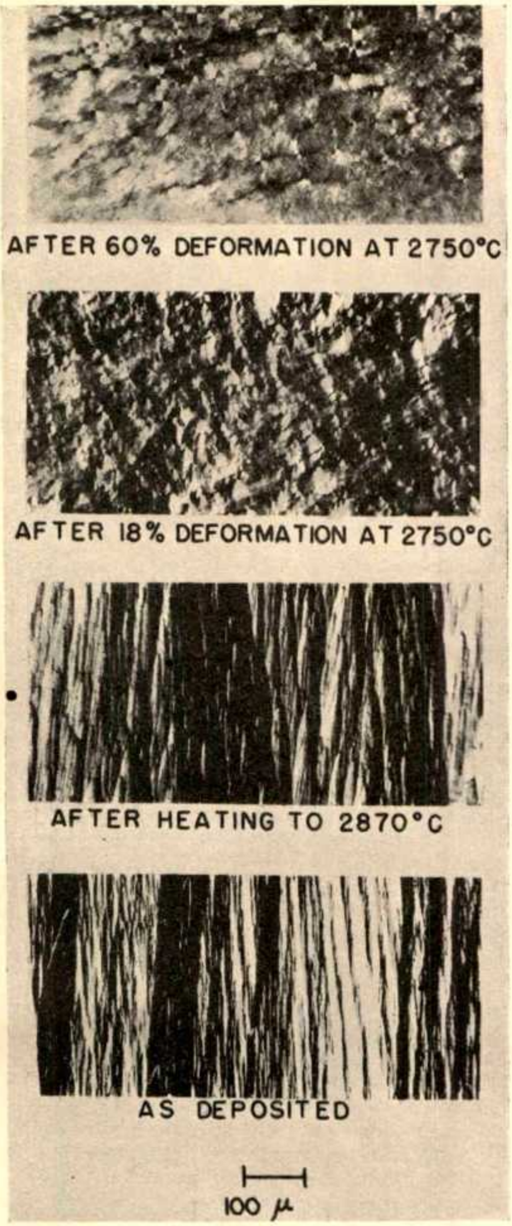

AFTER 60% DEFORMATION AT 2750°C
AFTER 18% DEFORMATION AT 2750°C
AFTER HEATING TO 2870°C
AS DEPOSITED
100 μ

Fig. 1. Microstructure of pyrolytic graphite

Table 1. Tensile Properties of Pyrolytic Graphite

Visible growth cone size	Location* of specimen and thickness of as-deposited material (in.)		Test temperature (° C.)	Ultimate tensile strength (lb./in.^{2})	Elongation in 0·75 in. (per cent)
Medium	*c.*	0·17	Room	9,050	0·1
Medium fine	Top	0·25	Room	10,670	0·1
Fine	Sub	0·27	Room	9,260	0·1
Medium fine	Top	0·25	Room	6,510	0·2
Fine	Sub	0·27	1,650	19,470	4·4
Medium	*c.*	0·17	1,650	3,490†	0·1
Medium fine	Sub	0·25	1,650	15,930	4·0
Coarse	*c.*	0·10	2,200	9,300	2·8
Medium fine	Top	0·25	2,200	15,670	1·8
Fine	Top	0·27	2,200	19,420	2·8
Medium	*c.*	0·17	2,500	34,100	7·6
Medium fine	Top	0·25	2,500	34,110	5·5
Fine	Top	0·27	2,750	29,680	24·0
Fine	Sub	0·27	2,750	60,860	59·2
Fine	Top	0·27	2,750	31,600	18·2
Fine	Top	0·27	2,750	50,310	26·4

All specimens heated in argon to 2,870° C. for 5 min. and cooled to room temperature before testing.

* *c*, Centre of specimen at centre of as-deposited material; Top, specimen from top 0·1 in. of as-deposited material; Sub, specimen from bottom 0·1 in. of as-deposited material.

† Fracture occurred at growth cone.

had a gauge section 0·75 in. long by 0·06 in. wide by 0·1 in. thick and were taken from blanks 3 in. long by 0·75 in. wide by 0·1 in. thick with the thickness direction perpendicular to the basal planes. In some cases the as-deposited material was greater than 0·25 in. thick, so that it was possible to obtain specimen blanks 0·1 in. thick from the material deposited during the latter part of the process (Table 1 'Top'), and also from the material deposited during the early part of the process (Table 1, 'Sub'). The stress was applied parallel to the basal planes at a cross-head speed of 1·5 × 10^{-4} in./sec. All elevated temperature tests were made in helium.

Results obtained are given in Table 1. These are in general agreement with preliminary results previously reported[3]. The present specimen configuration permitted measurement of ductility and confirmed the previous indication that at temperatures above 1,650° C. pyrolytic graphite has greater ductility than commercial synthetic graphite.

The microstructure before and after deformation at 2,750° C. is shown in Fig. 1. As seen, a marked change has occurred after tensile deformation in that the 'growth cone' structure has almost disappeared. This is true after 18 per cent as well as after 60 per cent deformation and is similar to the change reported by Pappis[4]. No change in microstructure was observed to be produced by heating at 2,870° C.

Spectrometer tracings (Fig. 2) show the effects of heating and tensile deformation on the three-dimensional graphite ordering. After the as-deposited material was heated to 2,870° C. and after 18 per cent deformation at 2,750° C. there appeared to be partial

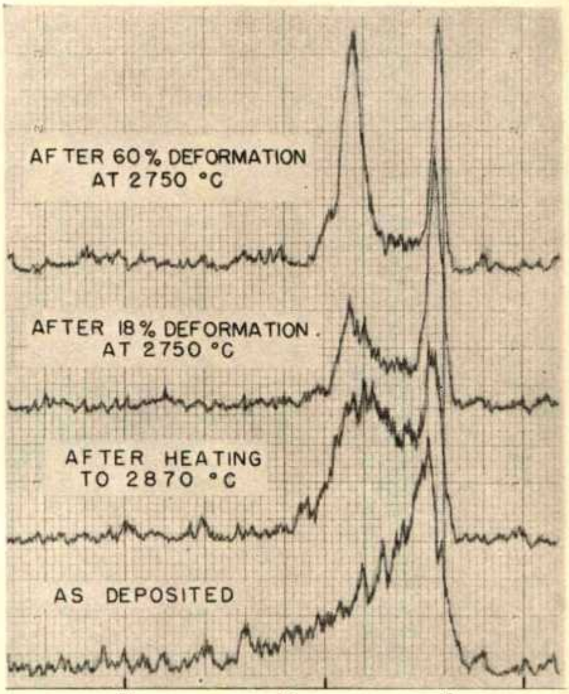


Fig. 2. Development of modulations in the (10) X-ray reflexion of pyrolytic graphite with heating and straining

three-dimensional ordering. After 60 per cent deformation at 2,750° C. there appeared to be complete ordering, as indicated by the complete splitting of the two dimensional (10) reflexion into the crystalline (100) and (101) reflexions.

This communication presents the results of one phase of research carried out at the Jet Propulsion Laboratory, California Institute of Technology, under Contract *NAS w*-6, sponsored by the National Aeronautics and Space Administration.

H. E. MARTENS
W. V. KOTLENSKY

Jet Propulsion Laboratory,
California Institute of Technology,
Pasadena.

[1] Martens, H. E., Jaffe, L. D., and Jepson, J. O., Proc. Third Conf. on Carbon, 529 (Pergamon Press, London, 1959); *Mém. Scientifiques Rev. Metallurg.*, **56**, 721 (1959).

[2] Martens, H. E., Button, D. D., Fischbach, D. B., and Jaffe, L. D., Proc. Fourth Conf. on Carbon (Pergamon Press, London) (in the press).

[3] Martens, H. E., and Jaffe, L. D., *J. App. Phys.*, **31**, No. 6 (1960).

[4] Pappis, J., "The Mechanical Properties of Pyrographite", paper presented at the Research Conference on the Mechanical Properties of Engineering Ceramics, March 9–11, 1960, North Carolina State College, Rayleigh, North Carolina.

CRYSTALLOGRAPHY

Effect of a Second Crystalline Modification in Polyethylene on X-Ray Crystallinity Measurements

FROM several investigations it is known that in solid polyethylene which has undergone severe mechanical treatment a second crystalline modification may occur besides the normal rhombic one[1]. In the X-ray diagram the strongest reflexion of this second modification coincides with the maximum in the so-called amorphous band (the broad halo of diffraction emanating from the amorphous regions). In view of the fact that the amorphous band in unbranched polyethylenes appears to be abnormally narrow, Slichter[2] suggests that the second modification also occurs in undeformed polyethylene. In this communication I want to point out that this suggestion may explain certain anomalies in the results of the density and crystallinity measurements described below.

If polyethylene is assumed to consist of an amorphous and a rhombic crystalline phase only, the density d_{tot} is related to the crystalline fraction φ as follows:

$$\frac{1}{d_{\text{tot}}} = \frac{\varphi}{d_{\text{rh}}} + \frac{1-\varphi}{d_{\text{am}}}$$

where d_{rh} and d_{am} are the (rhombic) crystalline and amorphous densities, respectively. Originally, our aim was to find d_{am} values for different specimens from measurements of the quantities d_{tot}, d_{rh} and φ. The measurements were made as follows: (1) d_{tot} was determined at 23° C. by a flotation method. (2) d_{rh} was calculated from the cell dimensions, which were determined from the X-ray diffraction angles of the (200), (020) and (011) reflexions. The polyethylene samples were mixed with sodium chloride which served as a standard. (3) The crystalline fractions were measured by Krimm and Tobolsky's[3] X-ray method. In this method the intensity of coherent scattering from the amorphous fraction is compared with the corresponding intensity from the molten sample. The necessary monochromatization of the X-ray beam was obtained by the double filter technique of Ross[4] as described by M. Kakudo and R. Ullman (private communication).

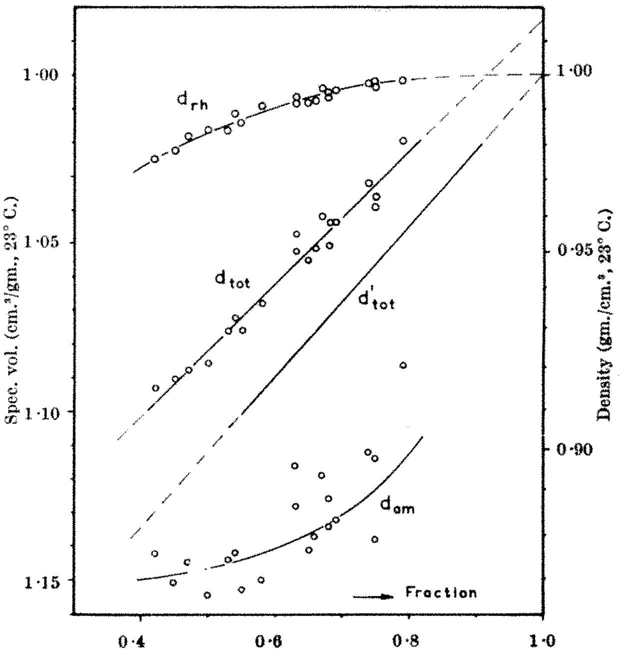


Fig. 1

Altogether five different polyethylene samples were investigated, each being cooled from the melt at four different rates.

In Fig. 1 both the measured values of d_{rh} and d_{tot} and the calculated values of d_{am} are presented as functions of the crystallinity φ. (The curve through the points d_{tot} is based on some twenty more incidental measurements, which are not shown in the figure.)

This graph is not satisfactory for two reasons. First, the calculated values of d_{am} are in the range 0·865–0·92 gm./cm.³, which is much higher than that found by extrapolating the density of molten polyethylene to room temperature (0·83–0·85 gm./cm.³). The maximum density to be expected for amorphous polyethylene can be estimated by calculating the density of a hypothetical phase in which the chain molecules are parallel and close-packed, and can rotate around their chain axes. With the shortest possible distance between the centres of the chains (4·95 Å.), the calculated density is 0·86 gm./cm.³, which is lower than the values shown in Fig. 1.

Secondly, the extrapolated curves for d_{tot} and d_{rh} should intersect at $\varphi = 1$, which they clearly do not.

A possible explanation of these discrepancies is that some systematic error was made in our measurements. This explanation seems to be supported by the fact that the density-crystallinity relation d'_{tot} (Fig. 1), which was obtained in our laboratory from infra-red measurements, leads to much higher crystallinities and can moreover be extrapolated to intersect the d_{rh}-curve at $\varphi = 1$. The line d'_{tot} also agrees with nuclear magnetic resonance measurements made in our laboratory of the 'mobile' fraction in different polyethylene samples at room temperature.

However, the differences between the amorphous fractions following from the lines d_{tot} and d'_{tot}, respectively, seem to be too large to be attributable to experimental errors alone. We believe that the discrepancies must be explained by the above-mentioned suggestion, namely, that also in normal polyethylene a second crystalline modification is present. In the X-ray method this fraction is 'seen' as amorphous, in the other methods as crystalline.

This view is supported by measurements of the integral breadth of the amorphous band, from which it followed that for highly crystalline samples this breadth is only about two-thirds of the value found for molten polyethylene. This agrees with the idea that a (perhaps highly broadened) crystalline peak is hidden under the amorphous band.

If this explanation is assumed, the fraction φ_2 of the second modification may be roughly estimated to correspond with the horizontal distance between the lines d_{tot} and d'_{tot}. Using for the density d_2 of the second modification the value suggested by Teare and Holmes (0·965 gm./cm.^{3}, ref. 1), the amorphous density may now be calculated anew from the relation :

$$\frac{1}{d_{\mathrm{tot}}} = \frac{\varphi_{\mathrm{rh}}}{d_{\mathrm{rh}}} + \frac{\varphi_2}{d_2} + \frac{1 - \varphi_{\mathrm{rh}} - \varphi_2}{d_{\mathrm{am}}}$$

This leads to values of about 0·84 gm./cm.^{3} for all samples, which is in good agreement with the range of values found by extrapolation of the density of molten polyethylene.

I am indebted to Dr. Westrik for many helpful suggestions. The density, infra-red, and nuclear magnetic resonance measurements were made by Dr. Fortuin, Dr. Veerkamp and Dr. Smidt, respectively, who kindly gave me permission to use their results in this discussion.

C. G. Vonk

Central Laboratory,
Staatsmijnen in Limburg,
Geleen, The Netherlands.

---

[1] Teare, P. W., and Holmes, D. R., *J. Pol. Sci.*, **24**, 496 (1957).

[2] Slichter, W. P., *J. Pol. Sci.*, **21**, 141 (1956).

[3] Krimm, S., and Tobolsky, A. V., *J. Pol. Sci.*, **7**, 57 (1951).

[4] Ross, P. A., *J. Opt. Soc. Amer.*, **16**, 433 (1928).

CHEMISTRY

Preparation of Pure Standard Metallic Perchlorate Solutions

Acid-free standard solutions (0·05 *M*) of the perchlorates of the divalent metals copper, nickel, cobalt, iron, zinc and manganese suitable for use in the determination of stability constants of chelates by the potentiometric method can be prepared utilizing an ion-exchange technique. A column 1·6 cm. diameter containing 50 ml. 'Amberlite' cation exchange resin *IR* 120(*H*) is treated with a solution (0·1 *M*) of the pure sulphate or chloride of the divalent metal until the *p*H's of the entrant and issuing solutions are identical. After eluting the excess metal salt solution with water the metal ions bound to the resin are displaced by passing a pure solution of barium perchlorate (0 052 *M*) on to the resin. Since barium ions have a stronger affinity for the resin than the divalent ions of copper, nickel, cobalt, iron, zinc and manganese, the latter are displaced and the barium-free fractions of the eluates contain the pure perchlorate solutions of these metals. A yield of about 400 ml. 0 05 *M* metal perchlorate solution is obtained under these conditions. An analysis of each of the solutions was carried out using both gravimetric and ion exchange methods. In the latter a 20-ml. portion of the metal was passed on to a small column of 'Amberlite' resin *IR* 120(*H*) and the eluate titrated with standard alkali. The results obtained by the two methods agreed to within 0·3 per cent.

The ferrous perchlorate solution can be conveniently stored in the ion exchange column which, for ease of dispensing, is connected to a burette fitted with an oxygen trap. The solution should be standardized immediately before use and contains less than 10 p.p.m. Fe^{3+}. In order to obtain a maximum yield it is necessary to exclude air from the solutions used for the quantitative conversion of the resin into the form $(RSO_3)_2Fe$. However, while the yield is lowered by the presence of Fe^{3+} on the resin the purity of the ferrous perchlorate is not affected since during the subsequent treatment with barium perchlorate only ferrous ions are displaced from the resin.

E. P. Serjeant

Department of Analytical Chemistry,
University of New South Wales,
Box 1, P.O., Kensington,
New South Wales.

Catalytic Effects in the Alkaline Oxidation of Cellulose

Michie and Neale[1] have reported results which suggest that copper has an unexpectedly high catalytic effect in the reaction of cellulose with oxygen in the presence of low concentrations of alkali. By comparing their observed rate of reaction for copper-treated cotton containing fully carbonated sodium hydroxide with a value calculated from Davidson's[2] results for the uncatalysed reaction at high sodium hydroxide concentration, they deduced that the copper increased the rate by a factor of 80 or more. Very much smaller increases, namely, less than tenfold, had been found by other workers, concerned with alkali concentrations of 5 *N* or higher, on addition of metallic catalysts.

A more direct demonstration of a large catalytic effect at fairly high alkali concentration is provided by the results in Fig. 1, which shows the variation of the initial rate of oxygen consumption of jute fibre at 60° C. with the iron content of the fibre. The

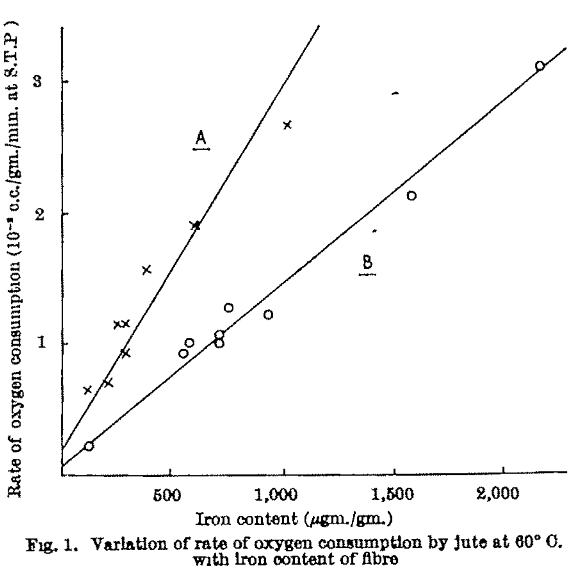


Fig. 1. Variation of rate of oxygen consumption by jute at 60° C. with iron content of fibre

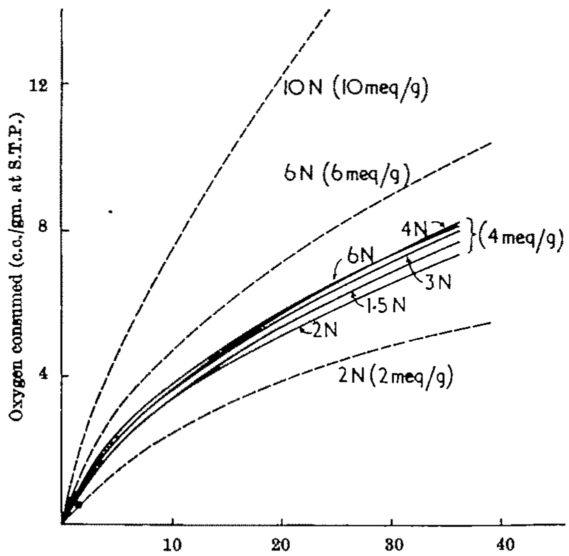


Fig. 2. Oxygen uptake of jute at 60° C. Figures on curves: concentration of sodium hydroxide solution. Figures in brackets: weight of sodium hydroxide per gm. of fibre

natural iron content of jute fibre is normally in the range 250–500 μgm./gm., and the samples used in these experiments included untreated fibre, fibre treated with acid to reduce the iron content, and fibre impregnated with different amounts of ferric sulphate. The rate at which oxygen was consumed by the fibre was determined from the fall in pressure in a closed vessel, filled with pure oxygen, in which the powdered fibre, moistened with a measured volume of sodium hydroxide solution, was spread over the inner surface. The oxygen uptake was normally linear with time over the first few hours and thereafter gradually decreased. An induction period, such as found by Davidson[2] for cotton, was not observed with jute fibre. The rates plotted in Fig. 1 were estimated from the slope of the initial linear portion of the uptake curves. The two lines, *A* and *B*, are drawn through points for two sets of experiments in which different quantities of sodium hydroxide were added to the fibre, as follows:

A, 2·67 ml. 3 *N* sodium hydroxide per gm. of fibre (8 m.equiv. sodium hydroxide/gm.).

B, 1·33 ml. 3 *N* sodium hydroxide per gm. of fibre (4 m.equiv. sodium hydroxide/gm.).

These results demonstrate two points of interest:

(*a*) Over the range of iron contents covered, the rate of reaction increases linearly with the iron content. In the results of set *B* a catalytic factor of about 40 is involved on increasing the iron concentration from zero to the highest experimental iron content of 2,170 μgm./gm. Other experiments at higher iron contents, however, showed that the linear relation did not hold above 2,000 μgm./gm., the rate apparently becoming independent of iron concentration, in agreement with the conclusion reached by Michie and Neale[1].

(*b*) The ratio of the slopes of lines *A* and *B* is very close to 2·0, indicating that the rate of reaction is proportional to the weight of sodium hydroxide per unit weight of fibre and not to the concentration of the sodium hydroxide solution applied to the fibre. This relationship is confirmed by the results in Fig. 2, which shows the uptake of oxygen with time of samples of natural jute fibre moistened with different volumes of sodium hydroxide solutions of various concentrations. The group of solid lines, for a constant weight of 4 m.equiv. sodium hydroxide per gm. of fibre, indicates a rate of oxygen consumption that is constant within the reproducibility of these experiments, although the concentration of the alkali solutions varies from 1·5 *N* to 6 *N*. If this relationship applies to cotton as well as to jute, the finding of Michie and Neale[1] that the rate of oxidation is to a first approximation proportional to the sodium hydroxide concentration would seem to be valid only if equal volumes of alkali solution were applied to a given weight of fibre.

W. A. Bell

British Jute Trade Research Association,
Dundee.

---

[1] Michie, R. I. C., and Neale, S. M., *Nature*, 183, 534 (1959).

[2] Davidson, G. F., *J. Text. Inst.*, 23, T95 (1932).

Infra-Red Spectra of Deoxyribonucleic Acids from Human Leucocytes

As part of a study on the physico-chemical behaviour of deoxyribonucleic acid obtained from human leukæmic leucocytes, we have examined the infra-red spectra of many normal and leukæmic samples in solutions in water and deuterium and in the dry state. Since we did not find complete agreement between previous reports of the infra-red spectra of calf thymus deoxyribonucleic acid[1-3], we have also studied samples from this source. The effects of heating, *p*H changes, degradation with deoxyribonuclease, mild and strong acid hydrolysis were examined and the spectrum of apurinic acid has also been determined.

A Perkin–Elmer, model 21, double-beam spectrometer with sodium chloride and calcium fluoride optics has been used. With slit-widths narrower than those used by Blout and Lenormant[4] and with suitable adjustments, we were able to improve the resolution. The deuterium solutions were prepared in the manner described by previous authors[4].

The samples were examined in demountable cells of thallium bromo-iodide with spacers of 0·015 mm. In order to avoid the small lack of compensation due to absorption by atmospheric water in studying details of the bands in the region between 1,700 and 1,500 cm.$^{-1}$, we flushed the spectrometer with dry nitrogen.

The spectra were observed in the regions: dry state, 4,500–650 cm.$^{-1}$; deuterium solution, 2,000–650 cm.$^{-1}$; water solution, 1,500–850 cm.$^{-1}$. All samples of deoxyribonucleic acid from normal and leukæmic sources had identical spectra. The physical or chemical treatments resulted in the same spectral modification for all samples.

The spectrum of deoxyribonucleic acid in deuterium solution, in the region between 1,700 and 1,500 cm.$^{-1}$, shows the following bands: 1,575 cm.$^{-1}$(*w*) with a shoulder at 1,563 cm.$^{-1}$; 1,622 cm.$^{-1}$(*m*); 1,645 cm.$^{-1}$ strong and sharp; 1,680 cm.$^{-1}$ strong and broad.

These results are in agreement with those obtained by DeLozé[3] for calf thymus deoxyribonucleic acid at 100 per cent relative humidity in deuterium, except that we did not find the band at 1,695 cm.$^{-1}$ in any sample.

The physical and chemical treatments mentioned above induce no change in the frequency or shape of the band at 1,575 cm.$^{-1}$, though the band becomes stronger at *p*H 13. This band does not appear in the spectrum of apurinic acid. The band at 1,622 cm.$^{-1}$ has been found in the spectra of all samples: it became sharper after treatment with deoxyribonuclease or upon change of *p*H. For all samples, the band at 1,645 cm.$^{-1}$ completely disappears after acid hydrolysis or treatment with deoxyribonuclease and is replaced by a strong band at 1,660 cm.$^{-1}$. On heating at 100° the band at 1,660 cm.$^{-1}$ becomes broader. The band at 1,680 cm.$^{-1}$ which is strong and broad in the original spectrum decreases considerably, but does not disappear on treatment with enzyme, acid hydrolysis or on heating and there is a frequency shift to 1,690 cm.$^{-1}$. The spectrum of all samples of *p*H 13 shows a new weak band at 1,592 cm.$^{-1}$.

These results are of particular interest in relation to the nature of the specific interaction between purine and pyrimidine units in deoxyribonucleic acid structure[6-9].

Our observations are in disagreement in some respects with previous reports[1], and the explanation of the spectral changes is still open to discussion. Further data are required, and a more detailed study of the spectra changes of deoxyribonucleic acid under different *p*H conditions is now being carried out. The results and a proposed interpretation will be published elsewhere.

In previous determinations of infra-red spectra of deoxyribonucleic acid in mineral oil suspension, preparations of myeloid leukæmia leucocytes were found to exhibit a band which was not present in preparations from normal leucocytes[5]. The results of the present work, however, do not confirm this observation.

We are indebted to Dr. E. Mantica for his interest and helpful discussion.

G. ZERBI*

Istituto di Chimica Industriale
del Politecnico, Milano.

P. A. BIANCHI
E. E. POLLI

Istituto di Clinica Medica Generale,
Università di Milano.

* Present address: University of Minnesota School of Chemistry, Minneapolis, Minnesota.

[1] Blout, E. R., and Lenormant, H., *Biochim. Biophys. Acta*, 17, 325 (1955).
[2] DeLozé, Chr., *Ann. de Chim.*, 13, 161 (1958).
[3] Sutherland, G. B. B. M., and Tsuboi, M., *Proc. Roy. Soc.*, A, 239, 446 (1957).
[4] Blout, E., and Lenormant, H., *J. Opt. Soc. Amer.*, 43, 1093 (1953).
[5] Villa, L., Polli, E., Semenza, G., Sensi, A., and di Majorca, G. P., *Rev. Belg. de Path.*, xxxiv, 5, 360 (1955).
[6] Miles, H. T., *Biochim. Biophys. Acta*, 30, 326 (1958).
[7] Miles, H. T., *Nature*, 183, 1814 (1959).
[8] Miles, H. T., *Biochim. Biophys. Acta*, 35, 274 (1959).
[9] Rich, A. A., *Rev. Mod. Phys.*, 31, 191 (1959).

[For "deuterium" read "deuterium oxide" throughout.—Editors]

Use of Solvents containing Ethyl Iodide in the Investigation of Phosphorescence Spectra of Organic Compounds

M. KASHA[1] has suggested that the yellow colour produced when α-chloronaphthalene and ethyl iodide are mixed is due to the enhancement of the lowest singlet–triplet absorption band of the naphthalene molecule. He interpreted this effect in terms of a collisional perturbation of spin-orbital coupling in the aromatic molecule, by the heavy iodine atom. The singlet–triplet absorption bands reported for benzene by a number of workers[2] as well as those for a wide number of other aromatic molecules have been shown by Evans[3] to be due to spin orbit perturbation by the inhomogeneous fields of dissolved paramagnetic oxygen molecules. The perturbing effects of ferric and cupric acetonyl acetonates have also been demonstrated[4].

It was thought that a similar effect of perturbation might be observed during phosphorescent emissions from organic compounds, both by increasing the likelihood of phosphorescent return to the ground-state, and by increasing the conversion from the excited singlet to triplet states. The effect of ethyl iodide on the emissions of the eight isomeric dinitronaphthalenes, and on N,N-dimethyl-4-nitroaniline, coumarin and acid fluorescein was investigated. The phosphorescence spectra were first measured with the compounds dissolved in a glass made by cooling a mixture of four parts of ethanol to one of methanol to the temperature of liquid air. The spectra were then remeasured in a glass containing one part of ethyl iodide to four parts of mixed alcohols. The apparatus used was a high-pressure a.c. mercury arc lamp fed through a rectifier, and a glass prism spectrometer with a photomultiplier at the exit slit. Phosphorescence was identified and recorded by 'chopping' the photomultiplier current supply so that the sample emission was only recorded during the ½ a.c. cycles when the lamp arc intensity was zero. The ratio of the intensities of the readings obtained for a given band with and without the 'chopper' was approximately 1 : 2 for long-lived phosphors. This is because the total luminescence involved viewing for twice the time available for phosphorescence readings. For short-lived phosphors, this ratio was smaller due to the rapid decay of the emission with respect to the time of an a.c. cycle. The results of these investigations are shown in Table 1. 1,5-Dinitronaphthalene is quoted as typical of the dinitronaphthalene series.

Table 1

Compound	Total luminescence : phosphorescence ratio		Life-time (sec.)	
	Alcohol	Alcohol + Et I	Alcohol	Alcohol + Et I
1,5-Dinitronaphthalene	1·97	2·28	> 0 1	0 008
N,N-Dimethyl-4-nitronaphthalene	1·97	2·32	> 0·1	0·008
Coumarin	—	2 94	> 0·1	0 005
Acid fluorescein	—	2·35	> 0·1	0·007

In all cases the effect of the addition of ethyl iodide was to increase the intensity of the phosphorescence bands and increase the ratio of the total luminescence to phosphorescence. Since the phosphorescence intensity did not appreciably decrease, the effect of the iodide on the ratio was not merely to increase the radiationless deactivation to the ground-state, but must also have increased the probability of the triplet–ground singlet transition. This evidence would seem to show that even in a rigid glass solvent 'heavy atom' perturbation occurs, thus providing the inverse effect of Kasha's observations.

Two other effects are of interest: first, the phosphorescence band peaks were shifted towards lower energies by about 200–300 cm.$^{-1}$; and, secondly, the coumarin and acid fluorescein fluorescence intensities were also increased. It is possible that some form of complex might lead to charge transfer effects such as those reported by Reid[5]. These points will require further investigation.

It should be noted that, although ethyl iodide is well known to undergo photolysis in strong ultraviolet light, no appreciable decomposition was found under the conditions of the present work.

We wish to thank Dr. E. J. Bowen for help and encouragement. This work was carried out during the tenure of a maintenance grant from the Department of Scientific and Industrial Research by one of us (J. M. C.).

I. J. GRAHAM-BRYCE*

Physical Chemistry Laboratory,
Oxford.

J. M. CORKILL†

Dyson Perrins Laboratory,
Oxford.

---

* Present address: Department of Agriculture, University of Oxford.

† Present address: Thomas Hedley and Co., Ltd., Newcastle upon Tyne 1.

[1] Kasha, *J. Chem. Phys.*, **20**, 71 (1952).

[2] Sklar, *J. Chem. Phys.*, **5**, 669 (1937). Lewis and Kasha, *J. Amer. Chem. Soc.*, **67**, 994 (1945). Pitts, *J. Chem. Phys.*, **18**, 1416 (1950).

[3] Evans, *J. Chem. Soc.*, 1351, 3885 (1957); 2753 (1959).

[4] Chaudhuri and Basu, *Trans. Farad. Soc.*, **54**, 1605 (1958).

[5] Reid, *J. Chem. Phys.*, **20**, 1212, 1214 (1952). Moodie and Reid, *ibid.*, **22**, 252 (1954).

Rate of Ligand Exchange with its Metal Complex by a Polarimetric Method

OPTICALLY active 1,2-propylenediamine tetraacetic acid[1] (H_4PDTA) co-ordinates in a completely stereospecific manner[2] with Co(III), Rh(III) and Cr(III). Courtauld models of either co-ordinated optical isomer show the methyl group to be sterically hindered for one configuration of the metal complex irrespective of whether the ligand is attached at 4 (non-planar), 5 or 6 points to the metal atom. The absolute stereospecificity of complex formation provides a simple polarimetric method of measuring the exchange-rate of the free ligand with its metal complexes.

Equivalent amounts of the metal complex containing one optical form of the ligand and the free optical antipode were mixed in buffered aqueous solution, and the rate of loss of optical activity determined.

$$[M\ d\text{-PDTA}]^{n-} + l\text{-PDTA} \rightleftharpoons [M\ l\text{-PDTA}]^{n-} + d\text{-PDTA}$$

It will be evident that the rotation will have fallen to zero when half the ligand is exchanged. The concentrations of unreacted initial complex and the added free ligand at any time may be calculated from the observed rotation and the respective initial rotations before mixing. In general, there is a considerable difference between the rotatory powers of the free ligand and the metal complex even when the latter is colourless. The difference may be magnified by a suitable choice of the wave-length of the light when the complex is coloured.

Preliminary studies of the rate of exchange of the cadmium complex with the ligand have shown a first-order dependence on both complex and ligand at *p*H 6. The approximate specific rate constant at 20° C. was found to be 0·07 l.-moles^{-1}-sec.$^{-1}$. During the reaction, the rotation changed from $-0{\cdot}66°$ to zero for 0·005 *M* solutions of complex and ligand in a 20-cm. tube.

Table 1

Complex	*p*H	Time for half-exchange with *l*-PDTA
[Ni(*d*-H_2.PDTA)]	0 70	30 min.
	2 90; 6·40	No exchange in 3 days
[Cu(*d*-H_2.PDTA)]	2 90	< 1 min.
	6·40	16 hr.
[Cd(*d*-H_2.PDTA)]	2 90	<40 sec.
	6 30	1 hr.
[Zn(*d*-H_2.PDTA)]	2·90	<40 sec.
	6 32	3 hr.
[Ca(*d*-H_2.PDTA)]	7 80	< 1 min.
[Al(*d*-H.PDTA)]	2 90	20 hr.
[Y(*d*-H.PDTA)]	2 90	< 1 min.
[Mn(*d*-H_2.PDTA)]	3 00	< 1 min.
	6·30	5 min.
[Co(*d*-H_2.PDTA)]	2·90	< 1 min
	6·30	7 days
[Fe(*d*-H.PDTA)]	0 7	7 hr.
	6 5	No exchange in 2 days

The approximate times for exchange between half of the PDTA and a number of its metal complexes at 20° C. are shown in Table 1. The metal complexes were prepared in the acid forms, [*M*(H_2.PDTA)], or [*M*(H.PDTA)] by reaction between the metal acetate and active propylenediamine tetraacetic acid and, after recrystallization, dissolved in the appropriate buffer solution. The complexes like those with ethylenediamine tetraacetic acid are either quinquidentate or sexadentate. Detailed studies will be published later.

We are indebted to the Dow Chemical Co., Midland, Michigan, for a gift of *d,l*-propylenediamine tetraacetic acid.

B. BOSNICH
F. P. DWYER
A. M. SARGESON

John Curtin School of Medical Research,
Australian National University, Canberra.

[1] Dwyer and Garvan, *J. Amer. Chem. Soc.*, **81**, 2955 (1959).

[2] Dwyer and Garvan, *J. Amer. Chem. Soc.* (in the press).

BIOCHEMISTRY

Specific Detection of Glucose on Paper Chromatograms

MIXTURES of monosaccharides derived from complex polysaccharides often present difficulties in identification when the compounds migrate close to one another on paper chromatograms. Difficulties of this kind have been encountered with certain bacterial polysaccharides containing glucose, galactose and heptoses. With the use of the glucose oxidase[1]-indicator reagent, 'Glucostat' (Worthington Biochemical Corporation) it has been possible to locate specifically the glucose and then reveal other monosaccharides on the same paper chromatogram.

Monosaccharides were separated on Whatman paper No. 1, with the *n*-butanol–pyridine–water (6 : 4 : 3 v/v) solvent system, the paper chromatograms dried in air and then sprayed with the 'Glucostat' reagent prepared as for the quantitative estimation of glucose in biological fluids[2]. As the 'Glucostat' reagent is in the form of a buffered, aqueous solution, flooding of the paper chromatograms was avoided to prevent spreading of the various monosaccharides. When sugars were separated with acidic solvents such as *n*-butanol–acetic acid–water (6 : 1 : 2 v/v) the chromatograms were steamed for 5–10 min. before spraying. The indicator dye, *o*-dianizidine, in the 'Glucostat' reagent locates the glucose by turning a permanent pinkish-brown colour. The colour develops rapidly at room temperature and no further treatment is necessary. The method readily detects 10–20 μgm. glucose separated on paper chromatograms and will detect less than 10 μgm. providing little spreading of the 'spot' occurs during chromatography. Attempts to adapt the method for direct quantitative estimation have been unsuccessful, as the coloured complex adheres strongly to the paper and could not be extracted quantitatively in a variety of solvents. Thus, for determination of glucose, it is necessary to elute after separation on paper chromatograms and then develop the colour in the normal manner with the glucose oxidase–*o*-dianisidine reagent[2].

After detection of glucose, the paper chromatograms were dried in air and over-sprayed with aniline phthalate for the identification of other monosaccharides. There is some loss in sensitivity towards reaction with the aniline phthalate, presumably due to the buffer constituents, protein, etc., of the 'Glucostat' reagent. However, for differentiation between glucose and other monosaccharides poorly separated from the former sugar, spraying first with the glucose oxidase reagent and then over-spraying with aniline phthalate provides a rapid and reproducible technique. The recent report of a galactose oxidase[3] suggests that such an enzyme could also be applied in a similar fashion for the specific identification of galactose.

M. R. J. Salton*

Department of Bacteriology,
University of California,
Berkeley, U.S.A.

---

* Permanent address: Department of Bacteriology, University of Manchester, Manchester 13.

[1] Keilin, D., and Hartree, E. F., *Biochem. J.*, 42, 230 (1948).

[2] Teller, J. D., Abstract of Papers, 130th Meeting, Amer. Chem. Soc., 69, C (Sept. 1956). Huggett, A. St. G., and Nixon, D. A., *Lancet*, ii, 368 (1957). Saifer, A., and Gerstenfeld, S., *J. Lab. and Clin. Med.*, 51, 448 (1958).

[3] Cooper, J. A. D., Smith, W., Bacila, M., and Medina, H., *J. Biol. Chem.*, 234, 445 (1959).

Glutathione Stability and Pyrophosphatase Activity in Reticulocytes; Direct Evidence for the Importance of Glutathione for the Enzyme Status in Intact Cells

In the course of studies on the maturation of red blood cells we confirmed the report of Malkin and Denstedt[1] that reticulocytes show a tenfold higher activity of inorganic pyrophosphatase as compared with erythrocytes. Pyrophosphatase appears to contain a functional SH— group. Traces of cupric ions, *para*-chloromercury benzoate and iodo-acetate cause an inhibition which is reversible by cysteine[2,3]. To test the assumption that the lability of the SH— group may be connected with the decrease of pyrophosphatase activity during maturation, the effect of conditions which change the oxidation status of glutathione on the activity of pyrophosphatase was studied.

The experiments were performed on intact cells and hæmolysates of rabbit blood, in which a reticulocytosis of 35–40 per cent was brought about by bleeding. Table 1 contains the results of an experiment on intact cells in which phenylhydrazine was employed to oxidize the glutathione according to Beutler's procedure[4]. It may be seen that incubation of washed cells without phenylhydrazine did not occasion a decline of pyrophosphatase activity; this did occur in the presence of phenylhydrazine. Addition of glucose prevented the loss of enzyme activity. In Table 2 is shown a similar experiment on stroma-free hæmolysate. Here the loss of enzyme activity could be prevented by the addition of glucose-6-phosphate. The mechanism of the action of phenylhydrazine is in all likelihood a hæmin-catalysed oxidation of glutathione[5,6]. The conservation of glutathione with glucose or glucose-6-phosphate occurs by way of the chain of enzymes hexokinase, glucose-6-phosphate-dehydrogenase and glutathione reductase[7].

Table 1

	I	II	III	IV
Incubation time (hr.)	0	10	10	10
Phenylhydrazine (5 mgm./ml. susp.)	—	—	+	+
Glucose (2×10^{-2} *M*)	—	—	—	+
Pyrophosphatase units	22·1	21·4	9 5	19 8

The reaction system for the determination of pyrophosphatase activity contained in 2 0 ml.: 1×10^{-3} *M* $Na_4P_2O_7$ $10H_2O$, 2×10^{-3} *M* $MgSO_4.7H_2O$, 1×10^{-1} *M* *tris*-buffer *p*H 7 6, 0·1 ml. hæmolysate. Incubation for 15 min. at 37° C. The reaction was stopped by precipitation with trichloracetic acid. The liberated inorganic phosphate was measured by the method of Fiske and Subbarow (ref. 11). Pyrophosphatase activity is reported as γ phosphorus liberated/ml. reaction mixture.

Table 2

	I	II	III	IV
Incubation time (hr.)	0	4	4	4
Phenylhydrazine	—	—	+	+
Glucose-6-phosphate (5×10^{-3} *M*)	—	—	—	+
Pyrophosphatase units	25 9	22·1	8·2	22·1

In the following experiments the direct effect of oxygen was studied and further evidence for the depicted course of events was sought. Table 3 records an experiment in which hæmolysates with and without stroma, which had been dialysed for 60 hr., were incubated. It may be seen that oxygen alone in the presence of stroma caused more than 85 per cent loss of enzyme activity (II). The addition of glutathione alone (IV) diminished the inactivation only to a small extent. Addition of glucose-6-phosphate (VII) also showed only incomplete stabilization of pyrophosphatase. In the presence of nicotinamide (VI), presumably by virtue of inhibition of triphosphopyridine-nucleosidase[8], a higher degree of stabilization was observed. In a complete system (V), complete stabilization was achieved. In the absence of stroma the decrease of enzyme activity was much less (2), and the addition of glutathione alone (4) was sufficient for stabilization. The experiments not only prove that oxygen without intervention of phenylhydrazine may oxidize glutathione but also show that stroma, probably by way of autoxidation of the unsaturated fatty acids, combined with the action of hæmin[9], may favour this oxidation. In addition, stroma increases the inactivation by way of destruction of triphosphopyridine nucleotide through its enzyme. The partial stabilization of pyrophosphatase without addition of triphosphopyridine nucleotide is in consonance with the report of Carson[10], which showed the triphosphopyridine nucleotide is tightly bound to glucose-6-phosphate dehydrogenase.

Table 3

	Complete hæmolysate							Stroma-free hæmolysate			
	I	II	III	IV	V	VI	VII	1	2	3	4
Incubation time (hr.)	0	6	6	6	6	6	6	0	6	6	6
Glutathione ($2·5 \times 10^{-3}$ *M*)	—	—	—	+	+	+	+	—	—	—	+
Glucose-6-phosphate (5×10^{-3} *M*)	—	—	+	—	+	+	+	—	—	+	—
Triphosphopyridine nucleotide ($1 5 \times 10^{-5}$ *M*)	—	—	+	—	+	—	—	—	—	+	—
Nicotinamide (5×10^{-3} *M*)	—	—	+	—	+	+	—	—	—	+	—
Pyrophosphatase units	30 8	4·8	28·2	9 5	28 6	17·8	11 5	30 0	19·3	28 8	28 6

Table 4

	I	1	II	2	x*	y*
Incubation time (hr.)	0	0	6	6	12	12
Cysteine (2×10^{-3} *M*)	—	+	—	+	—	+
Pyrophosphatase units	13·2	16·5	6·6	12·7	1·2	2·9

* x, y from another experiment, activity without incubation, 18·7.

In Table 4 is shown the fact that the inactivation of pyrophosphatase is to a large extent reversible by addition of cysteine after a short period of incubation. The conclusions of these experiments may be summarized as follows.

The stability of pyrophosphatase in the reticulocytes is closely linked with glutathione, which is maintained in the reduced state by way of the oxidation pathway of glucose-6-phosphate. Eliminations or blocking of any single step in the chain may cause a stoichiometric oxidation of glutathione with conequent loss of activity of pyrophosphatase.

Oxidation of glutathione leads to a denaturation of pyrophosphatase, the first reversible step of which is formation of disulphide-bonds. Thus there is close interaction between metabolic processes, such as are concerned with the maintenance of glutathione, and the structural changes of denaturation.

The experiments reported are, so far as we know, the first instance of a direct effect of glutathione on the activity of an enzyme within an intact cell. Other SH— enzymes are in progress.

The mechanism described may have general importance for the conservation and the decline of enzymes in the processes of differentiation and maturation of cells.

S. RAPOPORT
D. SCHEUCH

Physiologisch-chemisches Institut der
Humboldt-Universität,
Berlin.

[1] Malkin, A., and Denstedt, O. F., *Canad. J. Biochem. Physiol.*, **34**, 121 (1956).
[2] Naganna, B. J., *Biol. Chem.*, **183**, 693 (1950).
[3] Cafiero, M., *Boll. Soc. Ital. Biol. Sper.*, **27**, 1427 (1951).
[4] Beutler, E., Robson, M., and Buttenwieser, E., *J. Clin. Invest.*, **36**, 617 (1957).
[5] Warburg, O., Kubowitz, F., and Christian, W., *Biochem. Z.*, **242**, 170 (1931).
[6] Lyman, C. M., and Barron, E. S. G., *J. Biol. Chem.*, 121, 275 (1937).
[7] Carson, P. E., Flanagan, C. L., Ickes, C. E., and Alving, A. S., *Science*, **124**, 484 (1956).
[8] Hofman, E. C. G., *Biochem. Z.*, **329**, 428 (1957).
[9] Rapoport, S., Gerischer-Mothes, W., and Nieradt, C., *Hoppe-Seyler's Z. phys. Chem.*, **300**, 174 (1955).
[10] Carson, P. E., Schrier, S. L., and Kellermeyer, R. W., *Nature*, **184**, 1292 (1959).
[11] Fiske, C. H., and Subbarow, Y., *J. Biol. Chem.*, **66**, 375 (1925).

Characterization of a New Purine Riboside isolated from *Fusarium* Species

AN investigation of the acid-soluble nucleotides occurring in a *Fusarium* species[1] has shown that, in addition to a number of previously known compounds, several new ultra-violet absorbing substances are present in this mould. One of these was identified as the mononucleotide of nicotinic acid[2], a compound which has also been isolated from baker's yeast[3]. The present communication reports the characterization of a second substance, an N^2-substituted guanosine which is probably 2-(1-carboxyethylamino)-6-hydroxy-9-β-D-ribofuranosylpurine.

The compound was isolated from perchloric acid extracts of the micro-organism by ion exchange chromatography[4] and purified by paper chromatography. From a 50-l. culture grown in a stirred fermentor[5] on Czapek–Dox medium 2·5 μmoles were obtained, as calculated from the pentose content of the chromatographically pure substance. The product was phosphorus-free and had ultra-violet absorption spectra at different *p*H values very similar to those of guanosine, except for a small bathochromic shift of the maxima and the minima. Paper electrophoresis in 0·1 *M* ammonium acetate, *p*H 6·5, indicated the presence of a negatively charged group. The orcinol reaction for pentoses was positive; the pentose was liberated on acid hydrolysis (2 hr. at 100° C. with 1 *M* hydrochloric acid) and identified as ribose by paper chromatography in *n*-butanol–acetone–water (2 : 7 : 1, v/v/v). The ribose moiety of the new compound had the furanosidic structure, as shown by the formation of glycerol after degradation according to the procedure of Viscontini, Hoch and Karrer[6] scaled down to 0·3 μmole[7]. Acid hydrolysis yielded, in addition to ribose, an ultra-violet absorbing compound which was purified by ion exchange and paper chromatography. It gave a negative reaction for pentoses, had ultra-violet spectra at acid, neutral and alkaline *p*H values nearly identical to those of 6-hydroxy-2-methylaminopurine[8], and paper electrophoresis indicated the presence of an acidic group. When heated with 4 *N* formic acid (15 hr. at 125° C.) it yielded guanine, which was identified by paper chromatography in two solvent systems and by its ultra-violet spectrum.

These results strongly suggested that the compound isolated from the mould was the ribofuranoside of an N^2-substituted guanine containing an acidic group. The close similarity of the ultra-violet spectra of the hydrolysed compound to those of 6-hydroxy-2-methylaminopurine indicated that the acidic group was most likely carried by the N^2-substituent, so that the aglycone would be an N-(6-hydroxy-2-purinyl)-amino-acid. To test if this were correct a number of compounds of this type were synthesized by treating at *p*H 8·5–9·0 aqueous solutions of 2-chloro-6-hydroxypurine[8] with each of 22 amino-acids in sealed tubes for about 15 hr. at 110–125° C. The amino-acids used were α- and β-alanine, α-, β- and γ-aminobutyric acid, ε-aminocaproic acid, β-amino*iso*butyric acid, aspartic acid, glutamic acid, glycine, *iso*leucine, leucine, methionine, S-methylcysteine, norvaline, phenylalanine, sarcosine, serine, taurine, threonine, tyrosine, valine. The ultra-violet spectra of the synthetic compounds were practically identical to those of the natural aglycone, except for that of the compound prepared from sarcosine, which showed a remarkable bathochromic shift of the maxima at acid and neutral *p*H values (a similar behaviour is shown by 2-dimethylamino-6-hydroxypurine, as compared with 6-hydroxy-2-methylaminopurine[8]) and for that of the compound prepared from tyrosine, which is strongly influenced by the amino-acid chromophore.

When the paper electrophoretic and chromatographic mobilities of the synthetic compounds were determined, a definite correlation with some chemical features of the N^2-substituent was found. Among the whole set of model substances prepared, only those obtained by treating 2-chloro-6-hydroxypurine with α-aminomonocarboxylic acids behaved electrophoretically as the natural purine. This, moreover, could be distinguished from all of the synthetic compounds, except for the α-alanine and threonine derivatives, by paper chromatography in two solvent systems. In order to decide which, if either, of these two products was identical with the aglycone of the ribo-

Table 1. PROPERTIES OF THE RIBOSIDE ISOLATED FROM *Fusarium* SPECIES, CORRESPONDING AGLYCONE, AND SYNTHETIC 6-HYDROXY-(1-CARBOXYETHYLAMINO)PURINE

	Riboside from *Fusarium* sp.	Aglycone of *Fusarium* sp. riboside	Synthetic 6-hydroxy-(1-carboxyethylamino)-purine
Paper chromatography (R_F) *			
Solvent 1	0·73	0·66	0·67
Solvent 2	0·55	0·67	0·66
Solvent 3	0·57	0·59	0·60
Solvent 4		0·56	0·56
Solvent 5		0·41	0·41
Solvent 6		0·64	0·65
Solvent 7		0·15 ; 0·19	0·15 ; 0·19
Solvent 8		0·46	0·48
Paper electrophoresis (cm./hr. moved towards the anode at 25 V./cm.)			
*p*H 2·7 (phosphate–citrate)		−5·9	−5·6
*p*H 8·1 (phosphate–citrate)		+1·4	+1·6
*p*H 4·7 and 6·5 (acetate)	+9·5	+10·3	+10·3
Ultra-violet absorption at :			
*p*H 1, maximum (mμ)	258	251, 278	250, 278
minimum (mμ)	229	228, 270	227, 270
inflexion (mμ)	274		
*E*250 : *E*260	0·88	1·27	1·42
*E*280 : *E*260	0·64	0·75	0·74
*p*H 6, maximum (mμ)	255	248, 279	248, 279
minimum (mμ)	227	226, 265	225, 266
inflexion (mμ)	274		
*E*250 : *E*260	1·08	1·44	1·45
*E*280 : *E*260	0·67	0·97	0·85
*p*H 13, maximum (mμ)	259	251, 278	250, 277
minimum (mμ)	236	247, 261	246, 262
inflexion (mμ)	266		
*E*250 : *E*260	1·86	1·11	1·07
*E*280 . *E*260	0·75	1·18	1·14

* With the exception of solvents 6 and 7, descending chromatography was used. Solvents were: No. 1, *iso*propanol–12·5 *M* hydrochloric acid–water (170 : 41 : 44, v/v/v) ; No. 2, *iso*butyric acid–1 *N* ammonia (100 : 60, v/v) ; No. 3, ethanol–1 *M* ammonium acetate, *p*H 3·8 (75 : 30, v/v) ; No. 4, as No. 3, but *p*H 7·5 ; No. 5, *n*-propanol–water (70 : 30, v/v) ; No. 6, 16 per cent ammonium bicarbonate ; No. 7, ammonium sulphate–*n* propanol–0·1 *M* phosphate buffer, *p*H 6·8 (600 gm. : 20 ml. : 1,000 ml.) ; No. 8, *n*-propanol–16 *M* ammonia–water (60 : 30 : 10, v/v/v).

side isolated from the mould, a number of chromatograms were run with different solvent systems. A satisfactory separation was achieved in ammonium sulphate–*n*-propanol–0·1 *M* phosphate buffer, *p*H 6·8 (600 gm. : 20 ml. : 1,000 ml.). In this solvent the threonine derivative gave a single spot, whereas the α-alanine derivative divided into two spots, a behaviour also observed with its next higher homologue, that is, the α-aminobutyric acid derivative. The natural aglycone also gave two spots having the same R_F values as the synthetic α-alanine derivative.

In conclusion, the natural base and the synthetic compound prepared from α-alanine and 2-chloro-6-hydroxypurine appeared to be identical when compared by paper chromatography in eight solvent systems, by paper electrophoresis at four different *p*H values and by ultra-violet absorption spectra (Table 1). Furthermore, both gave guanine when heated with 4 *N* formic acid.

The evidence described above is probably the most that could reasonably be obtained with the minute amount of material available ; on this basis it is proposed to assign provisionally the structure of 2-(1-carboxyethylamino)-6-hydroxy-9-D-ribofuranosylpurine to the new nucleoside isolated from *Fusarium*. The configurations of the amino-acid residue and of the ribose-base linkage are unknown, but it is probable that the latter is β-D by analogy with the majority of nucleosides and nucleotides found in Nature. The close similarity of the ultra-violet spectra of the nucleoside with those of guanosine[10] and of the riboside of 6-hydroxy-2-methylaminopurine[11] suggests that the ribose is linked to the 9 position of the purine base.

We are indebted to Prof. E. B. Chain for his interest and encouragement throughout this investigation, and to Dr. Gertrude B. Elion for samples of methyl-substituted guanines.

ALESSANDRO BALLIO
CARLO DELFINI
SERENA RUSSI

Istituto Superiore di Sanità,
International Centre for
Microbiological Chemistry,
Rome.

---

[1] Ballio, A., Russi, S., Serlupi-Crescenzi, G., and Tonolo, A. (in preparation).

[2] Ballio, A., and Serlupi-Crescenzi, G., Abstr. of Communications, Fourth Internat. Congr. Biochem., 135 (1958). Ballio, A., and Russi, S., *Arch. Biochem. Biophys.*, 85, 567 (1959).

[3] Wheat, R. W., *Arch. Biochem. Biophys.*, 82, 83 (1959).

[4] Hurlbert, R. B., Schmitz, H., Brumm, A. F., and Potter, V. R., *J. Biol. Chem.*, 209, 23 (1954).

[5] Paladino, S., Ugolini, F., and Chain, E. B., *Rend. Ist. Super. Sanità* (English ed.), 17, 87 (1954).

[6] Viscontini, M., Hoch, D., and Karrer, P., *Helv. Chim. Acta*, 38, 642 (1955).

[7] Ballio, A., and Serlupi-Crescenzi, G., Selected Scientific Papers from the Ist. Super. Sanità, 2 (II), 265 (1959).

[8] Weissmann, B., Bromberg, P. A., and Gutman, A. B., *Nature*, 176, 1217 (1955). Elion, G. B., Lange, W. H., and Hitchings, G. H., *J. Amer. Chem. Soc.*, 78, 217 (1956).

[9] Montgomery, J. A., and Holum, L. B., *J. Amer. Chem. Soc.*, 79, 2185 (1957).

[10] Pabst Laboratories, Circular *OR*-10 (1956).

[11] Smith, J. D., and Dunn, D. B., *Biochem. J.*, 72, 294 (1959).

Role of the Triplet State in the Photoreduction of Chlorophyll

IN 1948, Krasnovsky reported[1] that chlorophyll can be photochemically reduced, in dry pyridine, by ascorbic acid. The product is a pink pigment. The quantum yield of the reaction was not measured ; but indirect evidence[2] indicates that it was of the order of magnitude of 10^{-3}. The reaction is reversible ; the green colour of the solution returns slowly on standing, or more rapidly if a suitable oxidant is added. The regeneration of chlorophyll is never complete ; part of it being converted into phæophytin. This and analogous photochemical reactions were studied extensively, in subsequent years[3], by Krasnovsky and Evstigneev *et al.* They have adopted the view that the reversible photoreduction of chlorophyll plays an essential part in photosynthesis and in chlorophyll-sensitized reactions *in vitro*.

The photochemical reduction must involve a direct reaction between an excited molecule of chlorophyll and a normal molecule of the reductant. Evstigneev *et al.*[4] demonstrated that ascorbic acid does not appreciably quench the fluorescence of chlorophyll, dissolved in pyridine. Since this eliminates the possibility that the first excited singlet state reacts directly with ascorbic acid, it has been postulated that the lowest triplet state undergoes this direct reaction. However, Fujimori and Livingston[5] were unable to detect any effect of ascorbic acid (at concentrations as high as 0·10 *M*) upon the rate of decay of the triplet state of chlorophyll, when the solvent was dry pyridine.

Recent work of Bannister[6] suggests a possible way of reconciling these apparently incompatible observations. He demonstrated that chlorophyll is not measurably reduced when it is illuminated in air-free, dry pyridine containing ascorbic acid. The reduction is readily detectable if the solvent contains 2 per cent, or more, of water. In pyridine containing 30 per cent of water and 0·10 *M* ascorbic acid, the quantum yield of photoreduction is about 0·10. Under these conditions, the pink pigment does not accumulate, and oxidation does not restore chlorophyll but produces phæophytin. When the water content is 2 per cent, the quantum yield is several-fold lower, but the reaction is much more nearly reversible. These observations indicate that Krasnovsky's[1] supposedly dry pyridine contained an appreciable amount of water (possibly about 2 per cent).

We have measured the quenching of the triplet state of chlorophyll by ascorbic acid in pyridine, either dried with calcium hydride or containing a known concentration of water. All solutions contained 5×10^{-6} M chlorophyll a and were carefully deoxygenated. Confirming the published results of Fujimori and Livingston, we were unable to detect any quenching of the triplet in dry pyridine; however, in the presence of water, ascorbic acid unmistakably quenches the chlorophyll triplet. Our preliminary results are given in Table 1.

Table 1

k_{I}, sec.$^{-1}$ dry, no Q	k_{I}, sec.$^{-1}$ dry, Q added	k_{I}, sec.$^{-1}$ wet, Q added	$[Q]$ moles/l	Water (per cent)	$k_Q \times 10^{-3}$ moles^{-1}/l./sec.$^{-1}$
850	750	3,400	0 0076	22 7	3·4
970	890	2,900	0·0017	22 6	10 0
780	780	2,450	0·0110	2 2	1 5

The rate of disappearance of the chlorophyll triplet conforms to the following equation[5,7], where $[GH]$, $[GH']$ and $[Q]$ represent the concentrations of ground-state chlorophyll, triplet-state chlorophyll and ascorbic acid, respectively, and $m = [GH] + [GH']$.

$$
\begin{aligned}
-\frac{d[GH']}{dt} &= (k_1 + k_2[GH'] + k_3[GH] + k_Q[Q])[GH'] \\
&= (k_1 + k_3 m + k_Q[Q])[GH'] + (k_2 - k_3)[GH']^2 \\
&= k_{\mathrm{I}}[GH'] + k_{\mathrm{II}}[GH']^2
\end{aligned}
$$

The averages of the numbers in the first two columns, 870 and 790, do not differ significantly, and what difference there is between them is in the wrong sense to be explicable in terms of quenching by ascorbic acid. The mean of the values of k_{I}, 840 sec.$^{-1}$, should be compared to the published values of k_1 and k_3 (ref. 7), as follows:

$$730 \text{ sec.}^{-1} + 2{\cdot}3 \times 10^7 \text{ sec.}^{-1} m^{-1} \times 5 \times 10^{-6} m = 850 \text{ sec.}^{-1}.$$

The agreement is fortuitously close. The quenching constants, k_Q, were obtained by dividing the difference between the values given in the first and third columns by $[Q]$. The spread of these preliminary values of k_Q is greater than would be predicted in terms of the reproducibility of the individual measurements. It suggests that, in the range investigated, k_Q is a function of the water content and possibly of the concentration of ascorbic acid. In spite of this uncertainty, the results establish the reality of the quenching by ascorbic acid in wet pyridine and show that it is about ten thousand-fold less efficient than the quenching by oxygen, quinone, etc.[5].

In the presence of water and ascorbic acid, flash illumination produces a long-lived form of chlorophyll in addition to the triplet state. Since its mean life is about 0·01 sec. and it absorbs more strongly at 4800 than at 5200 Å., it cannot be Krasnovsky's[1] pink pigment, but may be one of the 'electrode active' intermediates which were discovered by Evstigneev *et al.*[4].

The available evidence demonstrates that the photoreduction of chlorophyll cannot be an essential step in efficient, chlorophyll-sensitized photochemical reactions occurring in ordinary organic solvents. However, it is not justifiable to draw a similar conclusion about the photosynthesis of plants.

This investigation was made possible by a Research Grant (*A*-2733) from the Division of Arthritis and Metabolic Diseases of the United States Public Health Service.

ROBERT LIVINGSTON
A. C. P. PUGH

Department of Chemistry,
University of Minnesota,
Minneapolis.

[1] Krasnovsky, A., *Doklady Akad. Nauk.*, **60**, 421 (1948).
[2] Krasnovsky, A., and Brin, G., *Doklady Akad. Nauk*, **96**, 1025 (1954).
[3] Rabinowitch, E., "Photosynthesis", **2**, Part 2, 1501, 1513, 1805 (Interscience Pub., New York, 1956).
[4] Evstigneev, V., Gavrilova, V., and Krasnovsky, A., *Doklady Akad. Nauk*, **74**, 315 (1950).
[5] Fujimori, E., and Livingston, R., *Nature*, **180**, 1036 (1957).
[6] Bannister, T., *Plant Physiol.*, **34**, 246 (1959).
[7] Linschitz, H., and Sarkanen, K., *J. Amer. Chem. Soc.*, **80**, 4826 (1958).

PHYSIOLOGY

A Phenylthiocarbamide Test

425 BELGIANS (225 males and 200 females) were tested with phenylthiocarbamide and quinine following the technique of Harris and Kalmus[1,2]. Fisher's linear discriminant function was used to class the subjects as tasters and non-tasters. The chi square test for smoking habit gives no significant result, but the influence of sex and age is important as proved by a homogeneity test (Fisher 2 × 10 table for sex; $\chi^2 = 40{,}905$ with 5 d.f.) and a 'Student' test for the mean threshold for $\bar{T}$ and $\bar{t}$, males and females. ($t = 5{\cdot}04$ for $\bar{T}$ and $t = 3\ 258$ for $\bar{t}$.) The correlation coefficient between age and phenylthiocarbamide is:

$$r = -0{\cdot}390 \pm 0{\cdot}109 \text{ for non-tasters}$$

$$r = +0{\cdot}032 \pm 0{\cdot}078 \text{ for tasters}$$

General results are summarized in Table 1.

Table 1

	Males	Females
n	225	200
Age	18–71 y.	14–26 y.
Number (t)	61	44
Frequency (t) (per cent)	27·11	22 00
Gene frequency (t)	0·521	0 469
Phenylthiocarbamide		
Mean total sample	7·498 ± 0·217	8·320 ± 0·247
Mean tasters	9·268 ± 0·107	10 045 ± 0 100
Mean non-tasters	2 738 ± 0·225	2 205 ± 0 180

Creteur obtained in 1952, with a different technique, 28·8 per cent of non-tasters among 679 subjects[3].

ANDRÉ LEGUEBE

Laboratoire d'Anthropologie,
Institut royal des Sciences naturelles
de Belgique,
Bruxelles.

[1] Harris, H., and Kalmus, H., *Ann. Eugen.*, **15**, 24 (1949).
[2] Kalmus, H., *Ann. Hum. Genet.*, **22**, 222 (1958).
[3] Creteur, Chr., *Rev. méd. Liège*, 7, (13), 415 (1952).

Passage of Insulin through the Wall of the Gastro-intestinal Tract of the Infant Mouse

Mosinger, Placer and Koldovsky[1], in a recent communication, have shown that insulin administered orally to suckling rats 2 and 8 days old causes a large drop in blood-sugar levels, but does not do so in 21- and 30-day old rats. Previously I had found that the gut of the 8-day old mouse is permeable to insulin but that this permeability declines thereafter. This work was quoted by Halliday[2] and, although Mosinger *et al.* refer to that paper, they do not mention my findings.

LAB grey mice were used, the young being removed from the mother 2 hr. before the administration of insulin and kept in an incubator at 37° C. for the duration of the experiment. Administration was direct to the stomach with a polythene tube on a tuberculin syringe. Injections were made intraperitoneally. The insulin used was standard crystalline insulin (B.D.H., *A.* and *H.* 22 units/mgm.) dissolved in 0·9 per cent saline acidified with hydrochloric acid to *p*H 2·5. Controls were given an equivalent dose of acidified saline. Observation of convulsions and death did not provide a satisfactory method of measuring the passage of the intact insulin molecule through the gut wall, as infant mice survived hypoglycæmia far longer than did adults. This agrees with the findings of Himwich, Fazekas and Hamburger[3], who showed that in the rat the capacity of the infant brain to endure hypoglycæmia is associated with its lower cerebral metabolic requirement. Therefore, estimations of serum sugar were undertaken. Repeated bleedings of 8-day old mice necessitated micro-methods of sampling and estimation. Blood samples each of *c.* 5 µl. were taken from the tail into capillary tubes before administration of the hormone, and at 30 min. and 60 min. after. The tubes were sealed and stored at 4° C. until tested. The serum was separated by centrifugation and 2-µl. samples tested in duplicate by the method of Stern and Kirk[4]. An 'Agla' micrometer syringe was used for the titrations.

The results are shown in Fig. 1. It is evident that the majority show a significant fall in serum sugar at 7, 8 and 16 days, and that only a small minority show this at 22 days. At 8 days of age, doses of 1 unit/gm. may be effective. At 22 days even doses of 8–10 units/gm. usually have no effect. It is evident from these results that the gut of the suckling mouse at 8 days, and even at 16 days, is permeable to insulin administered orally in very large doses, and that this permeability has almost disappeared at 22 days. The disappearance of permeability to insulin appears to occur rather later and to be less clear-cut than that to antibodies in the suckling mouse. The doses necessary are enormous in comparison with those of the order of 0·001 unit/gm. which are effective by parenteral injection. The wide individual variation in response to the oral administration of insulin at all ages studied is surprising, and for this I have no explanation to offer.

I am indebted to Prof. F. W. R. Brambell and Mr. W. A. Hemmings for their interest and advice during the course of this work.

W. A. Kelly

Department of Zoology,
University College of North Wales,
Bangor.
Jan. 23.

[1] Mosinger, B., Placer, Z., and Koldovsky, O., *Nature*, **184**, 1245 (1959).

[2] Halliday, R., *J. Endocrinol.*, 18, 56 (1959).

[3] Himwich, H. E., Fazekas, J. F., and Hamburger, E., *Endocrinol.*, 33, 96 (1943).

[4] Kirk, P. L., "Quantitative Ultramicroanalysis" (Wiley: Chapman and Hall, 1950).

Seasonal Differences in Ovulating Hormone in the Merino Ewe

Cessation of cyclic ovarian activity in ewes during anœstrus is thought to be associated with changes in the level and/or type of gonadotrophic substances reaching the ovary[1]. This supposition cannot be tested by direct means at the present time, but a recently developed technique for synchronization of ovulation in ewes[2] suggests possibilities of an indirect examination.

Merino ewes were injected daily with 10 mgm. of progesterone in oil intramuscularly for 14 days in either April (the middle of the breeding season) or October (anœstrus). At the same time as the final progesterone injection each ewe received 500 I.U. of pregnant mare serum gonadotrophin subcutaneously. 48 hr. later groups of ewes were injected with either 300 I.U. of human chorionic gonadotrophin intra-

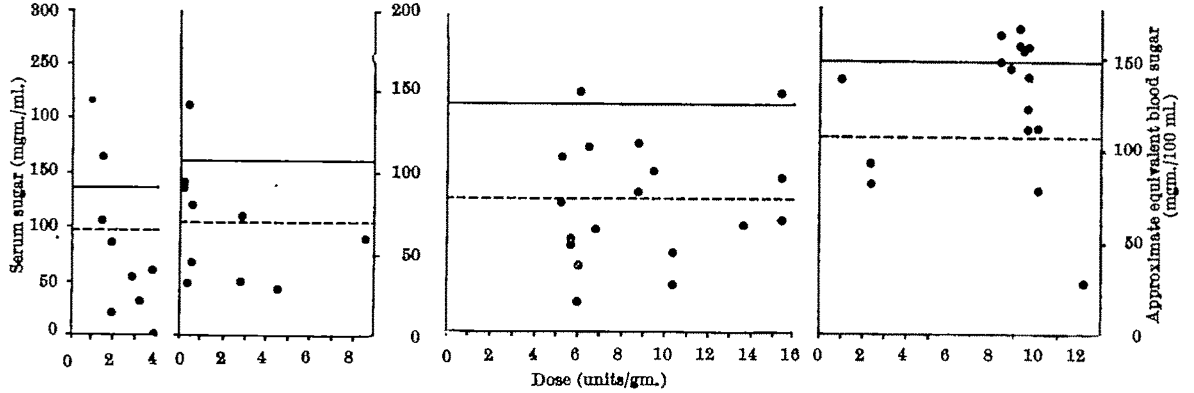


Fig. 1. Values of serum sugar in mgm./100 ml. 60 min. after oral administration of insulin to young mice of 7, 8, 16 and 22 days of age according to dose in units/gm. The corresponding approximate scales for blood sugar are inserted on the right for comparison with the serum sugar scale on the left; the blood sugar values being derived from the hæmatocrit values of 33 per cent for 8-day and 42 per cent for 16- and 22-day-old mice. The solid horizontal line represents the mean serum sugar-level before the administration of insulin and the broken line the value below which individual experimental results may be considered significant at the 5 per cent level

Table 1. TIME OF OVULATION IN MERINO EWES

All ewes received 10 mgm. of progesterone intramuscularly daily for 14 days and 500 I.U. of pregnant mare serum gonadotrophin on the fourteenth day. The human chorionic gonadotrophin was given 48 hr. after the pregnant mare serum gonadotrophin

Season	Human chorionic gonadotrophin (I.U.)	No. of ewes		Ovulations occurring in following periods after human chorionic gonadotrophin					Mean time of ovulation (hr.)
				<22 hr.	22–29 hr.	29–44 hr.	> 44 hr.	Total	
April (breeding season)	300 intramuscular		4	3	3	0	0	6	23
	900 intramuscular		4	0	3	2	0	5	29
	300 intraperitoneal		5	0	1	6	0	7	32
October (anœstrus)	300 intramuscular	shorn	3	0	0	3	0	3	42
		unshorn	3	0	1	1	1	3	
	900 intramuscular	shorn	3	0	1	1	1	3	31
		unshorn	3	0	4	0	0	4	
	300 intraperitoneal	shorn	3	0	1	2	1	4	40
		unshorn	3	0	1	0	2	3	

ANALYSES OF VARIANCE—ESTIMATED TIMES OF OVULATION

Source of variation	DF April	DF October	Mean square April	Mean square October
Between doses				
300 intramuscular v. 300 intraperitoneal	1	1	261*	1
900 intramuscular v. rest	1	1	18	491†
Shearing effect		1		118
Interaction		2		19
Error	15	14	8·6	73·4

* $P < 0·001$. † $0·01 < P < 0·05$.

muscularly, or 900 I.U. intramuscularly, or 300 I.U. intraperitoneally. Laparotomy, which seems not to influence the time of ovulation[2], was performed 22, 29 and 44 hr. after the injection of human chorionic gonadotrophin. All ewes used in October were carrying eleven months wool but half were shorn 1–2 hr. prior to the injection of human chorionic gonadotrophin.

The treatment groups are shown in Table 1 together with the numbers of ovulations observed at the various times of laparotomy and the estimated mean time of ovulation for each group. The times of ovulation were estimated by visual examination. Ovulations which seemed to take place during the periods 19–32 hr. and 41–47 hr. were estimated to the nearest 1–2 hr.; others were estimated to the nearest 6–8 hr. The within-group variances were significantly greater in October ($\chi^2_{(1)} = 8·78$, $0·001 < P < 0·01$) hence the two sets of data were analysed separately. A summary of the analyses is appended to Table 1.

The mean time of ovulation following 900 I.U. intramuscularly of human chorionic gonadotrophin was apparently constant at the two times of the year ($P = 0·6$). A difference of approximately 20 hr. in the time of ovulation following 300 I.U. of human chorionic gonadotrophin intramuscularly suggests that during anœstrus there was present, at or soon after the time of injection, smaller amounts of a substance or combination of substances which acts in conjunction with human chorionic gonadotrophin to hasten ovulation in the breeding season. That the substance(s) is similar to human chorionic gonadotrophin is borne out by the response to the higher dosage-level, and since human chorionic gonadotrophin is generally thought to be similar to ovulating hormone[3] it is possible that there are seasonal differences in the endogenous production of ovulating hormone in Merino ewes. On this basis the greater variation in response in October suggests that individuals in this strain of Merino differ widely in the 'depth' of anœstrus.

In studying the hypothesis the following factors should be taken into account: (*a*) Pregnant mare serum gonadotrophin, given at the time of the final progesterone injection and known to be present in the blood of animals for several days, may influence the ovulatory response to human chorionic gonadotrophin. (*b*) Ovulation may be inhibited by high dosage-levels of human chorionic gonadotrophin[4]. (*c*) The rate of maturity of Graafian follicles after a constant progesterone – pregnant mare serum gonadotrophin treatment may be influenced by the time of year.

I am indebted to Dr. A. W. H. Braden, Commonwealth Scientific and Industrial Research Organization, Prospect, for helpful discussion.

D. R. LAMOND

Faculty of Rural Science,
University of New England,
Armidale,
New South Wales.

[1] Robinson, T. J., *Biol. Rev.*, 26, 121 (1951).

[2] Braden, A. W. H., Lamond, D. R., and Radford, H. M., *Aust. J. Agric. Res.*, 11, 389 (1960).

[3] Evans, H. M., and Simpson, M. E., "The Hormones", 2, edit. by Pincus, G., and Thimann, K. V. (Academic Press, New York, 1950).

[4] Lamond, D. R., *J. Endocrinol.* (in the press).

Oxygen Consumption in Cattle in Relation to Rate of Increase in Environmental Temperature

IN determining the responses of cattle to high, controlled temperatures, one of two procedures has usually been employed. Either the cattle were exposed for periods up to 7 hr. to temperatures ranging up to 110° F. (ref. 1), or they were exposed initially to lower temperatures which were increased progressively by small steps at 2-week intervals[2]. As there was some doubt as to whether cattle would react similarly to these two procedures, it was decided to subject the same animals to both types of heat exposure. It was hoped that this comparison would clarify any difference in the reactions of the animals produced by acclimatization or stress effects.

The specific objective of this experiment was to compare the changes in energy-levels (oxygen consumption) of cattle subjected to both acute and progressive types of heat stress.

Nine animals, including 3 Jersey, 3 Holstein and 3 Brown Swiss female calves, which had been raised at a constant temperature of 50° F., were available. At the beginning of the three treatments, shown by the three curves in Fig. 1, this group had reached 14 months of age. The results for all three breeds were

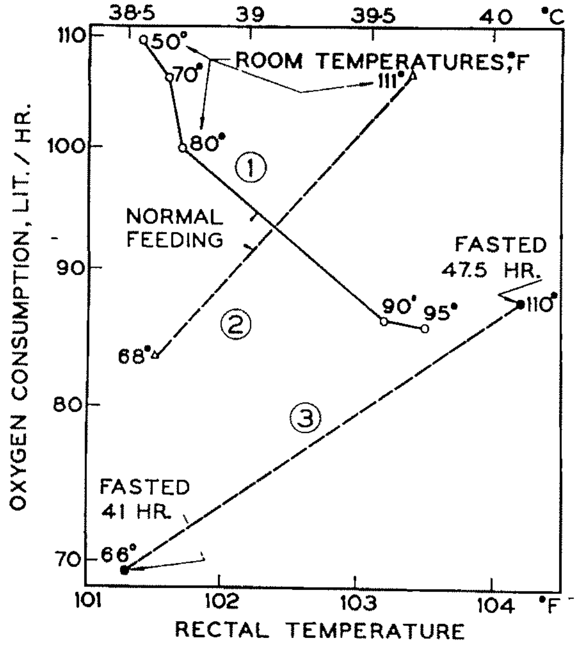


Fig. 1. Differences in the rates of oxygen consumption of cattle resulting from gradual and rapid changes in environmental temperature. Each plotted mean includes 18 observations for curves 1 and 3, and nine observations for curve 2

pooled since the changes with treatment were of primary interest. Oxygen consumption and pulmonary ventilation were measured with an open-circuit metabolism apparatus, which has been described in an earlier publication[3].

In the treatment which resulted in curve 1, the animals were kept for successive 2-week periods at 50°, 70°, 80° and 90° F., and for 4 days at 95° F. During this 2-month period of rising environmental temperature, the rectal temperature increased 2·1 deg. F. At the same time, the oxygen consumption decreased from 110 to 85 l./hr., even though the pulmonary ventilation increased from 49 to 129 l./min. and the body-weight increased from 347 to 365 kgm. Increased hydration may have been a factor in increasing the body-weight, as the plasma protein concentration decreased during this period[4]. The factors which tended to increase oxygen consumption, such as the greater muscular exertion required for high respiratory activity, the increased maintenance for greater body-weight, and the van't Hoff effect incident to high body-temperature, were obviously more than offset by decreases in thyroid activity[5] and consumption of total digestible nutrients (Johnson, H. D., and Ragsdale, A. C., unpublished work). The reduction in feed consumption at high temperatures was voluntary since feeding (except grain) was *ad libitum*.

Curve 2 for these same 9 animals shows that the effect of rapidly rising temperature on oxygen consumption was opposite to that of slowly rising temperature. Measurements made after the morning feeding at a room temperature of 68° F. were not as high as those made 5 hr. later after the room had been heated to 111° F. During the 5-hr. heating period, rectal temperature increased 1·9 deg. F., pulmonary ventilation increased from 45 to 140 l./min. and oxygen consumption increased from 83 to 107 l./hr. (significant at 0·05 level). The rise in oxygen consumption can be attributed to an increase in the muscular exertion of respiration, and the van't Hoff effect. The rapidity of heating the room and the cattle would tend to prevent a depression of any consequence by slow-acting factors. The available nutrients would remain relatively unchanged in a ruminant even though the appetite were depressed by the heat. It seems unlikely, also, that depression of thyroid activity was a major factor.

To eliminate effects of specific dynamic action related to time after feeding, the nine animals were fasted for 41 hr. at 65° F. temperature. Measurements were made at this time at a temperature of 66° F. and again 6½ hr. later after the room had been heated to 110° F. Averages of two such sets of fasting results are shown in curve 3. The 44 deg. F. rise in room temperature increased rectal temperature 2·9 deg. F. and pulmonary ventilation from 33 to 143 l./min. Oxygen consumption increased from 69 to 87 l./hr. (significant at 0·01 level). This rise in oxygen consumption was associated with increased respiratory activity and the van't Hoff effect. There is also the possibility that the combined stress effects of fasting and great heat may have elicited a particular group of reactions called by Selye[6] "the general adaptation syndrome". One of the main characteristics of this syndrome is hypersecretion of adrenal hormones including adrenaline, which is known to increase oxygen consumption in small animals.

Whatever mechanisms are involved, these results indicate that the reactions of cattle to high temperatures may differ with the rate of increase in environmental temperature. Gradual increases in temperature, within limits, depress oxygen consumption. Rapid increases in temperature elevate oxygen consumption.

This experiment was conducted in the Climatic Laboratory, Columbia, Missouri, as one part of a co-operative project between the University of Missouri and the Agricultural Research Service, United States Department of Agriculture.

H. H. Kibler

Department of Dairy Husbandry,
University of Missouri,
Columbia, Missouri.

[1] Rieck, R. F., and Lee, D. H. K., *J. Dairy Res.*, 15, 219 (1948). McDowell, R. E., Lee, D. H. K., Fohrman, M. H., and Anderson, R. S., *J. Animal Sci.*, 12, 573 (1953).

[2] See "Environmental Physiology and Shelter Engineering", 1–40, *Mo. Exp. Sta. Res. Bull.*, 1948–56.

[3] Kibler, H. H., *Mo. Exp. Sta. Res. Bull.*, 643 (1957).

[4] Kamal, T. H., Ph.D. thesis, Univ. of Missouri (1960).

[5] Johnson, H. D., and Ragsdale, A. C., *Mo. Exp. Sta. Res. Bull*, 709 (in the press).

[6] Selye, H., "Fifth Annual Report on Stress", 26 (MD. Publications Inc., New York, 1956).

Release of Methionine labelled with Sulphur-35 from Muscle Tissue and Mitochondria

Continuous renewal of the protein molecule is effected by balance between the incorporation and the removal of amino-acids. From these two processes incorporation has been examined and some intermediate reactions are already known. So far as the second process, that is, intracellular degradation of proteins, is concerned, only basic experiments have been made. Simpson[1] and Steinberg and Vaughan[2] found, for example, that anaerobiosis and 2,4-dinitrophenole inhibit the release of labelled amino-acids from prelabelled liver slices. The degradation of proteins was also found to be dependent on energy-yielding activity of the cell in homogeneous cultures of bacteria[3] as well as animal cells[4]. In subcellular particles, Korner and Tarver[5] found that anaerobiosis and 2,4-dinitrophenole inhibit the release of amino-acids from nuclei and mitochondria. The release from microsomes under the same conditions, however, is stimulated.

In the present communication the intracellular degradation of muscle proteins was studied. We have measured the release of methionine labelled with sulphur-35 from isolated rat diaphragm and from muscle mitochondria. 24 hr. before the experiment the rat received 150 μc. of ^{35}S-methionine per 100 gm. body-weight by intraperitoneal injection. Trichloracetic acid-soluble ^{35}S-methionine in one-half of the diaphragm and in a sample of mitochondria served as initial values. The remaining parts were incubated. The increase of free labelled methionine after 3 hr. incubation of the diaphragm and 2 hr. incubation of mitochondria under usual conditions was determined. This amount was then expressed in percentage protein-bound ^{35}S-methionine.

The mitochondria or homogenated diaphragm were extracted with trichloracetic acid in final concentration of 5 per cent. Following acid hydrolysis, labelled methionine of the protein precipitate was separated from cystine and cysteine by their precipitation as mercaptides. The amino-acids in neutralized trichloracetic acid extract of tissue (or mitochondria) and medium were concentrated on 'Dowex-50'. Taurine and sulphate pass through. Amino-acids were then eluted, and, after acid hydrolysis, cystine, cysteine and homocysteine were precipitated as mercaptides. Methionine of protein as well as of the trichloracetic acid extract was oxidized to sulphate and radioactivity was measured in benzidine sulphate precipitate with an accuracy of 2·5 per cent.

The results given in Table 1 demonstrate that the amount of labelled methionine released from both diaphragm and mitochondria is higher in a medium with 2-4-dinitrophenole and under anaerobic conditions. (The activity of proteolytic enzymes measured at pH 3 6 and 9·0 is not changed under these conditions.) On the contrary, the amount of labelled methionine released from liver mitochondria is, as in the experiments of Korner and Tarver[5], depressed. (Protein degradation, with the exception of release of labelled methionine, was measured on the basis of non-protein nitrogen and amino-acids increase and in the diaphragm also on the basis of non-collagenous proteins decrease. The same results are obtained by all these methods)

Table 1. RELEASE OF METHIONINE LABELLED WITH SULPHUR-35 FROM RAT DIAPHRAGM AND MITOCHONDRIA UNDER DIFFERENT CONDITIONS OF INCUBATION

Conditions	Diaphragm		
	c p.m. released (per 1 gm. wet wt.)	Percentage of ^{35}S - methionine released*	
Normal†	460 ± 10	1 40 ± 0·05	
Anaerobiosis	1,110 ± 20	3 64 ± 0 44	
2, 4-Dinitrophenole (10^{-4} *M*)	1,190 ± 50	—	
p-FPA (10^{-3} *M*.)‡	1,290 ± 80	4 14 ± 1 04	
	Mitochondria*		
	Rat Skeletal muscle	Pigeon Breast muscle	Rat liver
Normal§	0·61	1·09	5·28
Anaerobiosis	2·20	3 18	4·43

$$* \ \frac{\text{c.p m. of released } ^{35}\text{S-methionine}}{\text{c p.m. of protein-bound } ^{35}\text{S-methionine}} \times 100.$$

† Krebs-Ringer bicarbonate buffer containing 200 mgm. per cent glucose and carrier methionine in conc. 0·12 mgm./ml. Gas phase was 95 per cent oxygen and 5 per cent carbon dioxide.

‡ *p*-Fluoro-phenylalanine.

§ 3 ml of medium contained: 50 μ*M* potassium succinate, 20 μ*M* adenosine triphosphate, 0 01 *M* potassium phosphate buffer of pH 7·4, 0 005 *M* magnesium chloride, 0 003 *M* ethylenediamine tetraacetic acid and 1 ml. of mitochondria suspension in 0·25 *M* sucrose. Isotonicity was maintained by adding potassium chloride. Concentration of carrier methionine was 0·12 mgm./ml. Gas phase was oxygen.

Furthermore, a different reaction of liver and muscle tissue was observed after the action of amino-acids antagonist. While the release from liver slices is inhibited by p-fluoro-phenylalanine[1,2] it is stimulated from diaphragm.

The present results demonstrate that the degradation of muscle proteins is enhanced under conditions which limit the utilization of energy. This is quite contrary to the findings in tissues studied up to now (namely, liver and kidney slices, reticulocytes and macrophages). For these cells it was assumed that the degradation of protein involves a complex acceptor substance rather than water. The formation of this complex is dependent on energy. On the contrary, the degradation of muscle proteins is given rather by hydrolytic splitting of peptide bonds by tissue cathepsins.

What is the mechanism by which the effect of the inhibitors of oxidative processes is realized in our experiments? If it is not by influencing the activity of tissue cathepsins, they must affect some other reaction which then makes proteins more accessible to the hydrolytic action of cathepsins. It is important to note that not only inhibitors of oxidative processes but also antagonists of amino-acids stimulate the release of labelled methionine from isolated diaphragm. It is possible that the intracellular degradation of muscle proteins is always stimulated under conditions of inhibition of proteosynthesis.

R. ŽÁK
Z. DRAHOTA

Institute of Physiology,
Czechoslovak Academy of Sciences,
Prague, 6.

[1] Simpson, M. V., *J. Biol. Chem.*, **201**, 141 (1953).
[2] Steinberg, D., and Vaughan, M., *Arch. Biochem.*, **65**, 93 (1956).
[3] Halvorson, H., *Biochim. Biophys. Acta*, **27**, 255 (1958).
[4] Harris, H., and Watts, J. W., *Nature*, **181**, 1582 (1958).
[5] Korner, A., and Tarver, H., *J. Gen. Physiol.*, **41**, 219 (1957).

Duration of Stimulation of Phagocytic Activity of the Reticulo-Endothelial System after Cessation of Treatment with Diethylstilbœstrol

NICOL *et al.* have reported previously that diethylstilbœstrol is a strong stimulant of the phagocytic activity of the reticulo-endothelial system[1]. The present research was designed to ascertain the period of time during which the stimulative effect would persist after cessation of treatment with diethylstilbœstrol.

The following experiments were carried out on 80 male white mice (*T.O.* Swiss strain) of 20–28 gm. body-weight. Fifty-five animals were each given one subcutaneous dose of 0·5 mgm. diethylstilbœstrol in 0·05 ml. arachis oil daily for 6 days. On the second day after the treatment with diethylstilbœstrol ceased, the phagocytic activity of the reticulo-endothelial system was measured in five animals by the rate of disappearance of a known amount of specially prepared carbon from the circulating blood[2], the procedure used being that described previously[1], and the total body phagocytic activity or phagocytic index being denoted by the symbol *K*. On each successive day thereafter, up to the twelfth day, the phagocytic activity was measured in further groups of five animals.

Twenty-five of the animals were used as controls and were given 0·05 ml. arachis oil once daily for 6 days; the phagocytic activity was then measured on the eighth day by the carbon method referred to above. The arachis oil controls showed a phagocytic index or *K* value of 18 ± 5·8.

Table 1. DURATION OF STIMULATION OF PHAGOCYTIC ACTIVITY OF THE RETICULO-ENDOTHELIAL SYSTEM AFTER CESSATION OF TREATMENT WITH DIETHYLSTILBŒSTROL

Day after cessation of 6-day treatment with diethylstilbœstrol	Phagocytic index (*K* value)	Percentage change in body-weight
2nd	90 ± 10·8	−5
3rd	102 ± 13·1	−7
4th	56 ± 9·8	−3
5th	62 ± 11·5	+2
6th	55 ± 6·3	+5
7th	36 ± 4·7	+5
8th	34 ± 1 2	+10
9th	23 ± 1 4	+5
10th	24 ± 1·5	+10
11th	24 ± 2 7	+10
12th	22 ± 4·1	+9
Control values in 25 animals	18 ± 5·8	

The results are shown in Table 1. Compared with the controls it can be seen that after treatment with diethylstilbœstrol ceased the stimulative effect on the phagocytes persists for approximately one week, during which time it gradually diminishes. By the eighth–ninth day the phagocytic index or *K* value has returned to within normal control limits.

A corresponding change in the body-weight of the animals also occurs. It was reported previously[3] that when the daily dose of diethylstilbœstrol rises above 0·1 mgm. the animals lose weight. From Table 1 it can be seen that this loss in weight continues for about 4 days after the diethylstilbœstrol treatment has ceased and thereafter there is gain in body-weight.

In these investigations we gratefully acknowledge assistance from the Central Research Fund of the University of London and from the Medical Research Council.

C. C. WARE
T. NICOL

Department of Anatomy,
King's College, London, W.C.2.

---

[1] Nicol, T., Bilbey, D. L. J., and Ware, C. C., *Nature*, 181, 1538 (1958).

[2] Biozzi, G., Benacerraf, B., and Halpern, B. N., *Brit. J. Exp. Path.*, 34, 441 (1953).

[3] Nicol, T., and Ware, C. C., *Nature*, 185, 42 (1960).

HÆMATOLOGY

Observations on Globin, Hæmoglobin and Haptoglobin using a Rabbit Antiglobin Serum

AN antiserum against human globin was raised in a rabbit by immunization with globin prepared from adult hæmoglobin by the methods of Anson and Mirsky[1] and Jope, Jope and O'Brien[2]. A 1 per cent solution was injected subcutaneously in Freund's adjuvant[3], and intravenously. The resulting antiserum precipitated both human globin and human hæmoglobin; 1 ml. precipitated about 0·5 mgm. of hæmoglobin.

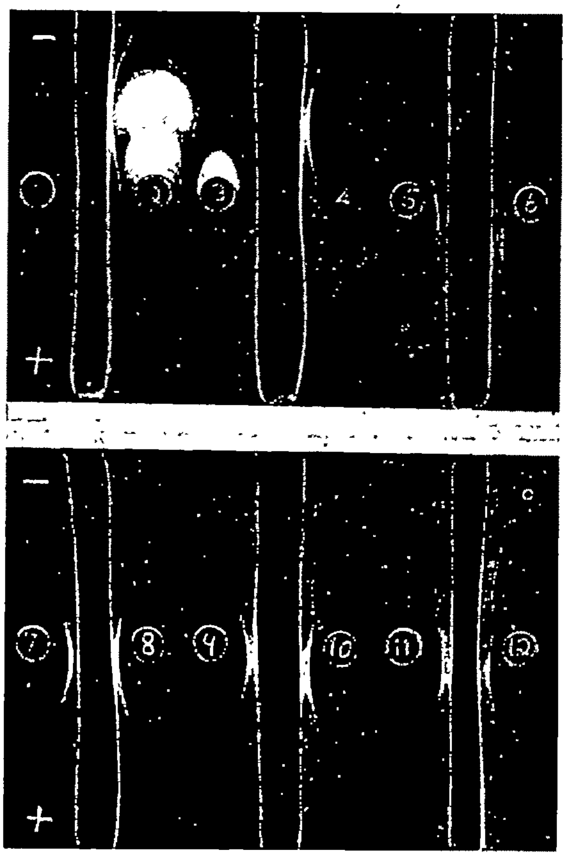


Fig. 1. Immunoelectrophoresis with antiglobin antiserum

A series of immuno-electrophoretic analyses in *p*H 7·0 0·05 *M* phosphate buffer in 0·8 per cent agar, using this antiserum, is shown in Fig. 1. The antigen cups are numbered. No. 1 contains human serum, which shows a faint precipitin line of a protein which has moved slightly towards the anode. This probably is haptoglobin-bound hæmoglobin. A 5 mgm./ml. solution of globin in 0·9 per cent sodium chloride was placed in cup 2. This shows a precipitin line due to protein which has moved towards the cathode, and in addition, a heavy precipitate of protein in the agar. A 1 mgm./ml. solution of globin in cup 3 shows a similar precipitate in the agar, but no immunological precipitate has occurred, presumably because of complete precipitation of the globin before it reached the antibody. The same concentration of hæmoglobin in cup 4 shows a precipitin line of similar electrophoretic mobility to the globin in cup 2.

The remaining analyses illustrate the effect of increasing the concentration of either globin or hæmoglobin in human serum. The same series of concentrations of both proteins was used, that is, 0·3, 0·6, 0·9 and 1·2 mgm. per 1 ml. of serum. The mixtures containing globin in cups, 5, 7, 9 and 11 and hæmoglobin in cups 6, 8, 10 and 12 are in order of increasing concentration.

All the hæmoglobin mixtures show a curved precipitin line of protein which has moved slightly towards the anode. In addition, at 10 and 12, there is a second arc of precipitation on the cathode side of the origin, the two arcs of precipitate forming a continuous line. Filter-paper electrophoresis of the mixtures in cups 6 and 8 showed the hæmoglobin

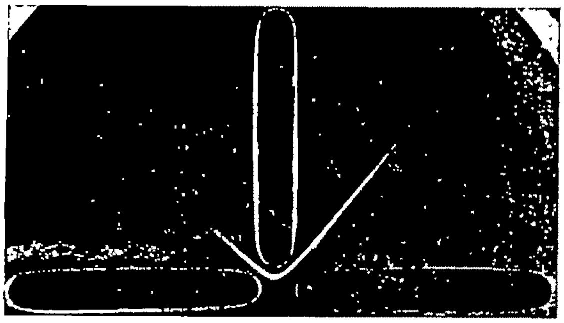


Fig. 2. Gel diffusion plate. Antiglobin antiserum in the vertical trough. Hæmoglobin in serum in the left-hand trough. Hæmoglobin in saline in the right-hand trough

to be entirely haptoglobin-bound, whereas those in cups 10 and 12 showed both haptoglobin-bound and also free hæmoglobin. The precipitin line on the anode side of the origin is therefore interpreted as indicating haptoglobin-bound hæmoglobin, that on the cathode side being free hæmoglobin, similar in mobility to that in cup 4. Similar double arcs of precipitate have been described by Boivin and Hartmann[4].

All the globin mixtures show an arc of precipitate of identical mobility to the haptoglobin-bound hæmoglobin, strongly suggesting that haptoglobin also binds globin. In addition, the higher concentrations of globin at 9 and 11 show precipitation on the cathode side of the origin similar to that shown by free globin in cups 2 and 3. If it is assumed that this precipitate is free globin, this would indicate that the globin-binding capacity of human serum haptoglobin is similar to its hæmoglobin-binding capacity.

Allison and Humphrey[5] deduced that when antigen and antibody at optimal proportions diffuse towards each other from troughs at right angles to each other in an agar gel, a straight line of precipitation is produced. The angle θ between the line and the antigen trough is related to the diffusion coefficients of the antigen (Dg) and antibody (Db) by the formula: $\tan\theta = (Dg/Db)^{1/2}$. They substantiated this by measurements of such angles produced by a series of antigens covering a wide range of molecular size, and their equivalent antisera. The antiserum against human globin enables us to measure such angles for free hæmoglobin, and for haptoglobin-bound hæmoglobin, that is for two proteins, antigenically identical, but of considerably different molecular size.

Fig. 2 is a photograph of such an agar plate, in which the antiserum was placed in the vertical trough, and hæmoglobin in identical concentrations, at optimal proportions to the antiserum, in the horizontal troughs. The hæmoglobin solution in the left-hand trough contained human serum at a concentration equivalent to 1 ml. per 0·5 mgm. of hæmoglobin. Filter-paper electrophoresis confirmed that all the hæmoglobin in this preparation was haptoglobin-bound. Straight lines of precipitation are obtained giving values of θ for free hæmoglobin of 51°, and for haptoglobin-bound hæmoglobin of 43°.

Assuming a diffusion coefficient of rabbit γ-globulin of $3{\cdot}8 \times 10^{-7}$ cm.^{2} sec.$^{-1}$, the diffusion coefficient of free hæmoglobin can be calculated as $5{\cdot}8 \times 10^{-7}$ (Gutter, Sober and Peterson[6] reported a value of $6{\cdot}0 \times 10^{-7}$ for carboxy-hæmoglobin). The diffusion coefficient of the complex is calculated as $3{\cdot}3 \times 10^{-7}$.

These results show that straight lines can be produced in this system when an antibody is treated at optimal proportions with its antigen at two widely different molecular sizes. The difference of molecular sizes is indicated by differences in the values of the angles θ.

We wish to acknowledge the assistance and advice of Dr. P. G. H. Gell.

D. S. ROWE
J. F. SOOTHILL
Department of Experimental Pathology,
Medical School, Hospitals Centre,
Birmingham, 15.

---

[1] Anson, M. L., and Mirsky, A. E., *J. Gen. Physiology*, **13**, 469 (1930).

[2] Jope, E. M., Jope, H. N., and O'Brien, J. R. P., *Nature*, **164**, 622 (1949).

[3] Freund, J., and McDermott, K., *Proc. Soc. Exp. Biol., N.Y.*, **49**, 548 (1942).

[4] Boivin, P., and Hartmann, L., *Rev. franç. et Clin. Bioç.*, **3**, 48 (1958).

[5] Allison, A. C., and Humphrey, J. H., *Nature*, **183**, 1590 (1959).

[6] Gutter, F. J., Sober, H. A., and Peterson, E. A., *Arch. Biochem. Biophys.*, **62**, 427 (1956).

Frequencies of the Haptoglobin Serum Groups among Blood Donors from Austria and Germany

THE frequency of the gene Hp^1 among the European populations so far tested have shown only a slight deviation of 40 per cent (Table 1). Samples from Austria and Germany have hitherto not been examined. For our studies we used sera of 201 blood donors from Münster, Westphalia (Germany), 273 blood donors from Bavaria (three districts of Upper Bavaria)[1], and sera of 621 blood donors from Vienna and environs (Austria).

Table 1

Author(s) and ref.	Population	n	Hp^1
Galatius-Jensen[7]	Denmark	2,046	0·397
Tarukoski[8]	Sweden	1,003	0·376
Nyman[9]	Sweden	275	0·451
Mäkela[10]	Finland	891	0·326
Fleischer *et al.*[11]	Norway	1,000	0·363
Allison *et al.*[12]	Gt. Britain	218	0·406
Moullec *et al.*[13]	France	406	0·402
Allison *et al.*[12]	Basque	107	0·379
Harris *et al.*[14]	Italy	422	0·380
Butler *et al.*[15]	Switzerland	920	0·396

A modified technique of starch-gel electrophoresis[2,3] has been applied using polyvinyl chloride trays with 10 channels (internal dimensions: 25 cm. long, 1 cm. wide, 0·8 cm. deep) for electrophoresis. The hydrolysed starch was obtained by the Connaught Medical Research Laboratories, Toronto, prepared by Smithies' method. Three serum samples to which hæmoglobin was added amounting to 300 mgm. per cent were placed in each channel at a distance of about 7 cm. The sera were applied to filter paper, Schleicher and Schüll No. 5703. A borate buffer (pH 8·4) was used for the gel as for the electrode chambers. Electrophoresis was performed with the high-voltage apparatus described by Wieland and Pfleiderer[4]. The voltage gradient was kept at 9 V./cm. and 95 m.amp. for 20 channels during a period of 3½ hr. After electrophoresis the slides were stained with a benzidine or o-dianisidine reagent for peroxidase activity.

The frequency of the three haptoglobin types and the gene frequency of Hp^1 are shown in Table 2. No individual of the Hp 0–0 group has been detected. The frequencies of the three phenotypes are in good agreement with the genetical theory of Smithies and

Table 2

	n	Hp 1–1	Hp 2–1	Hp 2–2	Hp^1	χ^2	P
Bavaria	278	19·4	54·2	26 4	0 465	2 188	>10
	obs.	58	148	72			cent
	exp.	59 1	135·8	78·1			per
Munster	201	19 9	46·8	33·3	0·433	0·453	>50
	obs.	40	94	67			per
	exp.	37·6	98·7	64·7			cent
Vienna and environs	621	16·1	48·2	35 7	0·402	0·002	>95
	obs.	100	299	222			per
	exp.	100 2	298 5	222·4			cent
Total	1095						

Walker[5,6] (χ^2-values between 10 and 50 per cent). The differences between the three samples are not significant ($\chi^2 = 6{\cdot}46$; $d.f. = 2$; P : ·5 per cent $> P >$ 2 per cent). The frequency of the Hp^1 in the German samples is somewhat higher than in most other European populations that have so far been tested.

The tests were carried out at the University Institute of Anthropology and Human Genetics at Munich (Director: Prof. K. Saller) under a grant given by the Deutsche Forschungsgemeinschaft.

We are indebted to Dr. Paul Speiser, Vienna, to the Blutspendedienst der Landesverbände DRK Nordrhein und Westfalen-Lippe, and to Dr. Rasch, Munich, for the blood samples.

H. BAITSCH
G. MEIER
Institute of Anthropology and
Human Genetics,
University of Munich.

L. SCHOELLER
University of Münster,
Westphalia.

D. M. KAHLICH-KOENNER
Institute of Forensic Medicine,
University of Vienna.

[1] Baitsch, H., and Meier, G., *Blut*, 5, 302 (1959).

[2] Smithies, O., *Biochem. J.*, 61, 629 (1955).

[3] Smithies, O., *Nature*, 175, 307 (1955).

[4] Wieland, Th., and Pfleiderer, G., *Angew. Chemie*, 67, 257 (1955).

[5] Smithies, O., and Walker, N. F., *Nature*, 176, 1265 (1955).

[6] Smithies, O., and Walker, N. F., *Nature*, 178, 694 (1956).

[7] Galatius-Jensen, F., *Acta genet. statist. med.*, 8, 232 (1958).

[8] Tarukoski, P. H., *Nordisk Med.*, 62, 1425 (1959).

[9] Nyman, M., *Scand. J. Clin. Lab. Invest.*, 11, Suppl. 39 (1959).

[10] Mäkela, O., Eriksson, A. W., and Lehtovaara, R., *Acta genet. statist. med.*, 9, 149 (1959).

[11] Fleischer, E., and Lundevall, J., Sixth Congr. Europ. Soc. Haematol., p. 906 (1957).

[12] Allison, A. C., Blumberg, B. S., and Rees, W., *Nature*, 181, 824 (1958).

[13] Moullec, J., and Fine, J. M., *Nature*, 184, 196 (1959).

[14] Harris, H., Robson, E. B., and Siniscalco, M., *Nature*, 182, 1324 (1958).

[15] Bütler, R., Metaxas-Buhler, M., Rosin, S., and Wandrey, R., *Schweiz. med. Wschr.*, 89, 1041 (1959).

Fœtal Hæmoglobin in the Monkey

SOME well-known physico-chemical differences between human adult and fœtal hæmoglobin prompted us to find if similar differences exist between hæmoglobins from adult and new-born monkeys. The present communication describes the examination of the blood of 8 adult and 4 new-born monkeys (*Macacus rhesus* of North India) by the alkali resistance test and paper electrophoresis. Pregnant monkeys were obtained and were delivered in the cage to provide the new-born monkeys. Heart blood from the new-born and venous blood from the adult monkeys was collected in citrate solution. The alkali denaturation method of Singer *et al.*[1] was employed for determining the proportion of alkali-resistant hæmoglobin. Electrophoresis was carried out in 'Elphor' apparatus using paper strip No. 2043 *a* Mg 1 at 250 V. for a period of 16 hr. in veronal buffer of *p*H 8·6 and ionic strength 0·05.

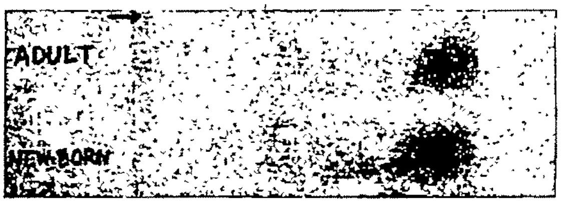


Fig. 1. Electrophoretic mobilities of hæmoglobin from adult and new-born monkeys

Fig. 1 shows the electrophoretic mobilities of hæmoglobin from adult and new-born monkeys. Hæmoglobins from both the adult and the new-born monkeys consist of one component only and have identical electrophoretic mobilities. Jacob and Tappen[2], however, obtained more than one component in a few of the other species of adult monkeys examined by them.

Table 1 shows the percentage of alkali-resistant hæmoglobin found by us. Adult monkeys contain 1·0–5·0 per cent alkali-resistant hæmoglobin, with an average of 2·9 per cent, whereas new-born monkeys contain 38·8–60·0 per cent, with an average of 48·9 per cent. Though the number of animals in the new-born group is rather small, the results are sufficiently indicative of the existence of a specific fœtal hæmoglobin characterized by resistance to alkali denaturation. In a recent communication, Beaven and Gratzer[3] have obtained evidence of a specific fœtal hæmoglobin by electrophoresis in agar gel. By using a moving-plate spectrograph, these workers have further shown that fœtal rhesus monkey hæmoglobin has the tryptophan fine-structure band at about 289·7 mμ, whereas the adult pigment has its band at 291·0 mμ—a condition very similar to that for fœtal and adult human hæmoglobins.

Characterization of the fœtal monkey hæmoglobin by its resistance to alkali denaturation, however, allows its easy detection by a relatively simple procedure. The quantities of fœtal hæmoglobin in the new-born monkeys have been measured at intervals of 15 days for 90 days in order to ascertain the time of disappearance of the fœtal pigment. Table 2 shows the percentage of fœtal hæmoglobin in the blood of these young animals. It was found that the amount of fœtal hæmoglobin is reduced to 1·4–

Table 1. PERCENTAGE OF ALKALI-RESISTANT HÆMOGLOBIN IN ADULT AND NEW-BORN MONKEYS

Animal No.	Adult Alkali-resistant hæmoglobin (per cent)	Animal No.	New-born Alkali-resistant hæmoglobin (per cent)
1	1·8	1	38 8
2	5 0	2	50·0
3	4 5	3	47 0
4	2 5	4	60 0
5	3·4	—	—
6	1 0	—	—
7	3 0	—	—
8	2 0	—	—
Mean	2·9	Mean	48·9
Range	1 0–5 0	Range	38·8–60 0

Table 2. PERCENTAGE OF ALKALI-RESISTANT HÆMOGLOBIN OF MONKEYS AT DIFFERENT DAYS AFTER BIRTH

Days	No. 1	No. 2	No. 3	No. 4*
0†	38·8	50·0	47·0	60·0
15	35·5	46·0	42·0	50·0
30	15·5	25·8	20·8	19·8
45	8·4	20·0	6·8	—
60	5·0	18·2	1·5	—
75	2·5	9·2	1·5	—
90	2·4	6·2	1·4	—

* Animal No. 4 died on the fortieth day.
† 0 day indicates just after birth.

6·2 per cent in the course of 60–90 days, with a variable rate of disappearance. For human new-born babies, though the amount of fœtal hæmoglobin varies between 30·0 and 85·0 per cent at birth[4], it gradually disappears, so that not more than 10·0 per cent is found after 4 months[5] and less than 1·0 per cent after the first few years of life[6].

The close similarity between monkey and human hæmoglobin reported here and elsewhere[3] indicates the need for further work using various parameters that characterize different hæmoglobin types.

N. N. Sen
K. C. Das
B. K. Aikat

Division of Hæmatology,
Department of Pathology and Bacteriology,
Institute of Post Graduate Medical
Education and Research, Calcutta-20.

[1] Singer, K., Chernoff, A. I., and Singer, L., *Blood*, 6, 413 (1951).
[2] Jacob, G. F., and Tappen, N. C., *Nature*, 181, 197 (1958).
[3] Beaven, G. H., and Gratzer, W. B., *Nature*, 184, 1730 (1959).
[4] Sen, N. N., Mukherjee, C. L., Das, K. C., and Aikat, B. K., *Bull. Inst., P.G. Med. Ed. Res.*, 1, 88 (1959).
[5] Beaven, G. H., Hoch, H., and Holiday, E. R., *Biochem. J.*, 49, 374 (1951).
[6] Beaven, G. H., Ellis, M., and White, J. C., *Nature*, 178, 857 (1956).

Differences in Numbers of Erythrocytes between Inbred Lines of Chickens

No breed differences in numbers of red blood cells have been reported in poultry[1] although Lucas and Dennington[2] have shown small differences in hæmoglobin concentration and in the volume of packed red cells between inbred lines of the same breed (White Leghorns, as used in this work). In the results reported here, much more extensive differences in all three characters, which appear to represent a distinct form of variation, have been found.

Adult females of the Reaseheath inbred White Leghorn strains *C*, *I* and *W* were used[3]. All three lines have been brother–sister mated continuously for over 20 generations, but the attained level of inbreeding is probably well below the calculated figure, as segregation of genes for differences in red cell antigens is still occurring[4].

Egg production in the birds tested varied somewhat, but no differences could be detected between birds in lay and those out of production. The method of housing, too, differed in that some of the *C*-line and all the *I*-line birds (the blood from these birds was kindly supplied by Dr. D. G. Gilmour, School of Agriculture, Cambridge) were kept in semi-intensive pens, whereas the rest were housed in battery cages. Again, there were no differences due to method of housing.

The birds were bled from the brachial vein into heparin, approximately 2 ml. being removed for determining hæmoglobin content and packed cell volume. Red blood cell counts could be carried out only on birds of the *C* and *W* lines.

For the hæmoglobin estimation, the concentration of oxyhæmoglobin was read in a Spekker photodensitometer, human blood with a known concentration being employed as the standard. Packed cell volume was determined by the microhæmatocrit method, using a micro centrifuge at 12,000 r.p.m. for 5 min. For red cells counts the methyl violet stain of Natt and Herrick[5] was employed and counting carried out visually with the improved Neubauer hæmocytometer.

The results in Table 1 suggest that the differences in red cell characteristics between the inbred line *C* and the others are due to a reduction in the number of red blood cells in the *C* line. Determination of plasma volumes with the dye dilution technique using azovan blue showed no substantial line differences, and indicates that a real reduction in numbers of circulating red cells is involved.

Table 1. DIFFERENCES IN RED CELL CHARACTERS BETWEEN INBRED LINES

Line	*W*	*I*	*C*	6 and 15 (ref. 2)
Hæmoglobin concentration (gm./100 ml. blood)	10·3	9·9	7·2	9·86
S.E. of difference	0·35 N.S.	0·16*	0·35*	
Number of birds	39	10	39	155
Hæmatocrit (packed cell volume, per cent)	33·6	32·6	23·8	30·9
S.E. of difference	1·12 N.S.	0·77*	1·12*	
Number of birds	31	10	33	155
Number of red blood cells (millions/ml.)	3·06		2·30	3·03
S.E. of difference		0·09*		
Number of birds	11		12	155
Mean cell volume ($\mu c.$)	109·8		104·0	102·0
Mean cellular hæmoglobin ($\mu\mu gm.$)	33·7		31·4	33·1
Mean cellular hæmoglobin concentration (per cent)	30·7	30·3	30·3	32·3

* Significant at the 0·01 per cent level. N.S., not significant.

Examination of blood films failed to reveal any evidence of reticulocytosis or other cytological signs of anæmia in the *C*-line birds. The heart-rate (as determined with a Cossor electrocardiograph) of birds of the *C* line averages 333, a value not significantly different from that of 338 for the *W* line. Their mature body-weight (1·57 kgm.) is well below that of the *W* line (2·00 kgm.), but exceeds that of the *I* line (1·29), whereas egg production (over a 44-week period) of the *C* line is 134 eggs, compared with only 80 for *W*, and 86 for the *I* line.

Tests so far carried out show no relationship between the observed oligocythæmia in line *C* with any hæmoglobin abnormalities. Electrophoresis of hæmoglobin solutions from birds of the *C* and *W* lines reveal no differences in the concentrations or mobilities of the two components previously reported by Johnson and Dunlap[6] either on filter paper at pH 8·6 or on agar gel at pH 6·4.

Further examination of the hæmoglobins for differences in resistance to alkali denaturation proved equally negative. Evidently a situation comparable with the human hæmoglobinopathies is not responsible for the differences observed in our inbred lines of poultry. Differences were, however, observed in resistance of the erythrocytes to osmotic pressure. Cells from birds of line *C* begin to hæmolyse at

Table 2. Osmotic Resistance of Red Blood Cells

Line	Beginning of hæmolysis (sodium chloride, per cent)	End of hæmolysis (sodium chloride, per cent)
C	0·495–0·480	0·300–0·285
W	0·435–0·420	0·300–0 285
Values quoted by Sturkie (ref. 7)	between 0·47 and 0 40	0 28

higher concentrations of saline than do those of the *W* line.

Figures based on visual assessments of the beginning and end of hæmolysis are given in Table 2. The proportions of hæmoglobin in solution at different concentrations of saline were also estimated using a 'Unicam' spectrophotometer set at 540 mμ. Expressed as a percentage of the amount released by distilled water, these are shown in Fig. 1.

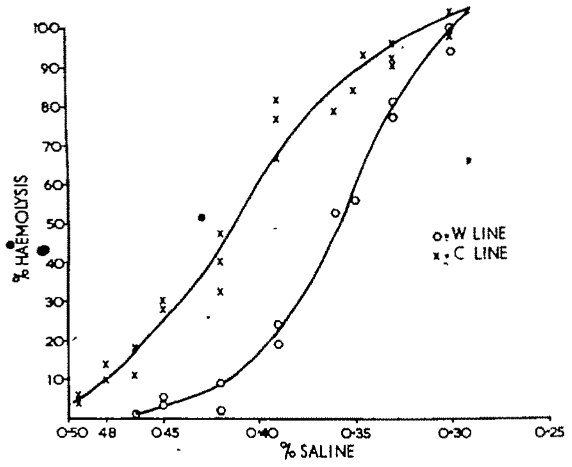


Fig. 1. Osmotic fragility curves

Diminished osmotic resistance is frequently indicative of lowered resistance to mechanical damage, leading to a reduction in the average life-span of the cells. This possibility is now under investigation as is the mode of inheritance of the condition.

P. Jaffe

School of Veterinary Science,
University of Bristol.

---

[1] Groebbels, F., "Der Vogel", 1 (Gebr. Borntraeger, Berlin, 1932).

[2] Lucas, A. M., and Dennington, E. M., *Poultry Sci.*, **36**, 1290 (1957).

[3] Pease, M., and Dudley, F., Tenth World's Poultry Congress, Edinburgh, 45 (1954).

[4] Gilmour, D. G., *Genetics*, **44**, 14 (1959).

[5] Natt, M. P., and Herrick, C. A., *Poultry Sci.*, **31**, 735 (1952).

[6] Johnson, V. L., and Dunlap, J. S., *Science*, **122**, 186 (1955).

[7] Sturkie, "Avian Physiology" (Comstock, New York, 1954).

PATHOLOGY

Alkaline Phosphatase in the Meninges and in Meningiomas

Little is known about the factors which influence cartilaginous and bony metaplasia in tumours apart from the presence of calcified debris and mucinous infiltration in the stroma of these tumours. Willis[1] discusses the association of frequent bony metaplasia in carcinomas of the large intestine, and suggests that this may be associated with the alkaline phosphatase content of these tumours. He furthermore suggests that studies of phosphatases and other enzymes should be undertaken in tumours which show a tendency to bony metaplasia. The presence of an alkaline phosphatase in the 'fibroblasts' of fibrous dysplasia[2,3] and in the so-called fibrocytes of ossifying fibromas[3] certainly lends support to the ossifying properties of this enzyme in certain tumours.

In view of the frequency of metaplastic bone formation in the dura mater, especially in the region of the falx cerebri and the high incidence of calcification and ossification in certain types of meningiomas, it was decided to investigate this problem with regard to its possible association with alkaline phosphatase.

For this purpose two meningiomas were investigated histochemically. Morphologically one was classified as a meningothelial and the other as a psammomatous type of meningioma. In addition, segments of the arachnoid and dura mater in the vicinity of the superior sagittal sinus were obtained from three different autopsies shortly after death and examined histochemically.

Alkaline phosphatase was demonstrated according to the methods described by Pearse[4]. A strong alkaline phosphatase was observed in the arachnoidal cap cells of the arachnoidal granulations and arachnoid membrane, and also in the arachnoidal cell nests in the substance of the dura and arachnoidal membranes. In the meningothelial meningioma a strong enzyme reaction was elicited by all the tumour cells and in the psammomatous type, the enzyme was localized to the cells around the psammoma bodies.

The finding of an alkaline phosphatase in the tumours and their cells of origin may offer some explanation for the frequency of metaplastic ossification in these sites. Of more importance, however, is that it supplies the pathologist with a method by which the relative proportions of arachnoidal cells and fibroblasts can be readily assessed in the tumours.

Details concerning these findings and further experimental work will be published elsewhere. This work was supported by a grant from the Council for Scientific and Industrial Research.

W. J. Pepler

Institute for Pathology,
Beatrix Street,
Pretoria.
Feb. 3.

---

[1] Willis, R. A., "The Borderland of Embryology and Pathology", 553 (Butterworth and Co., London, 1958).

[2] Changus, G. W., *Cancer*, 10, 1157 (1957).

[3] Pepler, W. J., *J. Path Bact.* (in the press).

[4] Pearse, A. G. E., "Histochemistry: Theoretical and Applied", 460 (Churchill, London, 1953).

Isolation of a Cytopathogenic Agent from Skin Lesions of Cattle

Recently, we observed an outbreak of a disease in indigenous cattle at Gikongoro, Ruanda-Urundi, characterized by lesions on the teats and occasionally on other parts of the body and on the buccal mucosa. Material was obtained from nine cases, and with each sample transmission experiments were carried out in cattle. Following intradermal inoculation or scarification of the mucous membrane of the tongue, a definite reaction was noticed in five out of nine animals. This reaction was characterized by the development of necrotic lesions at the inoculation site, which showed some resemblance to those described in both natural and experimental cases of lumpy skin disease[1–3].

An excised nodule from an experimentally infected calf was used for the inoculation of monolayers of bovine testis cells. Some cytopathic changes were observed already at the first passage, but they were much more marked at the second passage, and consisted of intranuclear inclusions and the formation of large syncytia. The syncytia covered the whole monolayer in a few days and led to complete destruction of the cell sheet. Similar changes were observed in cultures of lamb testis cells. The time of appearance and the evolution depended upon the cell type and the age of the monolayer at the time of inoculation.

The tissue culture-passaged virus was inoculated intradermally into a one-month-old calf, which developed a necrotic lesion about 5 cm. in diameter at the site of inoculation. Rabbits and guinea pigs, inoculated by scarification of the skin with the tissue culture-passaged virus, showed a marked local reaction after a few days.

The agent we isolated shows characteristics somewhat intermediary between those of the Neethling and Allerton types of viruses recovered from cases of lumpy skin disease by Alexander *et al.*[2] in South Africa and by Prydie and Coackley[4] in Kenya. It produces cytopathic changes closely resembling those produced by the Allerton type, but the reactions observed in experimentally infected bovines are similar to those induced by the Neethling type. On the other hand, the clinical symptoms in the natural cases are milder and somewhat different from those commonly described in other African countries.

Further research is in progress and a detailed report of the experiments will be published elsewhere.

C. HUYGELEN
D. THIENPONT
M. VANDERVELDEN

Veterinary Research Laboratory
and
School of Veterinary Assistants,
Astrida, Ruanda-Urundi,
Central Africa.

[1] Henning, M. W., "Animal Diseases in South Africa" (Cape Town, 1956).

[2] Alexander, R. A., Plowright, W., and Haig, D. A., *Bull. Epiz. Dis. Afr.*, 5, 489 (1957).

[3] Capstick, P. B., *Bull. Epiz. Dis. Afr.*, 7, 51 (1959).

[4] Prydie, J., and Coackley, W., *Bull. Epiz. Dis. Afr.*, 7, 37 (1959).

Induction of a Chorion-epitheliomatous Tumour in the Rat

CHORION-EPITHELIOMA of the uterus is a relatively rare tumour with many interesting features. It occurs only during or after pregnancy, and invasion and metastasis only take place *post-partum* or *post-abortum*. Spontaneous regressions occur in a small but significant number of cases[1]. It is the only known instance of naturally occurring tumour homograft[2]. A response to œstrogen therapy has been recorded[3] and remissions with folic acid antagonists have been reported[4].

The experimental induction of this tumour in laboratory animals would be of great interest. To our knowledge there are no records in the literature of spontaneous or induced chorion-epitheliomas in rodents, though Fischer and Kuehl[5] mention chorion-epitheliomatous structures in the ovaries of guinea pigs.

A tumour of the uterus in the pregnant rat has been induced in the following manner. A rat fœtus was removed after 2 weeks gestation by Cæsarean section, the placenta being left *in situ*. Benzpyrene powder was dusted into the gestational sac and the uterus then closed. After 4 months, vaginal bleeding was noted and exploratory laparotomy revealed the presence of enlarged cystic ovaries and thickened uterine horns containing hæmorrhagic fluid. Five months after the application of benzpyrene, a large tumour about 40 mm. × 30 mm. was palpated in the abdomen and the animal was killed. At autopsy a large, white, firm, nodular tumour measuring 60 mm. was seen in the uterine horn. There were numerous secondary deposits in the abdominal cavity. In the lungs there were pneumonic patches but no secondary deposits. Histologically, the tumour was a highly anaplastic growth having both sarcomatous and decidual elements. Many mitoses were present. This tumour was transplantable with a 100 per cent yield on subcutaneous passage and kills the host in 7–10 days.

The Ascheim–Zondek test was negative—but it was equally negative with urine from normal pregnant rats. Animals bearing intrauterine transplant tumours or very large subcutaneous growths have hæmorrhagic or lutein cysts in the ovary.

The action of folic acid antagonists on this tumour is being studied. Preliminary investigations have shown that it is sensitive to 'Methotrexate'[6] if the drug is given in high doses. An attempt is also being made to determine the sex of the tumour cells.

Twenty-five rats were similarly treated with benzpyrene and it appears that tumours are developing in two more animals.

A detailed report on this work will follow shortly.

I am indebted to Dr. S. S. Epstein for helpful discussion and criticism, and to Dr. C. P. Cherry for histological examinations.

R. STEIN-WERBLOWSKY

Marie Curie Hospital,
66 Fitzjohn's Avenue,
London, N.W.3.
May 10.

[1] Park, W. W., and Lees, J. C., *Arch. Path.*, 49/1, 73, and 49/2, 205 (1950).

[2] Dowling, E. A., *Southern Med. J.*, 50/2, 211 (1957).

[3] Hinglais, H., and Hinglais, M., *C.R. Soc. Biol., Paris*, 147, 555 (1953).

[4] Hertz, R., Bergenstal, D. M., Lipsett, M. B., Price, E. B., and Hilbish, T. F., *J. Amer. Med. Assoc.*, 168/7, 845 (1958).

[5] Fischer, W., and Kuehl, L., "Geschwuelste der Laboratoriumsnagetiere, 74 (Steinkopff, Dresden, 1958).

[6] Buckle, A. E R., *Brit. Med. J.*, ii, 1210 (1959).

Presence of Chicken Tumour Virus in the Sarcoma of the Adult Rat inoculated after Birth with Rous Sarcoma Tissue

THE heterotransplantation of Rous sarcoma to newborn rats results in lethal hæmorrhagic disease occurring in these animals[1–3]. Svet-Moldavsky[3] succeeded in determining the infectious virus in hæmorrhagic cysts, while Zilber and Kryukova[1] and Kryukova[4] had negative results. In our experiments, the virus was not found in every case, but we observed it in some of the animals[3,4]. Svet-Moldavsky[6] has also shown that Rous virus can induce the formation of rat sarcomas which do not contain the virus. On the basis of our material we came to a similar conclusion. In 2 out of 87 young rats inoculated 1–7 days after birth with a single dose of 0·3 ml. of cut fresh Rous sarcoma tissue diluted with physiological saline to make a 50 per cent suspension, large sarcomas were found in thigh muscle tissue in addition to hæmorrhagic cysts occurring in other parts of the body. The first case was observed 5 months and the second one 7 months following inoculation of Rous sarcoma; the cyst was localized in the axillary region, whereas the sarcoma grew in the thigh muscle of the hind leg.

Table 1. TESTS FOR THE PRESENCE OF AVIAN TUMOUR VIRUS IN THE WALL OF THE HÆMORRHAGIC CYST, IN BLOOD, SARCOMA AND ITS FIRST PASSAGE, MADE ON 20–29-DAY OLD CHICKENS

Material taken from the adult rat inoculated after birth with Rous sarcoma tissue

Inocula	Dose of 50 per cent tissue suspension in physiological saline (i.m.)	No. of chickens	No. of chickens dead from tumours
Cyst wall	0·8 ml.	3	1
Blood from the cyst	2·5 ml.*	2	0
Sarcoma	1 ml.	2	1
First passage of sarcoma in new-born rats. Removed on sixteenth day and irradiated with 5,000 r.	1 ml.	3	2

* Undiluted whole blood from the cyst.

In the case of the cyst, the presence of virus in the cyst walls, blood and tumour was shown after transfer of these tissues to chickens (see Table 1). In the case of the sarcoma, the blood remained ineffective, thus excluding the possibility of a mechanical transmission of the virus into the sarcoma. The virus was found to be present in the first passage of sarcoma made on newborn rats and taken on the sixteenth day after transplantation. Before transfer to chickens, the tumour tissue was killed by irradiation with 5,000 r. When tumours of the first passage were tested in chickens after 36 days, metastasizing sarcomas were also obtained (results not included in Table 1). In addition, Kryukova[9] found that after infection of rat *M*-1 sarcoma *in vivo* with Rous sarcoma virus, it was impossible to detect the virus after 6 hr. The *M*-1 sarcoma cells incubated with this virus when transferred into rats likewise induced tumours which do not, however, contain the virus. These findings emphasize that in our experiments an intimate association of virus with mammalian tumour cells took place which was promoted by infection of ontogenetically immature recipients.

All tumours obtained in chickens macroscopically and microscopically resembled the Rous sarcoma and contained a large amount of viscous intercellular ground-substance. Their growth was very similar to the growth of Rous sarcoma in non-tolerant[7] and tolerant[8] turkeys. At the site of implantation—in the pectoral region—distinct tumours were observed, but they never reached a large size, because the animals succumbed to a metastatic effusion localized largely in the lungs. The tumours were transferable to chickens both by means of tissue suspension and by extracts obtained through centrifugation at 13,000*g* for 15 min. However, after re-transplantation to newborn rats they did not grow.

All the findings provide evidence that the avian virus may participate directly in the formation of mammalian sarcomas and may be present there in an infectious form.

JAN SVOBODA

Biological Institute,
Czechoslovak Academy of Sciences,
Na cvičišti 2,
Prague 6.

---

[1] Zilber, L. A., and Kryukova, I. N., *Vopr. Virusol.*, 4, 289 (1957).
[2] Svet-Moldavsky, G. J., *Nature*, 180, 1299 (1957).
[3] Svoboda, J., and Grozdanovič, J., *Folia Biol. (Prague)*, 5, 46 (1959).
[4] Kryukova, I. N., *Vopr. Virusol.*, 4, 486 (1959).
[5] Svoboda, J., and Grozdanovič, J., *Folia Biol.* (*Prague*) (in the press).
[6] Svet-Moldavsky, G. J., *Nature*, 182, 1452 (1958).
[7] Duran-Reynals, F., *Cancer Res.*, 3, 569 (1943).
[8] Svoboda, J., and Hašek, M., *Folia Biol.* (*Prague*), 2, 256 (1956).
[9] Kryukova, I. N., and Lozneva, O. M., *Vopr. onkol.*, 5, 3 (1959).

RADIOBIOLOGY

Effect of X-Rays on the Development of the Infective Larvæ of *Oesophagostomum radiatum* (Rud. 1803) (Strongylidae : Nematoda)

FOLLOWING a report by Jarrett *et al.*[1] on the stimulation of resistance in sheep to infestation with *Haemonchus contortus* by dosing with X-irradiated infective larvæ, investigations are being undertaken at this laboratory on the value of this technique in producing resistance in calves to gastro-intestinal helminths.

In a trial with *Oesophagostomum radiatum* in which calves five months old and reared worm-free were used, 4 animals were each given 7,000 normal infective larvæ and 10 others a similar number of infective larvæ exposed to 20,000 r. of X-radiation. The radiation was given in a single dose at 1,000 r. per min. on a 220-kV. 'Maximar' at 220 kV., no filter, H.V.L. = 0·4 mm. copper. Calves from the group given irradiated larvæ were killed and examined for worms 3, 4, 5, 6 and 8 weeks after infestation, and a calf from the control group 6 weeks after infestation.

Table 1. WORMS PRESENT IN CALVES GIVEN X-IRRADIATED (20,000 R). AND UNTREATED LARVÆ OF *Oesophagostomum radiatum*

Calf No.	Time after infestation (weeks)	Worms present			
		5th stage		4th stage	3rd stage
		♀	♂		
	X-irradiated group				
365	3	160		2,140	0
366	4	920	40	45	0
372	5	465	5	105	0
367	6	268	4	9	0
374	8	1,440	75	0	0
	Control group				
362	6	1,825	1,880	0	0

The results of these examinations are set out in Table 1. Although only one calf in the control group was examined, the proportion of male to female worms in this animal was in conformity with that found in calves used in earlier studies on infestations with untreated larvæ. The presence of fourth-stage larvæ in the calves killed at 4, 5 and 6 weeks is not considered to be a result of radiation, for numbers of this stage have been seen in calves given single doses of untreated larvæ and killed at comparable times. The main effect of this level of radiation therefore was to prevent the establishment of an adult male population in normal numbers.

The fæcal egg counts of the survivors of the control group followed the trend usually seen in experimental infestations, whereas the egg counts of the survivors of the group receiving treated larvæ remained at a low level or were negative. Female worms from the calves of the latter group killed at 5, 6 and 8 weeks contained eggs which appeared to be infertile, and afterwards it was found that most of the eggs in the fæces of the surviving calves of this group could be detected only by sedimentation, as they did not float in the salt solution used in the standard egg counting technique of Roberts and O'Sullivan[2]. No division of the cell had occurred, and the eggs did not develop in fæcal cultures.

In addition to the selective action on the larvæ destined to be males it is possible then that the level of X-radiation used also had a sterilizing effect on one or perhaps both sexes, as recorded by Schwartz[3] for larvæ of *Trichinella spiralis* exposed to X-rays.

Further details of this experiment will be published elsewhere.

R. F. Riek
R. K. Keith

Division of Animal Health,
Commonwealth Scientific and Industrial Research
Organization,
Veterinary Parasitology Laboratory,
Yeerongpilly,
Queensland.

---

[1] Jarrett, W. F. H., Jennings, F. W., McIntyre, W. I. M., Mulligan, W., and Sharp, N. C. C., *Amer. J. Vet. Res.*, 20, 527 (1959).

[2] Roberts, F. H. S., and O'Sullivan, P. J., *Aust. J. Agric. Res.*, 1, 99 (1950).

[3] Schwartz, B., *J. Agric. Res.*, 20, 845 (1921).

Stimulating Effects of Nuclear Radiations on Development and Productivity of Rice Plants

In a report[1] which came to our notice in 1956, Kuzin showed the presence of the stimulating effects of ionizing radiations on the growth and development of several agricultural crops save rice. It was therefore felt desirable to study a possibility of obtaining an increase in development and productivity of rice crop through treatment with nuclear radiations.

Dry grains of rice varieties *C*33-18 and *D*17-88, the moisture contents of which had been stabilized in a room maintained at about 70 per cent relative humidity for 9 days, were exposed to 500 r., 1,000 r., and 1,500 r. of γ-rays from a 1,000-c. 'Theratron Junior' cobalt-60 teletherapy unit. Germination tests were conducted on moist filter papers in Petri dishes. The sprouts were transferred to nursery pots on the fifth day. When 30 days old, the seedlings were transplanted in unfertilized plots, each measuring 5 ft. by 33 ft. Plant heights and panicle lengths were taken just before harvest, followed by thorough gleaning to make up for the loss due to lodging. The results are summarized in Table 1.

Application of both tagged and untagged monoammonium dihydrogen orthophosphate, each in concentrations of 20 lb. phosphate/A., 40 lb. phosphates/A., and 60 lb. phosphate/A., to 6 plots of 39-day old transplants of rice variety *C*28-16 at the ground-level, was made on the ninth day after transplanting; the specific and total activities used being 175 μc./gm. total phosphate and 4554·82 μc., respectively. The results for plant height and grain yield are presented in Table 2.

Table 1. EFFECT OF γ-RAYS ON SEED GERMINATION, PLANT HEIGHT, PANICLE LENGTH AND GRAIN YIELD OF RICE VARIETIES *C*33-18 and *D*17-88 TESTED IN 1959

Variety	Treatment	Germination (per cent)	Average plant height (cm.)	Average panicle length (cm.)	Grain yield (kgm./A.)	Ratio to control (per cent)
*C*33-18	0 r.	95	129·5	22·2	1,260	100·0
	500 r.	94	134 6	22 5	1,320	104·8
	1,000 r.	96	141·8	22 9	1,371	108·8
	1,500 r.	94	131·8	22·6	1,464	116·2
*D*17-88	0 r.	100	125·3	29·1	1,160	100 0
	500 r.	100	125 4	28·9	1,285	110·8
	1,000 r.	100	129·0	29 8	1,219	105·1
	1,500 r.	100*	124 3	26·7	1,035	89·2

* Shortest plumule and longest radicle.

From Table 1 it appears that germination percentages of both control and irradiated seeds are the same in *D*17-88 and almost equal in *C*33-18. The yield response of *C*33-18 is positive and progressive at all three dosages, whereas that of *D*17-88 at 500 r. and 1,000 r. is positive, but regressive at the latter, and negative at 1,500 r. of γ-radiation. Over the range tested, dosages of 1,500 r. and 500 r. of γ-rays seem to be the best for the highest crop return of *C*33-18 and *D*17-88, respectively. Generally, no clear-cut differences in panicle length and plant height among the control and irradiated *D*17-88 are obtained. Apparently, there is some conspicuous difference only in plant height between control and irradiated *C*33-18, especially at the 1,000-r. level.

It is worth recording an observation that the number of plants lodged progressively increased from a very few at the 1,500 r. level to 100 per cent in the control in both varieties just before the maturity of grains. Irradiation treatment therefore seems to promote silicification of cell walls, that is to say, structural strength, through its favourable influence on utilization by rice plants of potassium and/or silicon from the soil. This point is being further studied.

Table 2 indicates that *C*28-16 yields considerably better and higher at all three levels of radioactive phosphate additions than at the corresponding levels of non-active phosphate applications. An increase in the yield of grain dropped by 16–17 per cent due probably to a relatively large total activity at the level of 60 lb. phosphorus-32 phosphate/A. A noticeable gain in stature over plants treated with phosphorus-31 is found among plants subjected to 748·36 μc. and 1517·92 μc. of phosphorus-32. Although phosphorus-32 has a short half-life of 14·30 days, and its activity in plant body and the soil is no longer readily detectable about 3–4 months after fertilization, it cannot as yet be recommended for practical applications in view of the serious problems of radiation protection and health hazards.

Table 2. EFFECT OF PHOSPHORUS-31 AND PHOSPHORUS-32 ON PLANT HEIGHT AND GRAIN YIELD OF RICE VARIETY *C*28-16 TESTED IN 1959

Treatment*	Total activity of ^{32}P† (μc.)	Average plant height (cm.)	Grain yield in lb. per 23 clusters	Increase (per cent)
0	—	64	0·40	—
20 lb. $^{31}P_2O_5$/A.	—	102	0·87	—
40 lb.	—	113	1·57	—
60 lb.	—	128	2·45	—
20 lb. $^{32}P_2O_5$/A.	748·36	114	1·27	46
40 lb.	1,517·92	123	2·27	45
60 lb.	2,288·54	127	3 16	29

* Applied 9 days after transplanting.
† Calibrated and supplied by Radiochemical Centre, Amersham, Bucks.

These results are clearly indicative of the stimulative effects of comparatively low levels of both β- and γ-rays on the growth and productivity of rice plants. The varietal difference in reaction to an equal dose of the same kind of nuclear radiation is observed. Future work is planned to test the stability or otherwise of these effects in the following season, and the overall interaction between γ-ray treatment of dry seeds over a wider range of doses, and the non-active or radioactive phosphate additions to be made later at various stages of plant growth from irradiated seeds of rice.

Thanks are due to U Hla Nyunt, director of the Union of Burma Atomic Energy Center; U Khin, director of the Department of Agriculture, and U San Khin, chief research officer, Agricultural Research Institute, for their support in the course of this work.

MAUNG MYA THAUNG

Department of Agriculture and Biology,
Union of Burma Atomic Energy Center.

---

[1] Kuzin, A. M., Proc. First Int. Conf. on Peaceful Uses of Atomic Energy, 12, 149 (Geneva, 1956)

A Comparison of Iodine-124 and Iodine-131 Thyroid Dosimetry

THE purpose of this communication is to show that the approximate estimate given by Doniach and Francois[1] of the ratio R of the quantities (in mc.) of iodine-124 to iodine-131 required to give the same average dose (in rads) to rat thyroids has been modified by more exact calculations; further, to demonstrate the effect of some biological variables on this ratio; and to discuss the implications in treatment of human thyroid disease with radioactive iodine. There are two such implications. First, the average doses within the human thyroid can be calculated for iodine-124, within certain limits of error, because the maximum and minimum do not differ by more than about 3 : 1. For iodine-131, however, with β-particles of much shorter range, the extreme non-uniformity of dosage, varying from 10 : 1 to 100 : 1 in thyroid tumours[2,3], would appear to render such estimates of 'average dose' of limited use. Iodine-124 would therefore be a therapeutic tool of greater precision than iodine-131, both for the control of thyrotoxicosis and for thyroid carcinoma. The accurate prediction of the amount of isotope required to be administered, which is possible, but is not always thought necessary for iodine-131, would be more worth while for iodine-124.

The second implication arises from the possibility that a smaller 'average physical dose' of relatively uniformly distributed radiation is required to produce the same biological effect in the rat thyroid than a given 'average dose' from iodine-131. Doniach had previously found a gain factor F of about 5 : 1 in rats for X-rays relative to iodine-131, after allowance for the different duration of irradiation, both in the inhibition of thyroid hyperplasia and in the induction of thyroid tumours[4,5]. Such gain factors should be enhanced in the human thyroid. The ratio of the millicurie quantity of iodine-124 to that of iodine-131 required to produce a given biological effect in a thyroid gland is not simply the ratio R of the 'average' physical doses, but is R/F. The factor F will be greater than unity if uniform radiation is more effective than the same 'average dose' of non-uniformly distributed radiation. A more relevant value of F may now be derived from the experiment of Doniach and Francois[1], since this experiment compares the effect of the two internally administered isotopes in rats.

Values of R (between 1·0 and 1·7) have been discussed[6,7] for human thyroids but values of F have yet to be determined.

To Doniach and Francois's experimental finding[1] of $R/F = 1{\cdot}8$ ($\pm 0{\cdot}2$ standard deviation) in rats, we wish to add that the theoretical ratio is $R = 2{\cdot}29$, if the following assumptions are made. Variables are discussed below. The shape of the thyroid gland was assumed to be a pair of cylinders each 5 mm. long and 2 mm. in diameter, of total weight 31·4 mgm., with centres 5 mm. apart, except where otherwise stated. The biological half-life was taken as 100 hr. The cylindrical shape gives rise to computational problems, the solution of which will be described elsewhere[7]. Allowance was made for radiation not absorbed within the gland. The k-factor of iodine-124 was taken to be 7·0 (refs. 8–10). The proportion of iodine-126 present as a contaminant of the iodine-124 was assumed to be 0·22 : 1 (in mc.), so as to be consistent with the material used by Doniach and Francois. The nuclides iodine-123 and iodine-125, in the amounts which were present, would not affect these results. The dose at the centre of one spherical lobe due to the other lobe was estimated to be less than 1 per cent and so this effect was neglected.

The biological half-life affects these results as shown in Table 1.

Table 1

Biological half-life	R (iodine-124 mc./iodine-131 mc. to give equal average physical doses in rads—2 cylinders)
2·9 days	2·22
4·17 days	2·29
5 days	2·30
10 days	2·40
Infinite	2·44

The fact that the maximal uptake is not achieved instantaneously would only increase these ratios by about 2 per cent.

Variation in the shape of the organ will affect the ratio as shown in Table 2.

Table 2

Shape	R (biological $t_{1/2}$ 5 days)
Two cylinders as above (31 mgm.)	2·30
Two spheres (total 30 mgm.)	2·12
Single sphere (total 30 mgm.)	1·88

Variations in weight of the rat thyroid will affect the results. The values given in Table 3 have been calculated for a pair of spheres[11], since this model shows the magnitude of the variation with sufficient accuracy.

Table 3

Weight of pair of spheres	R (biological $t_{1/2}$ 5 days)
20 mgm.	2·21
25 mgm.	2·19
30 mgm.	2·12

It will be seen that the extent of these variations is not unduly large compared with other errors in such experiments.

It should be mentioned that the proportion of iodine-126 present affects the calculated ratio R. This factor is not, of course, a biological variable, and the proportion present in any specimen of iodine-124 can be determined. In Doniach and Francois's experiment, the accuracy of this determination was ±5 per cent, and the change in R resulting from a change in proportion of iodine-126 from 0·21 : 1 to 0·23 : 1

would be from $R = 2.32$ to $R = 2.26$. (Subsequent batches of iodine-124, produced by bombardment at 30 MeV. instead of 18 MeV., have contained much smaller proportions of iodine-126.)

The general conclusions are not affected by such variations as are likely to occur. In particular, the experimental ratio for R/F of 1.8 ± 0.2 (excluding the k-factor uncertainty) found by Doniach and Francois is lower than the calculated value of $R = 2.29$, but the difference is only about twice the standard deviation of the experimental results. This shows that the gain factor F must be between 1 and 1·4. Therefore if the better uniformity of dose distribution affects this result *per se*, then the effect is small compared with the known non-uniformity of concentration of iodine-131 in rat thyroids[12], which was 5 : 1 for individual follicles. However, these follicles are of the order of 0·05 mm. diameter so that the dose in rads is likely to vary by less than 2 : 1 even for iodine-131. Therefore the experimental value of F is not inconsistent with the dosage non-uniformity factor in rat thyroids. The results of the comparison of X-rays and iodine-131 referred to above[5] depend upon other factors, that is, dose-rate, duration of exposure, and lower iodine uptake and dosage at the periphery of the glands. They are likely to be less relevant than a comparison of two isotopes.

In human thyroid tumours, however, there are areas up to 5 mm. diameter with little or no uptake of iodine[6], so that here F may be much greater.

Our thanks are due to the director of this Unit, Dr. C. A. P. Wood.

C. M. E. Matthews
J. F. Fowler

Medical Research Council
Radiotherapeutic Research Unit,
Hammersmith Hospital,
London, W.12.

[1] Doniach, I., and Francois, P. E., *Nature* (in the press).
[2] Oddie, T. H., *Brit. J. Radiol.*, **24**, 333 (1951).
[3] Sinclair, W. K., Abbatt, J. D., Farran, H. E. A., Harriss, E. B., and Lamerton, L. F., *Brit. J. Radiol.*, **29**, 36 (1956).
[4] Abbatt, J. D., Doniach, I., Howard-Flanders, P., and Logothetopoulos, J. H., *Brit. J. Radiol.*, **30**, 86 (1957).
[5] Doniach, I., *Brit. J. Cancer*, **11**, 67 (1957).
[6] Phillips, A. F., *Brit. J. Radiol.*, **30**, 247 (1957).
[7] Matthews, C. M. E., and Tucker, B. A. (to be published).
[8] Girgis, R. K., and van Lieshout, R., *Physica*, **25**, 133 (1959)
[9] Mitchell, A. C. G., Juliane, J. O., Greaser, G. B., and Keeher, C. W., *Phys. Rev.*, **113**, 628 (1959).
[10] Haybittle, J. L., *Phys. Med. Biol.*, **4**, 280 (1960).
[11] Loevinger, R., Japha, E. M., and Brownell, G. L., "Radiation Dosimetry", Hine, G. J., and Brownell, G. L., 784 (Academic Press, Inc., New York, 1956).
[12] Clayton, C. G., *Brit. J. Radiol.*, **26**, 99 (1953).

BIOLOGY

Are Macromolecules Required for Growth of Single Isolated Mammalian Cells ?

A few strains of mammalian cells have been grown from large inocula in a protein-free medium[1] ; but the multiplication of single isolated cells requires that the medium be supplemented with protein, usually supplied as whole or dialysed serum[2]. Recently, it has been shown that for HeLa cells the serum can be replaced by two purified proteins, fetuin and albumin[3]. However, the role of these proteins is obscure. The following experiments demonstrate that for one cell strain, at least, the role of serum is not to supply protein as such, but probably to act as a source of essential growth factors of low molecular weight.

Horse serum was dialysed aseptically on a shaker at 5° C. for 24 hr. against ½ vol. of Parker's chemically defined medium, *CMRL*-1066 (phenol red omitted)[4]. In some experiments several such 24-hr. dialyses were carried out on the same sample of serum. *L* cells (strain 929 *E*) were immediately plated in the dialysates, using a procedure described previously[5]. Fresh dialysate was used for feeding the cultures, after one and two weeks of incubation.

While in *CMRL*-1066 alone, the cells failed to undergo even a single division ; after incubation for five days in the dialysate most cells had grown into microcolonies. Cell multiplication continued until these colonies contained several thousand cells each. The plating efficiency was about the same as with 20 per cent serum (Table 1). Growth-rates were about the same in both media.

Table 1. Plating Efficiency of *L* Strain Cells in Media with and without Macromolecular Components

	Plating efficiency*		
	Exp. 1	Exp. 2	Exp. 3†
CMRL-1066 + 20 per cent whole horse serum	69	82	73
CMRL-1066 + 20 per cent dialysed horse serum	70	80	69
CMRL-1066	0	0	0
CMRL-1066 dialysed‡ against whole horse serum	65	70	73

* Percentage of 100 cells added to each Petri dish which formed macroscopic colonies.

† In experiment 3 the serum was subjected to two previous 24-hr. dialyses.

‡ Whole horse serum was dialysed against one-half volume of *CMRL*-1066 for 24 hr. at 5° C.

In the presence of serum the cells exhibited many cytoplasmic granules, were roughly polygonal in shape, and closely adherent. In striking contrast was their appearance in the dialysate. Here the cells contained relatively few granules, were extremely fusiform, and were seldom in contact with one another. This tendency for cells in the dialysate to separate from one another was also noted in attempts to adapt *L* cells to grow continuously from large inocula in *CMRL*-1066 alone. Possibly this behaviour may be characteristic of growth in a protein-free medium.

When the standard 24-hr. dialysis was repeated three times on the same sample of serum, the final dialysate gave as high a plating efficiency as the first (Table 1, Exp. 3). This result would be expected from the equivalence of whole and dialysed serum in supporting cell growth. However, the amount of active material at any time was small, since even a twofold dilution causes a marked (fivefold) drop in plating efficiency. Dialysates did not give the biuret reaction, indicating that the concentration of peptides, if present, was low.

These experiments demonstrate that serum as such is not required for the multiplication of single *L* cells. It is possible that dialysis against serum may adjust the concentrations of the constituents already present in *CMRL*-1066, but it is more likely that serum is supplying one or more essential dialysable growth factors not present in the synthetic medium.

Some batches of horse serum have failed to yield active dialysates. A possible reason for this is advanced in a paper by Eagle[6] which appeared as this communication was being written. His experiments show that cultures inoculated with 10^5 *L* cells per ml. failed to grow in a chemically defined medium separated by a 'Cellophane' membrane from dialysed serum unless proteolytic enzymes were added to the serum compartment. This suggests that growth factor(s) was released by breakdown of the serum proteins. Since proteolysis of serum varies with temperature and time of storage[6], neither of which was controlled in my experiments, such variation could explain my failure to obtain active dialysates in some instances. This hypothesis is being tested. If, indeed, proteolysis is responsible for the release of growth factor(s), then trace amounts released without added enzymes might allow growth of small numbers of isolated cells, but be inadequate to support the dense populations employed by Eagle.

This work was supported in part by a research grant from the United States Public Health Service (C-4534).

RALPH B. GWATKIN

Wistar Institute of Anatomy and Biology,
36th Street at Spruce,
Philadelphia 4, Pennsylvania.
May 11.

[1] Waymouth, C., *J. Nat. Cancer Inst.*, **22**, 1003 (1959).

[2] Sato, G., Fisher, H. W., and Puck, T. T., *Science*, **126**, 961 (1957).

[3] Fisher, H. W., Puck, T. T., and Sato, G., *J. Exp. Med.*, **109**, 649 (1959).

[4] Parker, R. C., Castor, L. N., and McCulloch, in "Cellular Biology, Nucleic Acids and Viruses", 308 (New York Academy of Sciences, New York, 1957).

[5] Gwatkin, R. B. L., Till, J. E., Whitmore, G. F., Siminovitch, L., and Graham, A. F., *Proc. U.S. Nat. Acad. Sci.*, **43**, 451 (1957).

[6] Eagle, H., *Proc. U.S. Nat. Acad. Sci.*, **46**, 427 (1960).

Non-specific Tolerance of Graft and the Dissociation of Two Types of Immunity

PREVIOUS work with induced immunological tolerance of skin grafts presented evidence of a strict specificity of acquired tolerance. The 'non-specific' tolerance should be induced in ducks by injecting them with a mixture of bone marrow and spleen cells from 60 pooled donors[1]. This finding, as well as other observations of 'non-specific' tolerance[2] can be explained by the antigenic overlapping between individuals genetically related to a certain extent. However, it was shown that, when heterografts were tolerated, tolerance of heterografts from other individuals of the same species could be also obtained. In one instance, tolerance of a turkey homograft[3] was found in a turkey which tolerated two chicken heterografts.

In chickens that had been in embryonal parabiosis with turkeys, the tolerance of skin heterografts in postfœtal life is of a much lower degree than that observed in turkeys. We have therefore sought to find out whether these animals would be able to tolerate chicken homografts even though they did not tolerate, or only partially tolerated, the turkey heterografts. In seven chicken parabionts, skin heterografts transferred at 14 days of age never survived longer than 20 days after transplantation. However, in five chickens, homografts continued to be tolerated. On four of them feathers grew, and the first signs of their destruction (feathers falling off, minor necrosis) were observed 35–60 days after transplantation. The destruction proceeded slowly and the final destruction of homografts was very difficult to determine (Fig. 1).

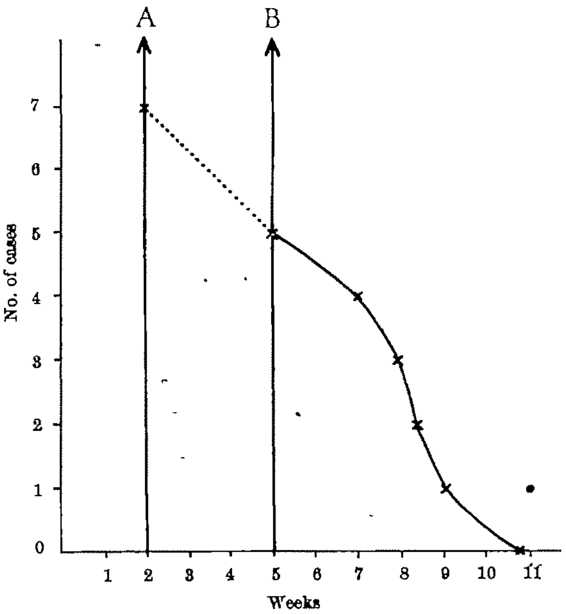


Fig. 1. Occurrence of the first signs of homograft destruction in parabiotic chickens with partial heterologous tolerance. *A*, Transplantation of skin at two weeks after hatching; *B*, the limit of maximal survival of homografts on control chickens and of heterografts on parabiotic chickens

It does not seem probable that the heterologous antigenic complex would involve the antigens which are necessary for the induction of homologous tolerance. Hašková (unpublished work) did not find that rat heterografts would induce immunity in *CBA* mice to skin homografts from *C* 57 and *A* strains of mice. Donors selected at random for homotransplantations in tolerant animals, and the persistence of homografts after the heterografts were sloughed, are inconsistent with the fact that individual specific antigens possessed in common by the two species might be involved in inducing this type of tolerance. It can be assumed that all heterologous cells were eliminated from the organism by the immune reaction and together with them all the sources of heterologous antigenic stimulus. The destruction of heterografts likewise shows that the animals are capable of immunological response. It seems, therefore, more probable that this non-specific immunological tolerance of homografts is due to a somewhat more complex mechanism. The heterologous antigenic complex induces in the embryo simultaneously and in even a higher degree the tolerance to homologous antigens which are not present.

In addition, the dissociation of two types of immunity has been found in tolerant animals, namely, transplantation immunity to skin grafts and antibody formation against erythrocytes, which is analogous to that found by Stark, O., Frenzl, B., and Křen, O. (personal communication) in homologous relationships in chickens. In turkey parabionts with a chick, the chicken heterografts are frequently tolerated for several months. In Fig. 2 one such case is included; the chicken graft tolerated by the turkey had been transferred to it 14 days after birth. The interspecies blood mosaicism disappeared from the turkey's circulation within two weeks after hatching. Between the eighth and twelfth week after hatching, immunization of animals with chicken blood was produced and around the graft repeated local applications were made of a large amount of turkey antiserum against chicken blood. The skin graft from the partner survived in spite of the fact that the recipient produced agglutinins against chicken erythrocytes of

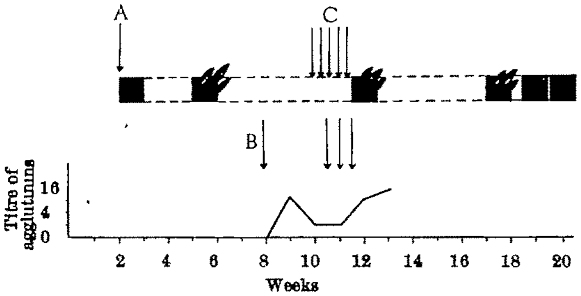


Fig. 2. Behaviour of a heterograft and formation of hetero-agglutinins in a parabiotic turkey. *A*, Transplantation of chicken skin from the partner to a parabiotic turkey; *B*, immunization with chicken blood; *C*, passive transfer of antiserum

the partner after starting with immunization. The first signs of destruction of the graft occurred seven weeks after the immunization had ended.

It may be possible that the formation of agglutinin and transplantation immunity are induced by different antigens; however, it seems more probable that the identical antigen releases two different types of immune mechanism. This difference may be due to binding the antigen with other substances which have no antigenic determinants, but do affect the further fate of the antigenic stimulus. Moreover, it appears that in heterologous relationships, the circulating antibodies do not disturb the tolerance of skin grafts, and the repeated local application of large amounts of heterologous serum (28 ml. within 9 days, the titre being 1 : 32) obtained by blood immunization fails to result in graft destruction. As in the case of a homograft[4], the serum antibodies do not induce the destruction of a tolerated graft.

MILAN HAŠEK
JAN HORT

Institute of Biology,
Czechoslovak Academy of Sciences,
Na cvičišti 2, Prague 6.

[1] Hašek, M., and Hašková, V., presented at the Conference on the Biological Basis of Tissue Transplantation, Prague, 1957, see *Transpl. Bull.*, 5, 69 (1958).

[2] Terasaki, P. J., Cannon, J. A., and Longmire, W. P., *J. Immunol.*, 81, 246 (1958). Billingham, R. E., and Brent, L., *Phil. Trans. Roy. Soc.*, B, **242**, 439 (1959).

[3] Hašek, M., Hraba, T., and Hort, J., *Nature*, 183, 1199 (1959).

[4] Brent, L., Brown, J. B., and Medawar, P. B., "Biological Problems of Grafting", 64 (Liège, 1959). Stetson, C. A., *ibid.*, 79.

Retarded Development of *Ostertagia* Species in Sheep

SOMMERVILLE[1,2] has indicated that the immature stages of *Ostertagia* species in sheep may remain dormant or slowly developing over a considerable period within the abomasal pits and glands. The factors controlling this delayed development have not yet been elucidated.

Experiments have been carried out to determine whether the size of a single infesting dose will influence the percentage of larvæ remaining in a partially developed state. Young sheep that had been raised 'worm-free' (excepting for *Strongyloides* species) were used. They received by a flank injection into the rumen either 1,000 or 100,000 infective larvæ. Autopsy was carried out 14 days later and a peptic digestion technique was used to ensure complete recovery of larvæ within the abomasal mucosa. The length was measured of at least 200 or 400 developing worms at the low and high dose-level respectively.

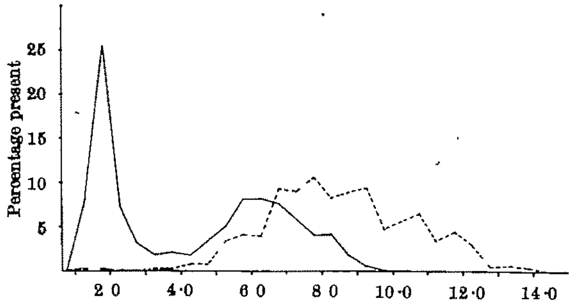


Fig. 1. Composite frequency polygon of size-distributions within the two groups of sheep. All sheep killed at 14 days. ----, larval dose 1,000; ——, larval dose, 100,000

At the higher dose-level a clearly bimodal size distribution appeared in each of the three lambs in this group. Of the developing larval worms 35–75 per cent were only 1–2 mm. in length; relatively few were 3–5 mm. and the remainder were grouped within and around the 5–8 mm. range, as seen in the accompanying composite frequency polygon prepared by combining the data from within each group of sheep (Fig. 1). Accurate mean, modal or median points cannot be obtained from these measurements because data from male and female worms were combined and the modal point for each sex is different.

At the lower dosage-level less than 2 per cent of developing worms were retarded in their growth, the great majority giving a more or less normal distribution around the 6–11 mm. size range.

Two features became apparent from these results, as shown in Table 1 and Fig. 1. At the higher dose-level a significantly greater ($P < 0 01$) percentage of larvæ had not attained 4 mm. in length in 14 days than at the low dosage-level. It appeared that the 'retarded' larvæ had failed to recommence growth following the third moult within the abomasal mucosa. This group consisted entirely of very small fourth-stage larvæ. Secondly, those larvæ at the higher dose-level that had developed beyond the 1–2 mm. size had still failed to attain the length achieved by the worms resulting from the low-level dose.

In the same experiment two additional sheep were given 100,000 larvæ and similarly autopsied at 56 days. It can be seen from Table 1 that although the total number of worms recovered at 56 days was similar to that recovered at 14 days, there was a great reduction in the proportion less than 4 mm. in length. It appears that retardation is not necessarily permanent and that growth and development may commence after a variable period of time. The limited data available also appear to support the suggestion that once growth has recommenced in the

Table 1

Sheep No.	Dose of larvæ	Days to autopsy	Dose recovered at autopsy (per cent)	Recovered larvæ less than 4 mm. (per cent)
C921	1,000	14	94·6	1·9
C939	1,000	14	92·6	1 1
C926	1,000	14	100 0	1 6
C930	100,000	14	56·7	35 9
C949	100,000	14	27·1	75·8
C944	100,000	14	32 4	59·1
C928	100,000	56	29·9	21·5
C927	100,000	56	27 2	19 6

retarded larvæ they develop rapidly to reach the same length as the others which showed a 'normal' development. It is noteworthy, however, that even at 56 days members of the high-dose populations had not reached the size of the worms in the low-dose populations, and had not, in fact, achieved the normal size quoted for *Ostertagia circumcincta*, the predominant member of the genus in the population. Despite their small size these worms appeared morphologically to be sexually mature and eggs were visible within the uteri of the females. Only relatively low and erratic egg counts (rarely more than 1,000 eggs per gram) were observed in these sheep, despite their heavy worm burden.

This work was carried out while I was the holder of the George Aitken Pastoral Research Scholarship.

J. D. Dunsmore

Department of Veterinary Pathology,
University of Sydney.

[1] Sommerville, R. I., *Nature*, 171, 482 (1953).

[2] Sommerville, R. I., *Aust. J. Agric. Res.*, 5, 130 (1954).

Boron Deficiency in *Grevillea robusta*

Grevillea robusta A. Cunn. is used as a shade tree in many tea plantations in Kenya. It is easily established, and is little subject to pests or diseases. In December 1959 it was reported that *Grevillea* were dying on the whole of one field in a tea plantation in the Nandi Hills district of Kenya. The trees were 2–3 years of age and were dying back from the tip. Of many, only the main branches near the apex of the tree were affected, while one or two lateral branches lower down the tree carried healthy leaves. The more seriously affected trees were almost completely defoliated; but leaves could in many cases be seen sprouting from the main trunk at heights of 4 ft. down to ground-level. In almost all trees showing advanced symptoms there was cracking of the bark and exudation of gum. The symptoms are similar to those described by Vail *et al.*[1] for boron deficiency in wattle. The fact that, prior to the planting of tea and trees of *Grevillea* in the area in question, an attempt to establish wattle had failed, led to an investigation into the boron status of the soil and of the *Grevillea* trees.

Leaf samples were taken from two dead trees, some apparently healthy trees in the same field, and some healthy trees about two miles away from the affected field. Boron analyses on these samples showed one healthy leaf to have the highest boron content (17 p.p.m.) and one from a diseased tree to have the least (13 p.p.m.); the results of further leaf analyses were somewhat inconsistent. The figures for water-soluble boron in the soil, however, supported the idea that boron deficiency was in fact responsible for the effects. Table 1 summarizes the relevant results.

Soil samples taken at a depth of 18–24 in. from a healthy area in the Kericho district some sixty miles to the south of Nandi Hills had a water-soluble boron content of 0·13 p.p.m.

Table 1. WATER-SOLUBLE BORON (P.P.M. OF DRY SOIL)

	0–9 in.	9–18 in.	18–27 in.	27–36 in.
Soil from affected area	0·13	0·07	0·03	0·03
Soil from healthy area	0·20	0·17	0·14	0·06

Treatment by applications of borax to the affected area is being tried and an investigation into the boron contents of soil in other parts of East Africa is proceeding. A fuller report will be published elsewhere.

It may be noted that tea bushes showed no symptoms, which may be due to their lower boron requirement[2], or more probably to the effectual 'scavenging' operations of the extensive tea root system.

My thanks are due to the Board of Management and the Director of the Tea Research Institute of East Africa for permission to publish this communication.

A. N. Smith

Tea Research Institute of East Africa,
P.O. Box 91,
Kericho, Kenya.

[1] Vail, J. W., Calton, W. E., and Strang, R. M., *East Afr. Agric. J.*, 23, 100 (1957).

[2] Chenery, E. M., *Nature*, 181, 426 (1958).

Effects of *Gibberella fujikuroi* on Fungal Root-infections of *Pinus*

In connexion with several communications in *Nature*[1–4] concerned with the effects of gibberellins on the nodulation of legumes, it would seem opportune to put on record the following experimental observations relating to the influence of *Gibberella fujikuroi* on certain other root associations.

The test plants were seedlings of *Pinus sylvestris* growing in pot-cultures with three different soils, namely, two podsols (pH 5) contrasting as regards their mycological contents, and a soil of the agricultural type (pH 6·8). *Gibberella* was inoculated into the soils at sowing, and re-inoculated twice at monthly intervals. Three months from sowing, the inoculated cultures started to exhibit a slight depression in development. The figures in Table 1 give the average heights of seedlings five months old.

Table 1

	Podsol *A* (cm.)	Podsol *B* (cm.)	Agricultural soil (cm.)
Plants from control cultures	6·0	5·2	4·9
Plants from inoculated cultures	5·7	4·4	4·4

The decrease in vigour and height of the treated seedlings was accompanied by a noticeable shift in the proportion of the various root-associations affecting the plants. In podsol *A* which, in the control cultures, showed about an equal amount of normal and subnormal mycorrhizas, the presence of *Gibberella* stimulated the formation of the subnormal type of association at the cost of normal mycorrhizas. Decrease in the incidence of true mycorrhizal infection and simultaneous spread of a parasitic association (formed by *Rhizoctonia sylvestris*) was observed for the seedlings in podsol *B* inoculated with *Gibberella*. The 'treated' cultures in the agricultural soil exhibited a marked increase in numbers of a harmful (haustorial) infection and considerable suppression of mycorrhizas.

In older seedlings, about 8 months old, the slight growth differences between controls and inoculated cultures had disappeared, and examination of the root systems revealed a less pronounced contrast in incidence of mycorrhizal and non-mycorrhizal associations. These findings agree, at least in some respects, with observations by Mes[4] on the effect of gibberellic acid which, when applied to *Vicia villosa* in the very early stages of growth, was recorded to decrease nodulation, but had little or no influence on nodule formation in older plants.

Mixed cultures on a nutrient agar medium (for composition of this medium cf. Levisohn[5]), showed antagonistic effects of *Gibberella* on several mycorrhiza-formers tested, for example, the basidiomycetes *Boletus granulatus*, *B. scaber*, and *Rhizopogon luteolus*, and also on the parasitic mycelium *Rhizoctonia sylvestris*. In this connexion it should be mentioned that gibberellic acid incorporated in the above medium (before sterilization) at a concentration of 100 p.p.m. affected the growth-rate of the mycorrhizal fungi adversely. Colony diameters after 4 weeks growth are given in Table 2. *Rhizoctonia sylvestris* showed a profuse development of sclerotia in the presence of gibberellic acid.

Table 2

	Control medium (cm.)	+ 100 p.p.m. gibberellic acid (cm.)
Boletus granulatus	4	2
B. scaber	15	10
Rhizopogon luteolus	11	6

Detailed observations relating to the effects in soil cultures and nutrient media of *Gibberella* and gibberellic acid will be published elsewhere.

IDA LEVISOHN

Department of Botany,
Bedford College,
University of London,
London, N.W.1.
January 21.

---

[1] Thurber, G. A., Douglas, J. R., and Galston, A. W., *Nature*, 181, 1082 (1958).

[2] Fletcher, W. W., Alcorn, J. W. S., and Raymond, J. C., *Nature*, 182, 1319 (1958).

[3] Galston, A. W., *Nature*, 183, 545 (1959).

[4] Mes, M. G., *Nature*, 184, 2035 (1959).

[5] Levisohn, I., *Nature*, 179, 1143 (1957).

Sex Ratio of Ammocœtes

IN a previous communication[1], it was suggested that variations in the sex ratio of adult brook lampreys (*L. planeri*) might be due to the effect of environmental factors on the course of differentiation in the so-called hermaphrodite gonad of the ammocœte larva. As a result of the examination of a very large number of ammocœte gonads (Table 1), this view is now considered to be untenable.

The material used for this work consisted of ammocœtes of *L. planeri* from the River Yeo (north Somerset); mixed collections of *L. planeri* and *L. fluviatilis* from the middle reaches of the River Usk and from the River Teifi a few miles above the estuary; and specimens of *P. marinus*, the land-locked sea lamprey of the Great Lakes from the Oqueoc River, Michigan.

In *L. planeri*, and probably also in *L. fluviatilis*, differentiation of the gonads is, in a majority of ammocœtes, completed towards the end of the second summer of larval life at lengths of 50–60 mm. In *P. marinus*, on the other hand, recognition of the definitive ovary or testis is not possible in all cases at lengths less than 90 mm. The figures in Table 1 refer, therefore, in the case of *L. planeri* and *L. fluviatilis*, to animals more than 60 mm. in length and for *P. marinus* to those more than 90 mm. Even so there remains a number of animals in which differentiation of the gonad is not complete. In some cases, these transitional gonads are smaller than the definitive ovary and contain both auxocytes and follicles of undifferentiated germ cells; the remainder consists of apparent ovaries in which degenerative changes are occurring involving the disintegration of oocytes and the development of a pronounced connective tissue stroma in the medullary part of the gonad. A close study of sex differentiation in the ammocœte has convinced me that both these transitional gonad types are to be regarded as eventual testes.

Table 1

	Total	♀	♂	Transitional gonads	Ovaries per cent all gonads
L. planeri (River Yeo)	281	162	94	25	57·7
L. fluviatilis and *L. planeri*					
(River Teifi)	49	25	24	—	51·0
(River Usk)	61	34	18	14	55·7
P. marinus	72	37	30	5	51·4

In none of the groups of animals examined is the number of males greater than the females, even when all those with indeterminate gonads are counted as males. In the large group of brook lamprey ammocœtes there is a small but significant excess of females (57·7 per cent) and this is also true of the material from the River Usk. In *P. marinus* ammocœtes, and in those from the River Teifi, the sex ratio does not differ significantly from equality.

Reports on the sex ratio of adult brook lampreys have almost invariably indicated some excess of males over females, although individual estimates[2-7] have varied widely from near equality to as much as 5 : 1. In a survey of the spawning population of the River Yeo, carried out during 1947–60, I have found an overall sex ratio of 2·05 ♀ : 1 ♂ for a total of 1,492 animals, with annual variations from 1·2 to 3·4. Observations by Applegate[8] on spawning runs of the sea-lamprey in the Oqueoc River have also shown an excess of males, and of the 24,643 animals examined in 1949 only 31·8 per cent were females. Thus the available evidence, both for *L. planeri* and *P. marinus*, points to an approximately equal sex ratio in the larval stage and a definite but variable excess of males in the adult spawning population. It must therefore be concluded that the female suffers a much higher mortality than the male at some stage in the life-cycle between metamorphosis and spawning, while the variations which have been observed within the same population indicate that the factors which are responsible for this increased female mortality must operate with varying intensity at different times and in different localities. Since a similar situation obtains in both parasitic and non-parasitic lampreys it is possible that this increased female mortality may operate during, or shortly after, the critical period when metamorphosis is taking place.

I wish to thank Dr. V. C. Applegate of the U.S. Department of the Interior, Fish and Wildlife

Service for his co-operation in supplying ammocœtes of *P. marinus*.

M. W. Hardisty

Department of Chemistry and Biology,
College of Technology, Bristol.

---

[1] Hardisty, M. W., *Nature*, 173, 874 (1954).
[2] Young, R. T., and Cole, L. J., *Amer. Nat.*, 34, 617 (1900).
[3] Reighard, J., *Science*, 17, 529 (1908).
[4] Okkelberg, P., *J. Morph.*, 35 (1926).
[5] Schultze, L. P., Occ. Pap. Mus. Zool. Univ. Mich., 221, 1 (1930).
[6] Ivanova-Berg, M. M., *Zool. Anz.*, 96, 330 (1931).
[7] Zanandrea, G., *Boll. Pesc. Pisc. e Idrobiol.*, 6, 1 (1951).
[8] Applegate, V. C., U.S. Fish and Wildl. Serv. Spec. Rep., 55, 1 (1950).

Caretta kempi Garman on Welsh Coast

On January 3, a Mexican or Kemp's loggerhead turtle, *Caretta kempi* Garman, was found at high-water mark on Kenfig Dunes in Glamorgan. It was dead, but the body was in a good state of preservation, though the shields of the carapace were mostly missing. The weight was 2,420 gm., the carapace being 244 mm. long and 224 mm. at its maximum width; the length of the plastron was 199 mm. Two other specimens of this species, one slightly larger and one slightly smaller, are in the collection of this Department, both taken alive; one near Freshwater West on the Pembrokeshire coast, in December 1930, the other at Mochras Island at the north end of Cardigan Bay, in November of the same year.

In December 1938, an example of the other species of loggerhead recorded from Britain, *Caretta caretta* (Linn.), was stranded near Tenby; while in February 1946 one weighing 8,180 gm. was found alive on the beach at Oxwich, Glamorgan, and is now in our collections.

Whereas *Caretta caretta* appears to have a fairly wide distribution in tropical and sub-tropical waters on both sides of the Atlantic (though the breeding grounds are on the American side), the natural habitat of the smaller *Caretta kempi* is stated to be restricted to the Gulf of Mexico and adjacent waters, and it is less likely to be carried to the British coasts. About twenty British occurrences of the former, as compared with ten of the latter species, have been recorded[1].

Deraniyagala[2] suggested that the presence of loggerheads in European waters was probably due mainly or entirely to currents, and that they might be of importance as current-indicators; and Parker[3], discussing turtle strandings in 1938 on British coasts, considered it "difficult not to associate their coming with the remarkably warm weather and almost uninterrupted series of south-westerly gales which characterized late November and early December. It seems probable that there has been a strong indrift of warm surface water into the English Channel from the south-west". Russell[4] suggested another possible explanation—the general extension in recent times of warm water farther towards the Arctic, with a resultant northward extension of the boundaries of certain animals. He instanced the capture of a flying fish, *Cypsilurus heterurus*, in Oslo harbour in 1937; and it may be noted also that a *Caretta caretta* was found stranded on the Norwegian coast in December 1951[5]. No loggerhead had ever before been recorded from Scandinavian waters nor from the area east and north of Shetland.

From information supplied by Mr. H. H. Lamb of the Meteorological Office, it would not appear that the warm summer of 1959 over Britain and Europe had any connexion with the present occurrence of *C. kempi* on the Welsh coast. In fact the western two-thirds of the North Atlantic were colder in 1959 than for many years past, only the Bay of Biscay, the North Sea and waters east of about 20° W. being slightly warmer than average. It seems much more likely to be associated with some anomaly of the prevailing water currents. Over the north-eastern Atlantic, especially the waters around the British Isles and farther north, there was a remarkable prevalence of southerly winds in the autumn of 1959. The autumn and early winter, including December, were also notable for the repeated occurrence of a great sweep of west to north-west winds across the whole width of the Atlantic fanning cold water eastwards towards the Bay of Biscay; and this might possibly have produced a flow of water from the Bay of Biscay northwards to the shores of Britain.

Note added in proof. Since the above was written, I have been informed that the British Museum (Natural History) received a specimen of *Caretta caretta* found alive at South Uist on January 8 this year.

Colin Matheson

Department of Zoology,
National Museum of Wales, Cardiff.

---

[1] Smith, M., "The British Amphibians and Reptiles", 264 (1954).
[2] Deraniyagala, P. E. P., *Nature*, 142, 540 (1938).
[3] Parker, H. W., *Nature*, 143, 121 (1939).
[4] Russell, F. S., *Nature*, 143, 206 (1939).
[5] Willgohs, J. F., Universitetet i Bergen Årbok 1952, Naturvitenskapelig rekke, No. 17, 8 (1953).

Elminius modestus Darwin in South-West Scotland

The present status of *Elminius modestus* Darwin in the British Isles has recently been summarized by Crisp and Southward[1]. They state that in 1958–59 "it is still relatively rare in Luce Bay and has not yet passed the Mull of Galloway. Similarly, there has been little change in the isolated and sparse colony in Lough [Loch] Ryan at the entrance to the Clyde Sea". In an earlier publication, Crisp[2] states that this Stranraer population, although dwindling in numbers, has persisted since 1950 and consists largely of old animals with corroded shells. According to his classification of abundance, rare is taken as "less than 1/m.^{2}; only a few isolated specimens in 1 hour's search" and occasional as "1–100/m.^{2}; often local and needing to be searched for; rarely close enough to breed".

Over a number of years we have been making an annual survey of the density of settlement of barnacles in the Clyde sea area and our observations on the present status of *Elminius modestus* in south-west Scotland are not entirely in agreement with those quoted above. The following results refer to early August 1959.

Elminius modestus is unevenly distributed in Luce Bay, possibly because of variations in local hydrographical conditions caused by a curious development of shingle spits. Nevertheless, it is readily found in many places, being most common on the western shore; for example, on an artificial structure running across the beach near Sandhead adults at a density of 1/cm.^{2}, young at 8–10/cm.^{2} and spat at 5–10/cm.^{2} were recorded. On parts of the shore at Drummore the species is common with individuals up to 2/cm.^{2}. Furthermore, the species has passed the Mull of Galloway since it was found at Port Logan on the open coast; although not common here, small groups were near enough for breeding if they reached maturity; large adults were not found.

There are at least two well-developed populations in Loch Ryan, with scattered individuals elsewhere on the shores. On the western side near Kirkcolm, *Elminius modestus* is abundant on artificial structures where weeds are infrequent. All size groups from fully grown adults to spat were recorded and in some 'cleared' areas cover is complete. On the town pier at Stranraer, although much less common than at Kirkcolm, all size groups are present and spat was settling in the late autumn. Scattered individuals are present on the railway pier. Larvæ were common in the summer plankton.

A full account of this work will be published elsewhere.

H. BARNES
MARGARET BARNES

The Marine Station,
Millport.

---

[1] Crisp, D. J., and Southward, A. J., *J. Mar. Biol. Assoc. U.K.*, **38**, 429 (1959).

[2] Crisp, D. J., *J. Mar. Biol. Assoc. U.K.*, **37**, 483 (1958).

Multiple Infections of Trematodes in a Snail

IN an investigation of the incidence of various larval trematodes in the estuarine snail *Valacumantus* (*Pyrazus*) *australis*, results have been obtained showing that two species of trematodes tend to occur together in individual snails surprisingly often. To my knowledge an observation of this kind has not been recorded before. Cort *et al.*[1] studied the incidence of various larval trematodes in the snail *Stagnicola emarginata angulata*, and from an analysis of more than 7,000 dissections concluded that, in certain instances, there must be an immunity produced by the penetration of one species of trematode which prevents penetration of the same snail by a second species; or that there is an antagonism present which prevents the development of one when the other is present. In other instances of multiple infection they concluded that there was no evidence of any immunity or antagonism. In view of their findings the present results are noteworthy.

Results from an examination of 1,146 snails from Narrabeen Lake, near Sydney, is tabulated below:

	No.	Per cent
Stictodora spp. (Heterophyidae)	269	23 5
Austrobilharzia terrigalensis (Schistosomatidae)	52	4·5
Stictodora/*Austrobilharzia* (multiple infections)	39	3·4
Immature and unidentified infections	16	1·4
Other infections (Echinostomatidae and Philopthalmidae)	169	14·8
Total infected	545	47·6

Several postulates are possible to explain the unexpectedly high incidence of multiple infections of heteropyids and schistosomes. They need not be mutually exclusive: (1) a snail infected with the schistosome is predisposed to infection with the heterophyid; (2) a snail infected with the heterophyid is predisposed to infection with the schistosome; and (3) when the two kinds of eggs occur in the same bird evacuation, which happens to be in close proximity to a suitable snail, infection with the heterophyid and the schistosome occurs simultaneously.

WM. H. EWERS

School of Biological Sciences,
University of New South Wales,
Sydney.

---

[1] Cort, W. W., McMullen, D. B., and Sterling Brackett, *J. Parasit.*, **23**, 504 (1937).

GENETICS

Apparent Double Crossing-Over in a Short Genetic Interval in *Drosophila melanogaster*

IN view of the reported occurrence of double crossing-over within a short genetic interval in *Aspergillus*[1] and of the purported existence of negative interference in bacteriophage[2], it is worth while to record the recovery in *Drosophila melanogaster* of apparent double cross-over types within a short genetic interval where interference is nominally expected to be complete. These double cross-overs were found incidentally to a study of pseudo-allelism at the white (*w*) loci[3]. The relevant genetic interval extends from the *X*-chromosome loci of yellow body colour (*y*) to split bristles (*spl*), mutants of which served as markers for the study of crossing-over between *w* pseudoalleles. The standard map distance for this interval is commonly given as three units, a value at least twice as great as more recent measurements indicate[4]. Throughout this study, parental females were always made heterozygous for the autosomal inversions *Cy* and Ubx^{130}. These inversions serve to increase crossing-over strikingly in the *y*-*spl* interval to values varying from 5 to 11 units[5].

In Table 1 the variety of crosses and detected double cross-overs are listed. Most exceptional individuals were found among the progeny of females heterozygous either for y^2 *su*-w^a w^a *spl* (*su*-w^a= suppressor of w^a; w^a=whiteapricot eye colour) or *y ac* w^{ch} *spl* (*ac*=acheate bristles; w^{ch}=white-cherry eye colour) since these *w* mutants were used as testers in studying pseudoallelism. No concerted effort was made to recover double cross-overs; rather those tabulated here represent individuals, mostly males, which were easily and effortlessly identified through their distinctive phenotype. At best, therefore, the frequencies noted in Table 1 are minimal. The exceptions are deemed to be double cross-overs because genotypically they represent the expected contrary double cross-over classes: w^a or w^{ch} with none of the marker genes, and the allelic or pseudoallelic mutant with all the markers. Where the former were recovered their genotype was confirmed as follows. The w^a exceptions were tested for suppression by *su*-w^a. This is a critical test since this suppressor's action is delimited to the w^a mutant[3]. Since w^{ch} does not show dosage compensation, this property was employed for its identification. Where the latter class of exceptions was detected, the distinguishing phenotypic effects characterizing the

Table 1. RECOVERED APPARENT DOUBLE CROSS-OVER WITHIN THE *y*-*spl* INTERVAL AMONG THE PROGENY OF ♀♀ HETEROZYGOUS FOR INDEPENDENT *w* MUTANTS.

All parental ♀♀ were heterozygous for the autosomal inversions *Cy* and Ubx^{130} and were crossed to *y w spl* sn^3 ♂♂

	Genotype parental ♀♀	Genotype double cross-over	Total progeny
(1)	y^2 *su*-w^a w^a *spl*/w^h	♂ y^2 *su*-w^a w^h *spl*	28,896
(2)	*y ac* w^{ch} *spl*/w^{col}	♂ *y ac* w^{col} *spl*	33,684
(3)	y^2 *su*-w^a w^a *spl*/w^{a4}	2 ♂♂ y^2 *su*-w^a w^{a4} *spl*	90,827
(4)	y^2 *su*-w^a w^a *spl*/w^{a2}	♂ y^2 *su*-w^a w^{a2} *spl*	68,940
(5)	y^2 *su*-w^a w^a *spl*/w^{sat}	♀ y^2 *su*-w^a w^{sat} *spl*/*y w spl* sn^3 ♂ w^a	74,840
(6)	y^2 *su*-w^a w^a *spl*/w^{col}	♂ w^a	102,145
(7)	y^2 *su*-w^a w^{a4} *spl*/w^a	♂ y^2 *su*-w^a w^a *spl*	27,705
(8)	y^2 *su*-w^a w^{a4} *spl*/w^{a3}	♂ y^2 *su*-w^a w^{a3} *spl*	50,210
(9)	*y ac* w^{ch} *spl*/w^{Bf}	♂ w^{ch}	20,065
(10)	*y ac* w^{ch} *spl*/w^{a61}	♂ w^{ch}	54,975
(11)	y^2 *su*-w^a w^a *spl*/w^{a61}	♂ w^a	47,110
(12)	*y ac* w^{ch} *spl*/w^{sp2}	♀ *y ac* w^{sp2} *spl*/*y w spl* sn^3	49,670
(13)	y^2 *su*-w^a w^a *spl*/w^{a71}	2 ♂♂ y^2 *su*-w^a w^{a71} *spl*	93,744
(14)	*y ac* w^{col} *spl*/w^{a2}	♀ w^{col}/*y w spl* sn^3	195,870
(15)	*y ac* w^{ch} *spl*/sp^2-*w*	♀ *y ac* sp^2-*w spl*/*y w spl* sn^3	92,400
(16)	*y* $w^{a4}B$ *spl*/w^a	♂ $w^{a4}B$	79,430
(17)	y^2 *su*-w^a w^a *spl*/w^{aM}	♂ w^a	93,670

w mutant served, in most instances, to verify its genotype. For example, the mutants w^{col}, w^{sat} and sp^{1}-w have such distinctive phenotypes and are mutationally so rare in occurrence that their recovery in association with all marker genes is best accounted for in terms of a double cross-over occurring on each side of the w loci.

Since the results do not represent a quantitative recovery of double cross-overs, there is little point in indulging in computations of the degree of interference. What these results do demonstrate is that, for a comparative short genetic distance, interference is not necessarily complete and double cross-overs do infrequently occur.

M. M. GREEN

Department of Genetics,
University of California,
Davis, California.
Jan. 14.

[1] Pritchard, R. H., *Heredity*, 9, 343 (1955).
[2] Chase, M., and Doermann, A. H., *Genetics*, 43, 332 (1958).
[3] Green, M. M., *Heredity*, 13, 302 (1959).
[4] Redfield, H., *Proc. U.S. Nat. Acad. Sci.*, 41, 1084 (1955). Green, M. M. (unpublished work).
[5] Green, M. M., *Nature*, 184, 294 (1959) (and unpublished work).

Thread Protein and β-Globulin Polymorphism in the Serum Proteins of Pigs

THREAD proteins, reported to be polymorphic in the sera of cattle[1], have now been demonstrated in serum samples from pigs, dogs, and horses. Thread protein polymorphism has been found in the pig also, but not in the relatively few samples from dogs and horses examined up to the present.

Pig thread proteins are readily seen in one-dimensional starch-gel electropherograms using the same pH 7·6 phosphate buffer and procedure described for cattle sera[2]. The zones are very narrow, indeed thread-like, in suitable gels. However, the zones may be faint, or not appear at all if the nature of the gel deviates only a little from the optimum. No difficulty has been experienced in detecting thread proteins in gels prepared from several batches of Hopkin and Williams potato starch after suitable acid hydrolysis[2]; but it has not been possible to detect thread proteins, particularly in cattle sera, using a commercially available starch hydrolysed ready for starch-gel electrophoresis.

Three thread-protein phenotypes have been found in sera from Large White and Essex Saddleback pigs, depending on the presence of one or both of a pair of thread proteins. The three phenotypes are shown in Fig. 1, after two-dimensional electrophoresis, first in agar then in starch gel. Sera of the three phenotypes were resolved initially in 1 per cent agar using pH 8·4 borate buffer (4·65 gm. boric acid in water adjusted with sodium hydroxide and diluted to 1 l.). Afterwards 0·5 cm. wide length-wise strips of agar containing the resolved albumin zone were cut from each of the three agar gels and inserted side-by-side across a previously prepared starch gel of suitable width. After electrophoresis the starch gel was sliced with fine wire and stained in nigrosine[2]. Fig. 1 shows that the agar albumin zones also contained some α-globulins, the thread proteins and a pre-albumin zone.

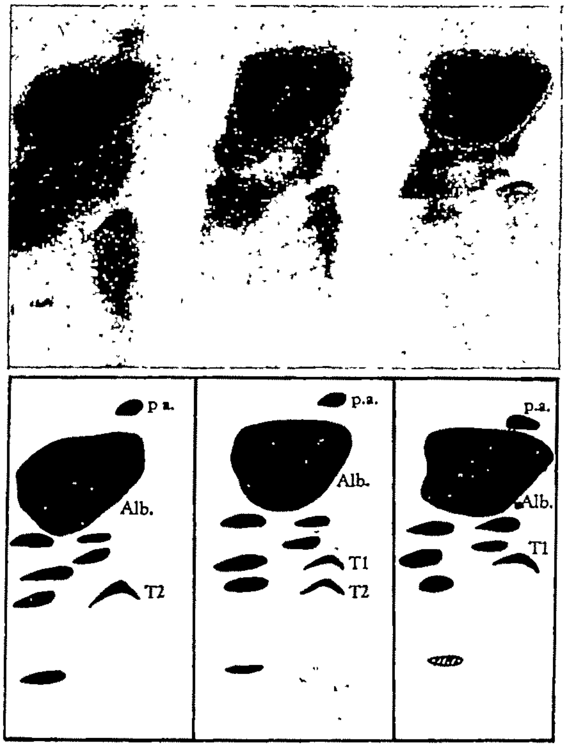


Fig. 1. The three thread-protein phenotypes in pig sera. The illustration shows the agar electrophoresis resolved albumin zones after further resolution in starch gel. The thread-protein phenotypes of the three serum samples are, from left to right, $T2$, $T1/T2$ and $T1$. In order to emphasize the thread proteins the starch gel was somewhat overloaded, resulting in poor resolution of the α-globulin zones. *p.a.*, Pre-albumin; *Alb.*, albumin; $T1$ and $T2$, thread proteins. Remaining zones are α-globulins. The β- and γ-globulins were not presented to the starch gel

The nature of the thread proteins is not clear. In all animals in which they have been found they occupy the same relative position after two-dimensional electrophoresis, that is, at the leading edge of the albumin zone in agar electrophoresis, and well separated from the α-globulins in the second starch-gel electrophoresis. In two-dimensional electrophoresis the thread protein zones usually appear crescent-shaped, a phenomenon not shown by the remaining zones.

Preliminary mating data suggest that the three pig thread-protein phenotypes comprise the two homozygotes and heterozygote of a two-allele system. By analogy with the thread-protein system in cattle it is suggested that the two alleles be named pig T^A and T^B, so that the faster migrating zone $T1$ is seen in the presence of T^A and the slower zone $T2$ is seen in the presence of T^B. The three genotypes T^A/T^A, T^A/T^B and T^B/T^B would then be represented by phenotypes $T1$, $T1/T2$ and $T2$ respectively.

In common with all other mammals so far examined pigs also exhibit β-globulin polymorphism. Three β-globulin phenotypes have been seen in the samples examined, comprising the two homozygotes and heterozygote of a pair of β-globulin alleles, pig β^A and β^B. Each allele gives rise to three zones in starch gel in phosphate buffer, a rather faintly staining zone followed by a moderately staining zone and then by a more intensely staining zone. This is very similar to the situation found in sheep[3], goats[4] and mice (Ashton and Braden, unpublished work). In view of the increasing numbers of β-globulin alleles being found in other mammals, to date five in humans[5], ten in sheep (Ashton and Ferguson, unpublished work) and five in cattle[6], it is very likely that further examples will be found in pigs.

I wish to acknowledge the assistance of Dr. K. C. Sellars in procuring samples of pig sera.

G. C. Ashton*

Animal Health Trust,
Farm Livestock Research Centre,
Stock, Essex.

* Present address: National Cattle Breeding Station, Commonwealth Scientific and Industrial Research Organization, Rockhampton, Queensland.

[1] Ashton, G. C., *Nature*, 182, 65 (1958).

[2] Ashton, G. C., *J. Agric. Sci.* (in the press).

[3] Ashton, G. C., *Nature*, 182, 1101 (1958).

[4] Ashton, G. C., and McDougall, E. I., *Nature*, 182, 945 (1958).

[5] Giblett, E. R., Hickman, C. G., and Smithies, O., *Nature*, 183, 1589 (1959).

[6] Ashton, G. C., *Nature*, 184, 1185 (1959).

MICROBIOLOGY

L Forms of Bacteria as Contaminants in Tissue Culture

The occurrence of pleuropneumonia-like organism as contaminants in tissue culture is a common experience in many laboratories[1-5]. Such infections may be inapparent or may cause progressive degeneration of the cells. The origin of this type of contamination has never been satisfactorily explained, and although the serum used in tissue culture media is often suspected we have never succeeded in isolating pleuropneumonia-like organisms from many samples of fresh human, bovine, horse and rabbit sera. Our results suggest that at least some of the pleuropneumonia-like organisms found in tissue culture are *L* forms of contaminating bacteria. This belief is based on the following observations.

Twenty cell lines carried in our laboratory yielded minute colonies when the medium in which they had grown was plated on soft meat digest agar containing 20 per cent heated horse serum. A complete minute colony derived from a HeLa culture was inoculated into 5 ml. of meat digest broth containing 20 per cent horse serum, 10 per cent yeast extract, and 100 units of penicillin per ml. This was sub-cultured and when slightly turbid a loopful was stroked out on the solid medium used for the initial isolations. Tiny colonies appeared following incubation for 2 days at 37° C. On the third day most of the small translucent colonies had produced further dense opaque outgrowths. These were found to be composed of a penicillin-sensitive *Corynebacterium*. It was clear that these *Corynebacteria* were derived from the small colonies. Pure cultures of the *Corynebacterium* and its *L* form were maintained in 20 per cent horse serum broth. Penicillin was always added to the *L* form cultures to prevent reversion to the bacterial form.

In order to test the hypothesis that the *Corynebacterium* gave rise to its *L* form in tissue culture, HeLa cultures were cured of *L* form infection by growing them for several sub-cultures in medium containing 200 units of neomycin ('Mycifradin sulphate', Upjohn Co.) per ml. Preliminary experiments had shown that the *L* forms from several cell lines were very sensitive to the tetracycline group of antibiotics and neomycin.

Terramycin, chloramphenicol and aureomycin were found to be toxic for the cells at effective concentrations. However, Hearn *et al.*[4] have used aureomycin at toxic levels to free tissue cultures from pleuropneumonia-like organism contaminants. This hazardous procedure was avoidable since neomycin was effective and had no observable toxic effect on HeLa cells at a concentration of 200 units/ml. At each sub-culture during neomycin treatment some cultures were grown without antibiotics for several sub-cultures with frequent changes of medium. When repeated tests for *L* forms in the medium were negative, the cells were deemed to have been cured. Up to 14 days treatment was necessary in some cases. It is of interest that the cells had to be maintained in medium containing 200 units of neomycin per ml. for several sub-cultures before *L* forms became undetectable, even although the organisms were susceptible to <10 units per ml. of the antibiotic in agar medium. The necessity for this high concentration in tissue culture may be due to poor penetration of the antibiotic into the cell or to some other factor related to the intracellular situation of the *L* form.

Cultures freed from *L* forms were then returned to the original medium with 100 units of penicillin and streptomycin per ml. Some cultures were infected with *Corynebacteria* and others with its *L* form. Although the cells infected with the *L* forms did not appear to be different from the uninfected controls when viewed by low-power microscopy, they had apparently become chronically infected and *L* forms could be isolated regularly from them. In the cultures infected with the *Corynebacterium*, this agent was undetectable in the medium of the infected cultures within 2 days, but persisted intracellularly for 9 days. *L* forms were first detected in these cultures at 6 days and regularly thereafter.

These experiments indicate that contamination of tissue cultures containing penicillin with penicillin-susceptible bacteria may cause an inapparent intracellular infection with the *L* form of the bacterium. This could lead to confusion in antigenic analysis of cells, and in metabolic studies the contribution of the commensal *L* form to the host cells' biochemical activity may be significant and should be excluded.

I. A. Macpherson*
K. Allner

Microbiological Research Establishment,
Porton, Wiltshire.

* Present address: Medical Research Council Unit for Experimental Virus Research, The University, Glasgow.

[1] Robinson, L. R., Wichelhausen, R. H., and Roizman, B., *Science*, 124, 1147 (1956).

[2] Collier, L. H., *Nature*, 180, 757 (1957).

[3] Rothblat, G. O., and Morton, H. E., *Bact. Proc.*, 73 (1958).

[4] Hearn, H. J., Officer, J. E., Elsner, V., and Brown, A., *J. Bact.*, 78, 575 (1959).

[5] Doherty, R. L., *Virology*, 6, 575 (1958).

VIROLOGY

Reactivation of Poxviruses by a Non-Genetic Mechanism

It has recently been shown that poxviruses inactivated by heat are reactivated in cells in which another poxvirus multiplies[1]. The virus yield from cells infected with inactivated virus of one strain and active virus of another strain contains infectious particles of both strains, and also, if the viruses are sufficiently closely related, recombinants[2]. Inactivation by heat, therefore, does not inactivate the deoxyribonucleic acid of the virus particles, since all the known genetic markers are preserved. Since proteins are in general less stable to heat than deoxyribonucleic acid, the role of the reactivating virus may be to provide some essential native protein which has been destroyed by heating. On this hypothesis, it should be possible to use, as the reactivating agent, virus of which the deoxyribonucleic acid has been specifically inactivated. In this case the genotype of the heat-inactivated virus only should survive.

Such inactivation might be achieved by treatment with the nitrogen mustard, di(2-chloroethyl)methylamine, which, although capable of combining with protein, reacts preferentially with nucleic acid. Loveless and Stock[3] have shown that nitrogen mustard inactivates phage probably by combination with its deoxyribonucleic acid without affecting the protein structures responsible for adsorption to host cells and combination with specific antibody, and they particularly comment on the low efficiency of multiplicity and cross-reactivation shown by phage treated with mustard.

Preliminary experiments showed that rabbitpox virus (RPu^+), treated with nitrogen mustard, would reactivate heated RPu^+, and also heated vaccinia *7N*, and that the product had the pock character of the heated parent. In order to provide a sensitive test for partial survival of the genome of the mustard-treated parent, the mutants RP*u*1 and RP*u*8 were chosen as the heated parent. The *u* mutants of rabbitpox virus, which produce white non-ulcerated pocks on the chorioallantoic membrane, differ from the wild type (RPu^+), which produces hæmorrhagic ulcerated pocks, at single genetic sites[4,5]. In mixed infections of the chorioallantoic membrane with RP*u*1 or RP*u*8 and RPu^+, the wild type outgrows both mutants[5], so that if there is survival of that part of the genome which carries the wild locus it should be readily detected.

RPu^+ was inactivated by exposure to various concentrations of nitrogen mustard in 0·005 *M* phosphate buffer, *p*H 7·2, for 20 min. at 37°. The excess mustard was then destroyed by a tenfold dilution of the suspension into 5 per cent sodium thiosulphate and further incubation for 2 hr. Assay of particles capable of reactivating heated virus was carried out by inoculating suitable dilutions of the material on the chorioallantoic membrane of 11-day old chick embryos together with 5×10^8 particles of *RPu*1 or *RPu*8 heated at 60° for 12 min.: the heated virus was completely non-infectious[1]. Residual active particles of RPu^+ were also titrated in the absence of heated virus.

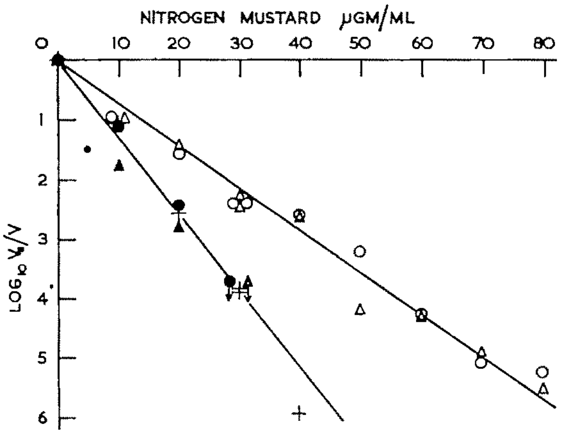


Fig. 1. Inactivation of RPu^+ by nitrogen mustard.
Assayed in the absence of heated virus: +, titre of U$^+$ pocks.
Assayed in the presence of heated RP*u*1: ●, titre of U$^+$ pocks; ○, titre of U pocks.
Assayed in the presence of heated RP*u*8: ▲, titre of U$^+$ pocks; △, titre of U pocks

The results are shown in Fig. 1. The infectivity of RPu^+ is seen to be destroyed by nitrogen mustard by a one-hit process, and the surviving particles can be assayed with equal efficiency in the presence or absence of heated virus. The ability of RPu^+ to reactivate heated RP*u*1 or RP*u*8 is destroyed less readily, though again this appears to be a one-hit process.

It seems, therefore, that in rabbitpox virus all the lethal damages caused by nitrogen mustard prevent expression of the genotype (as judged by one marker), but only about half of them fall in that part of the virus which is necessary for reactivation of heated virus. Thus the evidence is compatible with our hypothesis, namely, that reactivating virus provides some essential non-genetic material which is lacking in heated virus.

We are indebted to Prof. Frank Fenner for the *u* mutants.

W. K. JOKLIK
PAMELA ABEL
I. H. HOLMES

Department of Microbiology,
John Curtin School of Medical Research,
Australian National University,
Canberra, Australia.

[1] Fenner, F., Holmes, I. H., Joklik, W. K., and Woodroofe, G. M., *Nature*, 183, 1340 (1959). Hanafusa, H., Hanafusa, T., and Kamahora, J., *Biken's J.*, 2, 85 (1959). Joklik, W. K., Woodroofe, G. M., Holmes, I. H., and Fenner, F., *Virology* (May 1960).
[2] Fenner, F., and Woodroofe, G. M., *Virology* (May 1960).
[3] Loveless, A., and Stock, J. C., *Proc. Roy. Soc. B*, **150**, 486 (1959) **151**, 148 (1959).
[4] Gemmell, A., and Cairns, H. J. F., *Virology*, **8**, 381 (1959).
[5] Gemmell, A., and Fenner, F., *Virology* (May 1960).

Potato Virus *M* and Paracrinkle

Salaman and Le Pelley[1] found that scions of apparently healthy plants of the potato variety King Edward VII grafted on to supposedly virus-free Arran Victory resulted in the latter variety reacting with paracrinkle symptoms, that is, a pronounced deformity and rugosity of the leaves. Although both Kassanis[2] and Macarthur[3] suggest that King Edward contains only a single virus, Bagnall, Larson and Walker[4] found that a stock of King Edward, which they obtained from Canada and which had been supplied originally by Salaman, contained two viruses. One was a strain of virus *S* and the other resembled virus *M* which they had found in Irish Cobbler and several other American varieties. All normal stocks of Arran Victory were found by Macarthur[3] to contain virus *S*. Therefore, even if there are stocks of King Edward with only a single virus, the paracrinkle symptoms observed in Arran Victory after grafting with King Edward may be due either to the King Edward virus (presumably virus *M*) alone or to the combined action of viruses *S* and *M*, as is suggested by Bagnall, Wetter and Larson[5].

We have also found that King Edward apparently contains two viruses. Thus, for example, sap from King Edward inoculated into fathen (*Chenopodium album*) gave symptoms similar to those from virus *S*-infected Arran Victory, and inoculated on to *Datura metel* gave a systemic yellow spotting followed by an acropetal leaf-drop which resulted in the death of the plants. No such symptoms were shown by *Datura metel* inoculated with sap from virus *S*-infected Arran Victory.

By grafting King Edward on to the American variety Saco, which is immune to virus *S*, it was possible to obtain plants, the sap of which gave no symptoms when inoculated on to fathen but still produced virus *M* symptoms in *Datura metel*. Scions from these Saco plants produced paracrinkle symptoms in both virus *S*-infected Arran Victory and in plants of a virus *S*-free stock of Arran Victory produced by Kassanis[6] at Rothamsted by the apical meristem culture method. It would appear, therefore, that paracrinkle symptoms in Arran Victory are produced by the virus *M* component alone of the virus complex found in King Edward.

We are indebted to Mr. E. L. Calvert of The Queen's University, Belfast, for the supply of virus *S*-free tubers of Arran Victory.

H. W. HOWARD
J. WAINWRIGHT

Plant Breeding Institute,
Trumpington,
Cambridge.

---

[1] Salaman, R. N., and Le Pelley, R. H., *Proc. Roy. Soc.*, B, 106, 140 (1930).

[2] Kassanis, B., *J. Gen. Microbiol.*, 15, 620 (1956).

[3] Macarthur, A. W., Rep. Scot. Soc. Res. Plant Breed., 27 (1956).

[4] Bagnall, R. H., Larson, R. H., and Walker, J. O., *Res. Bull. Wis. Agric. Exp. Sta.*, 198 (1956).

[5] Bagnall, R. H., Wetter, C., and Larson, R. H., *Phytopath.*, 49, 435 (1959).

[6] Kassanis, B., Rep. Rothamsted Exp. Sta., 102 (1956).

AGRICULTURE

Determination of Dieldrin Deposits on Sprayed Mud Surfaces

CHEMICAL investigations into the behaviour of insecticides sprayed on to mud walls require a sampling technique which will remove the insecticide actually present on the surface, and available to the insects, but not that which is sorbed into the bulk of the mud. For laboratory work, Barlow[1] has used 'Sellotape' for this purpose, while Alessandrini[2] has used parchment paper coated with a film of silicone grease. Both these techniques suffer from the disadvantage that the sticky material which is used to pick up the insecticide particles is mounted on a comparatively rigid backing, which prevents its penetrating into the small depressions and irregularities which generally occur on mud surfaces, and which are accessible to insects. Unrealistically low figures are therefore obtained. It was thought that this difficulty might be overcome by the formation of an adhesive film *in situ* on the mud surface, and it has been found that in the laboratory satisfactory films for this purpose can be obtained using solutions containing 1–2·5 per cent w/v of high-viscosity grade (1,500–2,000 cp. for a 1 per cent solution at 25° C.) sodium carboxy-methyl cellulose. The addition of glycerol to the sodium carboxy-methyl cellulose solution is usually necessary; in most cases up to 5 per cent v/v suffices to give a pliable film, but on certain muds up to 25 per cent v/v of this has been necessary to prevent the formation of a hard, brittle film which removes an excessive amount of mud.

The sodium carboxy-methyl cellulose solution is applied to the mud surface mounted on a piece of cotton gauze and should be removed as soon as possible after drying is complete. The film is separated from the gauze by soaking in cold water, and, to ensure complete extraction of the insecticide, the resulting solution is treated with sodium hydroxide and potassium permanganate, and allowed to stand for 30 min. Excess permanganate is removed by careful acidification and treatment with sodium bisulphite. The insecticide is then extracted from the mixture with a suitable solvent, and determined by any convenient method. In the experiments described below, *n*-hexane was used as solvent, and a total chlorine determination using sodium diphenyl reagent was employed. Subsidiary experiments showed no significant loss of dieldrin occurred during the extraction and subsequent treatment.

A series of glass plates and blocks of Uganda mud were sprayed with an aqueous suspension of a dieldrin 50 per cent wettable powder; weighing of the plates before and after spraying showed an average deposit of 114 mgm. dieldrin/sq. ft. Using the above technique, recoveries of 86, 84, 92 and 82 mgm./sq. ft. were obtained from the surfaces of the mud blocks. A similar series of experiments using blocks of Babati (Tanganyika) mud gave recoveries of 74, 83 and 76 mgm. dieldrin/sq. ft., compared with an average deposit of 100 mgm./sq. ft. indicated by weighing of the glass plates. These figures indicate a recovery of between 70 and 80 per cent from both types of mud, and this is adequate to enable sorption to be demonstrated, as shown by the results in Table 1, which were obtained by spraying three series of mud blocks with a dieldrin 50 per cent wettable powder at 65 mgm./sq. ft. and determining the surface deposit at various times after spraying.

Table 1

Days after spraying	Dieldrin recovered (mgm./sq. ft.)		
	Babati	Uganda	Mexico, D.F.
0	54	49	50
1	—	7·0	39
2	—	5·5	—
7	9·7	3·7	24
14	4·0	2·5	15

Results are given for three muds, two of which (Uganda and Babati) have been shown from biological data to be highly active in sorbing dieldrin, and the third (Mexico D.F.) to be less active.

This technique has been tested satisfactorily in the laboratory on a number of different types of mud, although the concentrations of sodium carboxymethyl cellulose and glycerol required to give the most satisfactory film vary from one to another. Provided that care is taken in removing the film, the amount of mud removed is very small; it has been observed, however, that this is apt to vary with the type of mud used, and this factor should therefore be borne in mind when comparing results of experiments carried out on different muds. The applicability of this technique to muds which give a very loose and friable surface has not been examined.

Thanks are due to "Shell" Research Ltd. for permission to publish this work, and to various colleagues in this laboratory for helpful discussion and assistance with the analytical determinations.

R. E. FORD

Woodstock Agricultural Research Centre,
Sittingbourne, Kent.

---

[1] Barlow, F., *W.H.O. Bull.*, 12, 359 (1955).

[2] Alessandrini, R. C., *Ist. Sup. Sanita*, 19, 1 (1956).

FORTHCOMING EVENTS

Monday, June 20—Thursday, June 23

Laboratory Apparatus and Materials Exhibition (at the Royal Horticultural Society's New Hall, Westminster, London, S.W.1).

Wednesday, June 22

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. R. W. Fairbridge and Dr. Heli Badoux "Slump Blocks in the Cretaceous of Northern Syria"; Dr. L. J. G. Schermerhorn and Dr. W. I. Stanton. "'Tilloids' in the West Congo Geosyncline".

Challenger Society (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 5.45 p.m.—Miss Alison Kay: "The Ecology of the Hawaiian Species of *Cypraea*".

Friday, June 24

Victor Horsley Memorial Fund (in the Great Hall, British Medical Association House, Tavistock Square, London, W.C.1), at 11 a.m.—Prof. Norman M. Dott: "Brain, Movement and Time" (Eleventh Victor Horsley Memorial Lecture).

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned.

Senior Lecturer (with a good honours degree and teaching or other suitable experience) to teach Electronics and Mathematics to equivalent degree level for sandwich diploma courses—The Principal, Royal Radar Establishment, College of Electronics, Malvern, Worcs (June 22).

Assistant, Grade B, in Mathematics; and a Lecturer (able to teach to special (honours) degree standard) in Inorganic Chemistry—Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (June 24).

Senior Lecturer (with high qualifications and wide experience) in Physics, to teach to honours degree level—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (June 24).

Assistant Lecturer in Numerical Analysis—The Registrar, The University, Manchester 13 (June 25).

Lecturer (with medical qualifications registrable in this country) in Anatomy—The Registrar, The University, Manchester 13 (June 25).

Scientific Officer (male, with a good honours degree) for genetical, physiological and breeding research in barley—The Secretary, Plant Breeding Institute, Trumpington, Cambridge (June 25).

Assistants (2) in Zoology, one in the field of vertebrate zoology, and the other in comparative physiology—The Secretary of University Court, The University, Glasgow (June 27).

Research Assistant (with a good degree and preferably a higher degree, in physics, chemistry, engineering or ceramics) at the Houldsworth School of Applied Science, to work on the high-temperature properties of certain ceramics of potential interest as engineering materials—The Registrar, The University, Leeds 2 (June 27).

Lecturer in Psychology or a Temporary Lecturer in Psychology—The Secretary, The Queen's University, Belfast (June 29).

Lecturer or Assistant Lecturer in Applied Mathematics—The Secretary, The University, Exeter (June 30).

Research Assistant (with a biological first degree and research experience) in Tissue Culture, to take part in a programme of research in the behaviour of normal and malignant cells—The Secretary, University College, Gower Street, London, W.C.1 (June 30).

Assistant Experimental Officers, Chemists (with G.C.E. "A" level in chemistry or physics and another science subject or equivalent, if over 22 a pass degree in chemistry or microbiology or H.N.C. chemistry generally expected), at the Water Pollution Research Laboratory, D.S.I.R., Stevenage, Herts, for research on physico-chemical and biological problems in the study and prevention of the pollution of rivers—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. F.384/0A (July 1).

Research Student (with the degree of Bachelor or Master of a British university other than Manchester) in Science—The Registrar, The University, Manchester 13 (July 1).

Lecturer, and a Demonstrator (honours graduates in geography) in Geography, at the University of New England, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 2).

Research Assistant in the Department of Botany, to work for one year on the acetate metabolism of the alga *Chlorella*—The Secretary, University College, Gower Street, London, W.C.1 (July 4).

Lecturer or Assistant Lecturer in Inorganic Chemistry in the Faculty of Science—The Registrar, The University, Manchester 13 (July 8).

Bacteriologist (honours graduate, majoring in bacteriology or biochemistry, with some years research experience in bacteriology) at the Meat Research Laboratory, Commonwealth Scientific and Industrial Research Organization, Brisbane, Queensland, Australia, to supervise the work of a small group investigating the metabolism of psychrophilic micro-organisms and the application of the results to the microbiology of chilled and frozen meat—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 305/61 (July 9).

Biochemist, basic grade (with a first- or second-class degree in biochemistry, chemistry or physiology, or equivalent) in the Department of Chemical Pathology, to carry out research on lipid metabolism in disease—The Secretary, The United Liverpool Hospitals, 80 Rodney Street, Liverpool 1 (July 9).

Lecturer in Zoology in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (July 9).

Lecturer (with a good honours degree and preferably experience in the general field of applied mechanics) in the Department of Mechanical Engineering—The Registrar, The University, Liverpool, quoting Ref. CV/T (July 9).

Lecturer in the Computer Unit—The Director, University of London Computer Unit, 44 Gordon Square, London, W.C.1 (July 10).

Scientific Officer, Grade I (with an honours degree in mathematics or physics, and preferably relevant experience), at the Weapons Research Establishment, Salisbury, near Adelaide, South Australia, for research and development on frequency response techniques in optics—The Senior Representative (AV.63/1), Department of Supply, Australia House, Strand, London, W.C.2 (July 11).

Senior Lecturers/Lecturers (with an honours degree or equivalent, and in the case of Senior Lecturers a higher degree) in Applied Mathematics at the University of New South Wales, Australia—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (London and Australia, July 15).

Lecturer or Assistant Lecturer in the Department of Botany—The Registrar, The University, Edgbaston, Birmingham 15 (July 16).

Senior Lecturer in Physiology; and a Lecturer (Grade I) in Biochemistry in the Department of Physiology, University College, Ibadan, Nigeria—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (July 18).

Chairs of Botany, Chemistry, Mathematics, Physics and Zoology in the Royal Technical College of East Africa and proposed University College in Nairobi—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 25).

Lecturer in General Psychology—The Secretary of Faculties, University Registry, Oxford (July 25).

Associate Professor (with a higher degree in pharmaceutics and wide teaching and research experience in physico-chemical or microbiological applications to pharmaceutics) of Pharmaceutics at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 29).

Assistant Lecturer (preferably candidate hoping to undertake research in the general field of genetics) in the Department of Zoology—The Secretary, University College, Gower Street, London, W.C.1 (July 31).

Laboratory Superintendent in the Department of Physics, Fourah Bay College (University of Durham), Sierra Leone—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 31).

Lecturer (with at least a good honours degree in geography and preferably experience of teaching geography in a university department) in Geography at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong and London, July 31).

Senior Lecturer (with a Doctorate of Philosophy of Science conferred for research in some branch of physics) in Physics at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 15).

Lecturer in Microbiology at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 31).

Reader in Mathematical Statistics at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, August 31).

Assistant Professors (2) (with experience in the teaching of gross anatomy, and preferably willing to undertake some teaching in neuroanatomy, histology, or embryology) in the Department of Anatomy—Prof. R. L. de C. H. Saunders, Anatomy Department, Dalhousie University, Halifax, Nova Scotia, Canada.

Biochemist, basic grade—Dr. Walker, Biochemistry Department, Royal National Orthopædic Hospital, Stanmore, Middlesex.

Biochemist (with biological interests), to assist in research on the plasmin–anti-plasmin system—The Pathologist, Institute of Orthopædics, Royal National Orthopædic Hospital, Brockley Hill, Stanmore, Middlesex.

Biologist (with biochemical training), to assist in research on the plasmin–anti-plasmin system—The Pathologist, Institute of Orthopædics, Royal National Orthopædic Hospital, Brockley Hill, Stanmore Middlesex.

Chemist (with a good honours degree in chemistry or equivalent professional qualification and specialization or interest in inorganic analysis) in the Geological Survey Department, Tanganyika, for the analysis of rocks, minerals and ores, and the supervision of junior staff in routine analytical work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/8/09/T.

Editorial Assistant (graded Assistant Experimental or Experimental Officer) (with G.C.E. "A" level in two science or a science and mathematics subject, or equivalent, if over 22 a pass degree, H.N.C., or equivalent, generally expected) in the Publications Section, Road Research Laboratory, D.S.I.R., Harmondsworth, Middlesex, for work involving editing and preparing for publication articles to technical journals, official booklets issued by the Laboratory, etc.—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.21/0A.

Graduate Demonstrators (male, with a first- or second-class honours degree or equivalent) in Civil, Mechanical and Electrical Engineering, Physics, Metallurgy and Ballistics, at the Royal Military College of Science, Shrivenham, Berks—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. A.266/0A.

Junior Research Fellow in Physics—The Registrar, The University, Sheffield.

Lecturer in Physics, to teach Ordinary National Certificate and B.Sc. general degree students—The Principal, Peterborough Technical College, Eastfield Road, Peterborough.

Lecturer or Assistant Lecturer, Grade B, in Mechanical Engineering—The Principal, Kingston Technical College, Fassett Road, Kingston-on-Thames.

Research Assistant (preferably with experience in cytology), to take part in a programme designed to study human chromosome abnormalities and associated disorders—The Secretary, Genetics Department, The University, Sheffield 10.

Research Biochemist to work in the Department of Hæmatology on fractionation of blood components—The Secretary (R), The Hospital for Sick Children, Great Ormond Street, London, W.C.1.

Research Fellow (preferably with an interest in solid state physics or nuclear physics) in Theoretical Physics—Prof. M. A. Preston, Department of Physics, McMaster University, Hamilton, Ontario, Canada

Research Student (physicist, electrical engineer, or physical chemist, with a first degree from the University of London) in the Department of Electrical Engineering, for work in the field of ultrasonics—The Registrar, Royal Technical College, Salford 5, Lancs.

Senior Bacteriologist (Principal Scientific Officer), and a Bacteriologist (Scientific or Senior Scientific Officer) with the East Africa Veterinary Research Organization, Kenya, for research into bacteriological and immunological problems relating to animal disease but primarily for basic studies on immunology with a view to developing a satisfactory vaccine for use in African conditions against bovine pleuro-pneumonia—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/214/02.

Senior Lecturer (with a first- or second-class honours degree or equivalent in physics, preferably with teaching and/or research experience) in Physics at the Royal Military College of Science, Shrivenham, Berks, to lecture to degree courses (and possibly specialized courses), and assist with laboratory classes—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.265/0A.

Senior Lecturers, Lecturers, or Assistants, Grade B (preferably with special interests in applied analysis, mathematical statistics, or other branches of applied mathematics) in the Department of Mathematics—The Academic Registrar, Hatfield Technical College, Hatfield, Herts.

Senior Technician or Technician for duty in the Clinical Isotope Laboratory—The House Governor, St. Mary's Hospital, Paddington, London, W.2.

Temporary Demonstrators (with a good honours degree or equivalent qualification) in Physical and in Inorganic Chemistry—The Registrar, The Manchester College of Science and Technology, Manchester 1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Library Association: North Western Group—Reference, Special and Information Section. Occasional Papers No. 2: John Benjamin Dancer—Instrument Maker, Optician and the Originator of Microphotography. By L. L. Ardern. Pp. 19+2 plates. (London: Library Association, 1960.) 4*s*. [283

Powered Flight: a Series of talks broadcast in the External Services of the BBC. Pp. 52. (London: British Broadcasting Corporation, 1960.) 2*s*. 6*d*. [283

Russian Journal of Physical Chemistry, July, 1959. Cover-to-cover translation. Published monthly. Subscription rates. Ordinary Rate £30 (U S.A. 90 dollars) per annum including postage. Rate for Libraries of Universities and Technical Colleges £22 10*s*. 0*d*. (U.S.A. 67.50 dollars) per annum including postage. Rate for Single Copies for all Subscribers £4 0*s*. 0*d*. (U.S.A. 12 dollars) per part. (London: The Chemical Society, 1960. Distributed by Cleaver-Hume Press, Ltd.) [283

Henry Wiggin and Co., Ltd. Welding, Brazing and Soldering of Wiggin Nickel Alloys. Pp. 36. (Birmingham: Henry Wiggin and Co., Ltd., 1960.) [288

Ciba (A.R.L.), Limited. Technical Notes No. 207 (March 1960): Glued Timber Building Structures. Pp. 14. (Duxford: Ciba (A.R.L.), Ltd., 1960.) [288

Ministry of Agriculture, Fisheries and Food. Fishery Investigations, Series II, Volume XXIII, No. 1: Young Plaice Hauls off the English East Coast. By R. S. Wimpenny. Pp. iii+20. (London: H.M. Stationery Office, 1960.) 6*s*. 6*d*. net. [283

Library Association: North Western Group—Reference, Special and Information Section. Russian Journals—Union List of Titles held by four Libraries in Manchester and Salford. Pp. 14. (Manchester: Central Library, 1960.) [288

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 117: Potato Root Eelworm. Pp. 4. (Belfast: Ministry of Agriculture, 1960.) [283

The Postgraduate Training of Physicists in British Universities: The Report of a Joint Committee appointed by the Institute of Physics and the Physical Society. Pp. 19. (London: Institute of Physics, 1960.) 2*s*. [288

Report of the Rugby School Natural History Society for the year 1959. Pp. 24+2 plates. (Rugby: Rugby School Natural History Society, 1960.) [293

Colony of Fiji: Legislative Council of Fiji. Council Paper No. 1 of 1960: Report of the Commission of Enquiry into the Natural Resources and Population Trends of the Colony of Fiji, 1959. Pp. x+154+27 maps. (London: Crown Agents for Oversea Governments and Administrations; Suva: Government Printer, 1960.) 5*s*. [293

The Ramblers' Association. Annual Report 1959. Pp. 16. (London: The Ramblers' Association, 1960.) [293

Greenwich Observations in Astronomy and Magnetism made at the Royal Observatory, Greenwich; the Royal Greenwich Observatory, Herstmonceux; and the Royal Greenwich Observatory, Abinger, in the year 1953, under the direction of Sir Harold Spencer Jones. Pp. xxi+296. (London: H.M. Stationery Office, 1959.) 80*s*. net. [293

Other Countries

Die Krankheiten der Weide und deren Erreger. Von Dr. H. Butin. (Mitteilungen aus der Biologischen Bundesanstalt fur Land-und Forstwirtschaft, Berlin-Dahlem, Heft 98.) Pp. 46. (Berlin–Dahlem: Biologische Bundesanstalt fur Land-und Forstwirtschaft, 1960.) 5.40 D.M. [293

The Regional Research Centre of the British Caribbean at the Imperial College of Tropical Agriculture, Trinidad, W.I. A Report on Cacao Research, 1957–1958. Pp. 86. (St. Augustine, Trinidad and London: Imperial College of Tropical Agriculture, 1959.) 15*s*. [293

Companhia de Diamentes de Angola (DIAMANG). Servicos Culturais Dundo—Lunda—Angola. Museu do Dundo. Subsidios para a Estudo da Biologia na Lunda. Publicacoes Culturais No. 45: Estudos Diversos (XVII). Pp. 131. (Lisboa: Companhia de Diamantes de Angola, 1959.) [293

United States Department of the Interior: Geological Survey. Water-Supply Paper 1408: Quality of Surface Waters of the United States, 1955. Parts 9–14: Colorado River Basin to Pacific Slope Basins in Oregon and Lower Columbia River Basin. Prepared under the direction of S. K. Love. Pp. xiii+437. 1.50 dollars. Water-Supply Paper 1449: Surface Water Supply of Hawaii, 1955–56. Prepared under the direction of J. V. B. Wells. Pp. vi+150. 60 cents. Water-Supply Paper 1456: Ground-Water Levels in the United States, 1956. North Central States. Prepared under the direction of Philip E. LaMoreaux. Pp. v+76 40 cents. Water-Supply Paper 1485: Quality of Surface Waters for Irrigation, Western United States, 1956. Prepared under the direction of S. K. Love. Pp. viii+185+1 plate. Water-Supply Paper 1493: Geologic and Ground-Water Reconnaissance of the Loup River Drainage Basin, Nebraska. By R. T. Sniegocki. With a section on Chemical Quality of the Water by R. H. Langford. Pp. v+106+2 plates. (Washington, D.C.: Government Printing Office, 1959 and 1960.) [293

United States Department of the Interior: Geological Survey. Water-Supply Paper 1500: Quantity and Quality of Surface Waters of Alaska, 1957. Prepared under the direction of J. V. B. Wells. Pp. vi+100. 45 cents. Water-Supply Paper 1502: Surface Water Supply of the United States, 1957. Part 1–B: North Atlantic Slope Basins, New York to York River. Prepared under the direction of J. V. B. Wells. Pp. xii+596. 2 dollars. Water-Supply Paper 1551: Surface Water Supply of the United States, 1958. Part 1–A: North Atlantic Slope Basins, Maine to Connecticut. Prepared under the direction of J. V. B. Wells. Pp. viii+270. 1.75 dollars. Water-Supply Paper 1556: Surface Water Supply of the United States, 1958. Part 3–B: Cumberland and Tennessee River Basins. Prepared under the direction of J. V. B. Wells. Pp. vii+248. (Washington, D.C.: Government Printing Office, 1960.) [293

United States Department of the Interior: Geological Survey. Bulletin 1039–D: Geology and Cement Raw Materials of the Windy Creek Area, Alaska. By R. M. Moxham, R. A. Eckhart and E. H. Cobb. Pp. iv+67–100+Plate 11. Bulletin 1055: Uranium in Coal in the Western United States. Pp. vi+315+59 plates. Bulletin 1059–G: Selected Annotated Bibliography of the Geology of Uranium-Bearing Veins in the United States. By Basil G. Dean. Pp. iii+327–440+plate 4. 75 cents. Bulletin 1071–E: Geology of the Lower Marias River Area, Chouteau, Hill, and Liberty Counties, Montana. By J. Fred Smith, Jr., L. J. Witkind, and D. E. Trimble. Pp. iv+121–155+plates 10–12. Bulletin 1072–K: Geology and Oil and Gas Possibilities of Upper Mississippian Rocks of Southwestern Virginia, Southern West Virginia, and Eastern Kentucky. By Ralph H. Wilpolt and Douglas W. Marden. Pp. iv+587–656+plates 27–29. Bulletin 1076: The Square Buttes Coal Field, Oliver and Mercer Counties, North Dakota. By William D. Johnson, Jr., and Robert P. Kunkel. Pp. v+91+7 plates. (Washington, D.C.: Government Printing Office, 1959.) [293

United States Department of the Interior: Geological Survey. Professional Paper No. 309: The Geology of the Upper Mississippi Valley Zinc-Lead District. By Allen V. Heyl, Jr., Allen F. Agnew, Erwin J. Lyons, and Charles H. Behre, Jr. With special sections by Arthur E. Flint. Pp. x+310+24 plates. Professional Paper No. 322: Pre-Tertiary Stratigraphy and Upper Triassic Paleontology of the Union District, Shoshone Mountains, Nevada. By N. J. Silberling. Pp. iii+67+11 plates. (Washington, D.C.: Government Printing Office, 1959.) [293

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Bulletin No. 52: Palaeoecology of the Marine Pleistocene Faunas of Southwestern British Columbia. By Frances J. E. Wagner. Pp. ix+67+1 plate. (Ottawa: Queen's Printer, 1959.) 1 dollar. [308

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

CHEMICAL LABORATORY
Date 12.8.60.
SCIENCE COLLEGE

Pure Chemistry Library,
SCIENCE COLLEGE.
92, Upper Circular Road.

THE BALANCE OF SCIENTIFIC AND INDUSTRIAL RESEARCH

THE White Paper, "Industrial Research and Development Expenditure, 1958" *, issued by the Department of Scientific and Industrial Research, is somewhat slighter than that issued in 1958 under the title "Estimates of Resources devoted to Scientific and Engineering Research and Development in British Manufacturing Industry, 1955"; but it is claimed to be somewhat more accurate as a result of improvements in the method of compilation. Moreover, it is of particular interest at the present moment when the abandonment of the *Blue Streak* missile project has raised major issues in defence research policy and in our effort in space research, for the report brings out some remarkable changes in British industrial research and development during the period of three years. The trends revealed bear closely both on the relation of defence research to the civil economy and on the effort which Britain can afford to devote to space research.

Taking first the broad picture, the report estimates that in 1958 British manufacturing industry spent about £380 million on research and development (compared with an estimate of £190 million in 1955) or 4·2 per cent of manufacturing industry's contribution to national production (compared with 3·1 per cent in 1955). Of the total, 95 per cent was spent in industrial establishments, and about 5 per cent (£13·7 million) on payments to outside bodies, among which co-operative research associations took some 29 per cent, the universities about 4 per cent, and other research institutions 65 per cent. These included independent research institutions and industrial consultants, but, particularly in the newer electrical and motor vehicle industries, payments were largely for technical information from other companies, often parent or associated companies overseas. Such expenditure to outside bodies was highest in industries comprising a large number of small manufacturers, which tended to concentrate their effort in the co-operative research associations.

These figures suggest that research and development have more than kept pace with the change in the value of production. The volume of production during the period changed only very slightly, and the Economics Committee, over which Prof. C. F. Carter presided, responsible for the report, is confident that this conclusion cannot be invalidated by any imperfections in the statistics. The second broad conclusion that is particularly pertinent just now is that the proportion of expenditure on research and development in establishments maintained by manufacturing industry provided out of defence contracts has fallen from nearly two-thirds to less than half, so that in the period the expenditure on 'civil' research and development has approximately doubled.

The basic method used in this inquiry was to apply to the estimates of fully qualified man-power engaged in research and development obtained by the Ministry of Labour from all manufacturing establishments employing 500 persons or more, and to a sample of those employing between 11 and 499 persons, estimates of cost per fully qualified person obtained, industry by industry, from a sample questionnaire addressed by the Department of Scientific and Industrial Research to 502 companies. There was an 80 per cent response to the Ministry of Labour inquiry, and the replies from 292 companies to that of the Department of Scientific and Industrial Research covered 1,044 establishments, including nine central research establishments serving an unspecified number of factories. Together with data from an inquiry made by the British Iron and Steel Federation, the latter return accounted for more than half the fully qualified scientists and engineers estimated to be employed on research and development in all manufacturing industry in Britain other than the aircraft industry, and the estimates are regarded as more reliable than those for 1955.

The estimates of cost per qualified worker vary greatly from one industry to another, being related to the weight of development expenditure and to the amount of use made of supporting staff. In its own establishments, all manufacturing industry employed on research and development 113,508 workers, of whom 26,225 or 23 per cent were qualified scientists and engineers. The average cost per qualified worker is thus £10,791; but if the aircraft industry is excluded (for which the figure was nearly £31,000) the average falls to £7,968, which compares with an estimate of £5,600 in 1955. An increase of 14–15 per cent can be attributed to rising prices and incomes, but, even at constant prices, there appears to have been an increase in expenditure per qualified worker of about 27 per cent, attributed partly to an increase in the number of supporting staff, from about two in 1955 to three per qualified worker in 1958. The chemical and allied trades (6,368 out of 20,476) and electrical engineering and electrical goods (7,677 out of 31,848) employed the largest number of qualified workers in research and development and the cost per qualified worker was £6,655 and £7,472, respectively. These two industries accounted for £43 million and £64·5 million, respectively, of the expenditure on research and development, and the aircraft industry for £100 million; but it must be remembered that about 80 per cent of the defence contracts for research and development were let to the electrical engineering and the aircraft industries.

---

* Department of Scientific and Industrial Research. Industrial Research and Development Expenditure, 1958. Pp. iv+13. (London: H.M. Stationery Office, 1960.) 1*s*. 3*d*. net.

These estimates of expenditure on research and development, when compared with estimates of net output, again show remarkable variations between industries. Covering all industries, research and development expenditure averaged 3·8 per cent of net output; but if the aircraft industry, for which the figure was 35·7 per cent, is left out, the average is 2·6 per cent. For the industries based on science, such as electrical engineering (11·9), precision instruments (10·7) and the chemical industries (5·9), the figure was appreciably higher; whereas in the traditional industries such as food, drink and tobacco or manufactures of wood and paper and printing, it was as low as 0·6 per cent and 0·25 per cent, respectively. Capital expenditure accounted for just over 10 per cent (£29 million) of the total expenditure of manufacturing industry on research and development in its own establishments, and of this sum more than half was incurred by the chemical and engineering industries.

Looking at the total of £13,664,000, estimated as paid by manufacturing industry in Britain to outside bodies in 1958, it should be noted that the £546,560 going to the universities should be put alongside £2,286,212 provided from Government departments to the universities in 1959–60 and £2,797,060 provided in the 1960–61 estimates for specialized researches. This is included in the vote of £65,670,790 for the universities through the University Grants Committee, of which £42 million is by way of recurrent grants. But there appear to be no published figures for the expenditure on research and development by the Atomic Energy Authority, the vote for which in the 1960–61 estimates amounts to £92 million, apart from £5,430,000 on research and development contracts with industry, the universities, etc. It should be recalled that such expenditure by the Industrial Group alone increased by 280 per cent between 1956–57 and 1959–60, and the volume of such work placed with industry is to be trebled in the next few years.

The present review of research and development expenditure in industry loses something of its value for assessing the balance of the research effort in Britain through the absence of accurate figures for the corresponding Government expenditure against which to compare it. In opening a debate on capital investment in industry in the House of Commons on April 26, Mr. J. H. Osborn, who referred to the White Paper, put Government expenditure on civil research at about £38 million, with a further £204 million on defence research and £5·3 million by the nationalized industries. He did not indicate the source of his figures, and his total of £242 million compares with an estimate of £277 million given by the Financial Secretary to the Treasury in a memorandum on the Civil Estimates.

Even this total of £277,748,774, however, is incomplete. It includes £202,150,000 on research and development by the Ministry of Aviation, of which £162,920,000 is for research and development work by industry, £18·5 million on scientific services by the Admiralty, with another £12·29 million on shipbuilding, repairs, maintenance, etc., £544,000 on medical research by the Air Ministry, £650,000 on meteorological research and £137,000 on operational research. Then there is £459,350 on the Chief Scientist's Department of the Ministry of Power, £287,424 on the Science Museum, £793,200 on the Directorate of Overseas Surveys and £200,000 on Overseas Geological Surveys. On the other hand, some at least of the expenditure included, that on research under the Home Office, for example, is scarcely of scientific significance, though some of the £15,754,514 for educational services and research, not included by the Financial Secretary, could be.

Most of these items, however, are comparatively minor, though the absence of any figures for the Atomic Energy Authority and the nationalized industries is a major matter, even if only the first falls properly within the Civil Estimates. More significant, however, is the omission of the contributions made to research through international bodies; for example, £1,330,000 through the Department of Scientific and Industrial Research to the European Organization for Nuclear Research, £204,000 to the International Atomic Energy Agency, £300,000 to the European Nuclear Energy Agency, £1,242,000 to International Atomic Energy projects, and £6,250,000 in grants to the Nuclear Research Institute (all these through the Atomic Energy Authority), or the £125,925 to the scientific schemes of the North Atlantic Treaty Organization. Such contributions might become more important if the trend away from defence research revealed by the inquiry continues, and if the trend to co-operative research with other members of the North Atlantic Treaty Organization develops.

Such a trend is suggested both by the discussions arising out of the Government decision to abandon the development of *Blue Streak* as a missile and by the conclusions of Mr. D. Wilgress in his report to the Organization of European Economic Co-operation on "Co-operation in the Field of Scientific and Technical Research"*. Little was, in fact, said about this aspect in the House of Commons debate, although some increase in our investment in research and development was urged, and there was little support for a view expressed by Lord Grantchester in the House of Lords that it is possible to spend too much money on research; nevertheless, Mr. H. Rhodes suggested that in some industries scientific research is badly applied. The question of balance between fundamental and applied research or between the research effort conducted by industry itself, by Government departments and institutions, and by the universities and research institutes was not mentioned, and yet this balance may be all-important in considering whether or not Britain should extend its effort in certain of the more costly and spectacular fields at the expense of other fields requiring attention.

This question of balance is strongly emphasized by Mr. Wilgress in his report, which in fact includes several tributes to the British effort and its organization; for example, the development of the research association system and the device of the National Research Development Corporation. Mr. Wilgress was asked to discuss with government authorities as well as with senior representatives of national administrations, science and industry, the measures already taken or planned to intensify the scientific and technical resources of each member country of the Organization, to make those in high authority aware of the importance which scientific research and technological development are likely to have on the future economy, and to propose measures to increase technological resources and to favour the establishment of common action for their more rational use.

---

* Organization for European Economic Co-operation. Co-operation in the Field of Scientific and Technical Research. Report by Mr. D. Wilgress. Pp 27. (Paris. Organization for European Economic Co-operation, 1960.)

While he found an encouraging and increasing awareness in the past three years of the need for greater scientific and technological activity, Mr. Wilgress regards Europe as falling far behind the United States in utilizing the results of applied science. He makes some comments on the educational system, including the place of fundamental research in the universities and the need to ease some of the existing rigidities in the educational systems of Europe. He points out that the solution of really difficult problems in fundamental research is best left to the initiative and imagination of eminent scientists, although when more than one branch of science is involved, the team concept becomes useful. He recognizes the difficulty which sponsored research presents to the universities, but suggests that use of this method deserves some attention from the Organization for European Economic Co-operation, and an analysis of sponsored research in Europe made by Dr. F. N. Woodward (see *Chem. and Indust.*, 33; 1960) certainly suggests that there is plenty of scope for development.

On the whole, Mr. Wilgress considers that more intensive scientific research is a matter for national rather than international effort. His recommendations for reorganizing the scientific activities of the Organization are, in fact, strictly limited. He suggests that its Committee of Applied Research should in future report direct to the Council, and that it should be known as "The Committee for Scientific Research", so that it would cover the broad field of scientific research while concentrating on those aspects with important economic implications. Eventually he visualizes the Governing Committee for Scientific and Technical Personnel as merging with this Committee, and in the meantime he suggests the establishment of a scientific advisory committee of seven or nine persons, each serving in a personal capacity, to advise the Council on the general scientific policy of the Organization.

Mr. Wilgress concludes that the Organization for European Economic Organization is the only international organization in a position to develop co-operation in scientific and technical research between the countries of Europe. Such co-operation for economic ends will be increasingly important, and Mr. Wilgress fully recognizes the need to develop co-operative efforts in fundamental research, particularly the replacement of weak institutes by one strong one, though he also appreciates the value in fundamental research of work proceeding in several places. His stress is on the importance of wise and inspiring leadership, and he insists throughout that while the Organization offers the best scope for increasing European co-operation in science, such co-operation should have an economic basis or implications, and the Organization's real function is to assist in fact-finding and the dissemination of information and to stimulate the development of the scientific and technical resources of member-countries in the interest of the economic growth of Europe as a whole. He lends no support to the launching of projects involving large sums of money, and his very sensible report emphasizes points that we in Britain need to keep carefully in mind in considering the balance of research and development in Britain, and the effect on that effort of any large new undertaking whether in space research or elsewhere.

QUANTUM THEORY FOR THE SCHOLAR

Mécanique Quantique

Par Prof. Albert Messiah. Tome 1. Pp. xv+430. 3,900 francs. Tome 2. Pp. xvi+544. 4,800 francs. (Paris: Dunod, 1960.)

Principles of Quantum Electrodynamics

By Walter E. Thirring. Translated from the German by J. Bernstein. (Pure and Applied Physics: a Series of Monographs and Textbooks, Vol. 3.) Pp. xv+234. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 8 dollars.

TEXT-BOOKS on quantum theory in general and monographs on special topics in this field are appearing nowadays at an ever-increasing rate. "Mécanique Quantique" by Messiah is the latest addition to the text-book literature. It is of considerably more than average length; other authors usually cover much the same ground in less volume. This does not mean to say, however, that this work is verbose; given the author's intention, he could scarcely have made it shorter.

To-day there are basically two methods of expounding quantum theory—either one presents the theory as a set of rules, the justification of which is that they form a logically consistent scheme capable of describing Nature correctly, or alternatively, one traces the historic development, discusses the inevitability of quantum theory superseding classical theory and leads up, step by step, to the general rules. On a previous occasion I have remarked that perhaps it is time to move away from the idea that the second, historical approach to quantum mechanics is essential to a first introduction to the subject. In any event, quantum theory has many users to-day who are not primarily interested in the foundations of the discipline. The present volumes are not for these, but the student who wishes to go deeply, to understand, not just to use, should welcome the existence of an exposition such as this, which takes him carefully along the traditional road of approach with much attention to detail, but without ever losing a basic unity of outlook that makes the book eminently readable despite its length. Lest English readers may be deterred by the language barrier, let it be said that the characteristics of clarity and simplicity extend to the language side also. The general contents of the volumes are much what one would expect, though it should be noted that the stress throughout is on general questions rather than on applications. Thus, to give but one example, the structure of the Periodic Table is treated with unusual brevity and the structure of molecules is not discussed at all. On the other hand the appendixes include a full summary of mathematical group theory. Like most text-books the reader is taken right up to relativistic theory, with a chapter on the Dirac electron and a sketch of quantum electrodynamics. Such final chapters are of course only useful in providing the 'further outlook' that whets the reader's appetite. To treat them in detail in the author's individual style would surely have required two further volumes.

Thirring's "Principles of Quantum Electrodynamics" deals with precisely the last-mentioned questions. Superficially at least it is diametrically opposed to what one imagines a continuation of Messiah would be. This is a translation of a book that originally appeared in German and was at the time most favourably acclaimed by the experts. Though the English edition is an expanded version of the original, brevity is, even now, an outstanding characteristic of this author's style. Perhaps the most notable single aspect of this work is its combination of fully up-to-date mathematical treatment with a continual stress on the physical meaning of the formalism. However, for entirely different reasons, one can say of this work just as of Messiah's that, while it is probably not the best first introduction to this field, it is eminently recommendable to the reader who seeks to acquire depth of understanding—and not merely dexterity in manipulation—in a difficult subject.

N. KEMMER

WHAT IS AGRONOMY?

Advances in Agronomy

Vol. 10. Pp. xii+547. 12.50 dollars. Vol. 11. Pp. x+428. 12 dollars. Edited by A. G. Norman. (Prepared under the auspices of the American Society of Agronomy.) (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1958–59.)

WHAT *is* agronomy? Certainly, like 'billion' and 'suspender', it suffers a potentially embarrassing change of meaning in crossing the Atlantic. In England, little would be left for agronomy when the claims of chemistry, entomology, plant pathology and so on had been stated—perhaps the study of green manuring, seed-rates and sowing dates.

In the United States apparently the subject of agronomy comprises pretty well all agricultural science. Subjects covered by the present volumes range from liming to castor-beans and from wheat stem rust to water and its relation to soils and crops.

"Advances in Agronomy" is written mainly by Americans about conditions in the United States; out of 17 articles only 2 come from institutions in other countries. (References to recent British work are very rare.) Many articles (especially those on soil chemistry) deal with fundamental work and make little reference to field experiments or practice. Many are rather turgid summaries of their subjects, devoting only small space to recent advances.

Among articles which appealed to me are those on individual crops (safflower and castor-beans) and on stem rust of wheat; the last is an excellent account of the difficulties of plant breeders competing with an adaptable air-borne pathogen. The article on recent developments in agricultural machinery in the United States is excellent and is one of the few articles of direct interest to British farmers.

Two articles come from outside the United States. One is a full account of the classification of the soils of Australia with their pedological descriptions; the known incidence of mineral deficiencies is concisely set out on maps. The other deals with the soils of Holland, relating their origins to their present appearance and the farming systems which have been established on them.

The articles in these two volumes, with a few exceptions, read like a disjointed collection of condensed text-books, or chapters from text-books. The range of subjects covered is far too wide to justify the implied suggestion that they are all branches of one science. These volumes do not establish 'agronomy' as a science.

G. V. DYKE

FLUID DYNAMICS: A MIXED BAG

Fluid Dynamics

By Dr. D. E. Rutherford. (University Mathematical Texts.) Pp. ix+226. (Edinburgh and London: Oliver and Boyd, Ltd.; New York: Interscience Publishers, Inc., 1959.) 10*s*. 6*d*. net.

Introduction to the Theory of Compressible Flow

By Prof. Shih-I Pai. Pp. xiii+385. (New York: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1959.) 9.75 dollars; 73*s*.

Fluid Mechanics

By L. D. Landau and E. M. Lifshitz. Translated from the Russian by J. B. Sykes and W. H. Reid. (Course of Theoretical Physics, Vol. 6.) Pp. xii+536. (London and New York: Pergamon Press, 1959.) 105*s*. net.

AS an aftermath of the rapid development of fluid dynamics during and since the Second World War, books recording new results or re-interpreting old results are now appearing in large numbers. The variety of books on fluid dynamics is also increasing, and the above three volumes in particular are widely different in purpose, style and content.

Dr. Rutherford's addition to the valuable series of University Mathematical Texts is aimed at undergraduates taking an honours course in mathematics in Britain. This is a sensible aim, for there is a dearth of introductory texts on fluid mechanics that are up to date in spirit as well as in content. Most teachers of the subject are aware that the older books, which concentrated on 'perfect' fluids because greater analytical development was thereby made possible, are not very useful to-day and may even be educationally harmful. It is possible nowadays to teach aspects of theoretical fluid dynamics which are fundamental, which are capable of mathematical expression and elaboration, and which describe accurately what happens in reality; but the books which discriminate properly between what is merely a mathematical exercise without physical significance and what is sound theory are not yet numerous.

In accordance with this need, Dr. Rutherford has devoted nearly a half of his book to non-perfect fluids (first compressible and then viscous), and the book is given a physical flavour by the inclusion of four plates of flow photographs. The jacket claims that "care has been taken to emphasize the distinction between real fluids and the mathematical models in terms of which the applied mathematician makes his calculations". I do not think this claim is justified; and, inasmuch as the author seems to me not to have succeeded in this absolutely vital test, I am doubtful if his book has any advantages over older texts, except the undoubted merit of cheapness. Dr. Rutherford's other contributions to the series of University Mathematical Texts have been on less physical subjects and have been well received. In his new book there is the same clear exposition and appreciation of the needs of students, but there are many places where he reveals his amateur status and his lack of acquaintance with the realities of fluid mechanics. Perhaps the most important fact about a viscous or 'real' fluid is that the flow past a bluff body is in general not approximately the same as for a completely inviscid or 'perfect' fluid, not even when the viscosity is extremely small, and if the inclusion of a discussion of viscous fluids in an introductory text has point at all, it is surely to reveal this limitation on the applicability of inviscid fluid theory; but a statement to this effect is not to be found here, either in a general discussion or *à propos* of particular cases. The author repeats the old fallacy about fluid not being able to go round sharp edges because of "the physical impossibility of having an infinite fluid velocity", and this is made the basis of Joukowski's hypothesis about the circulation. He includes the change in internal energy of a gas in the expression for the "rate at which energy is being dissipated into heat". Such comments (which could be multiplied) would be captious if the more purely mathematical qualities of the book compensated for the lack of physical understanding. These mathematical qualities do exist, but they also exist in many older books. I feel that Dr. Rutherford has added one more to the list of text-books on fluid dynamics about which students have to be warned; although in view of its handy size and appealing price his book may well be the one students choose in spite of the warning.

Prof. Pai's book is quite different in type. He has prepared an account of the flow of compressible fluid, which, so far as level of treatment is concerned, is suitable for postgraduate students and for those taking up research in the subject. The military and technical importance of high-speed flow has led, by the usual unseen but inexorable processes, to this part of fluid dynamics being the favourite of young research workers (or did until recently, when magnetohydrodynamics became the 'chosen'-subject and displaced it), and there is a large and hungry market seemingly able to consume any number of books like this one. Avid readers encourage hasty authors, and the breathless unscholarly style of Prof. Pai's book will deter those who look to a book for enlightenment as well as information. There is insufficient space here for a detailed account of the contents of the book and of its merits; it must be sufficient to say that the scope of the book is very wide and that something is said on almost all aspects of gas dynamics, some of them quite advanced and the subject of current research. The writing is not careful, and the author's explanations of fundamentals do not inspire confidence. He has, perhaps, done research beginners a good turn in gathering so much material together, but they will need guidance in their use of it.

"Fluid Mechanics", by Landau and Lifshitz, is a translation from Russian of one of a set of nine volumes making up the authors' "Course of Theoretical Physics". The authors are already well known by name to Western physicists, but it is a fair guess that they will be much more widely known as a result of the translation of these nine volumes. When I first saw a list of the titles of the nine volumes, I ungenerously inferred that the volumes on theoretical classical physics (like the present one) had probably been written out of determination to be absolutely complete, and that they would be poor relations to the volumes on quantum mechanics, field theory and statistical physics. Reasonable though this inference may have been, at least if the authors had been theoretical physicists from Europe or America, it is in fact quite unjust here. We have been given 536 pages of first-rate writing, with no hint that the authors found the material any less interesting than that in their other volumes. The authors have surveyed the whole field of fluid mechanics, from a fairly advanced point of view, and, although the different branches of the subject are of course not carried to the boundaries of current research, the book is extraordinarily interesting to both teacher and specialist. Analytical lucidity of the kind expected of good theoretical physicists has been combined with remarkable breadth of knowledge of the subject (one's mind boggles at the thought of equal erudition displayed on eight other subjects) to produce a book of unusual quality.

It must be owned that it is not a book for beginners; a good deal of background material is taken for granted, and some of the arguments are rather sophisticated. Nor is it likely to be very useful for routine reference, since the authors' choice of material is sometimes strange and unsystematic and, moreover, they have made little attempt to include experimental data. But for a theorist who is advanced enough to appreciate new views on innumerable results, some standard and some merely 'well known', the book is a gold mine.
G. K. Batchelor

THIRD CANADIAN CANCER CONFERENCE

Canadian Cancer Conference

Vol. 3: Proceedings of the Third Canadian Cancer Research Conference, Honey Harbour, Ontario, June 17–21, 1958. Edited by R. W. Begg. Pp. xiv+461. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 12 dollars.

At this conference twenty-eight papers were presented on nucleic acids, genetics, viruses and tumours, and on the biology of cancer. At the two earlier conferences the subjects chosen were:

(1) experimental tumours, tumour–host relations, enzymes, ionizing radiation; (2) the cell, leukæmia and chemotherapy, hormones and cancer, immunity and basic mechanisms. Thus the organizers of the three conferences seem to have avoided any bias towards (*a*) carcinogens and carcinogenesis, and (*b*) environmental factors and the demography of cancer.

The first section of the third conference deals with nucleic acids and consists of nine papers. Their relation to the cancer problem is somewhat indirect and the term 'cancer' is brought in here and there a little surreptitiously; however, the nucleic acids are an important theme at most centres of cancer research at the present time.

The second section, on genetics, consists of seven papers, a few of which have a more direct bearing on cancer. The leading article, "Recent Contributions on the Genetic Concept for the Origin of Cancer—Studies on the Nature of Adaptation of the Transplantable Tumour", is by L. C. Strong; it is 36 pages in length and is illustrated by a graph three feet long (and double sided); it would be necessary to be very enthusiastic to follow Strong through these 36 pages. It is with something akin to relief to find Strong concluding that the whole affair is a little unsatisfactory, for he finally decides . . . "It seems likely that the concept of genic instability is the probable explanation of the irregularities of growth encountered in the study of this transplantable anaplastic carcinoma".

In the same section there is a paper by L. W. Law on "Some Aspects of the Etiology of Leukæmia", part of which is devoted to a discussion of one of the high-lights of experimental cancer to-day, namely, the Gross and the Stewart mouse tumour viruses. At first Law appears to be extremely critical of the Gross findings being interpreted as evidence of a transmissible virus, but after assembling the results accumulated separately by A. Gross, S. Stewart, C. Friend, S. O. Schwartz and A. Graffi, he concludes that . . . "Modification has occurred of an acellular material, obtained from an *AKR* source in serial passage indicating a self-perpetuating characteristic. The bulk of the evidence to date, therefore, would suggest that the acellular materials derived from several sources are leukæmogenic, in certain situations, resembling the capacities of X-rays, estrogens and carcinogens". One is almost tempted to ask, "When is a cancer-producing virus not a virus?" . . . "When it is a leukæmogenic, self-perpetuating acellular material obtained from an *AKR* source in serial passage . . . etc." There seem to be three alternatives, either the agent is a virus, or a chromosomal fragment, or it is infectious ribonucleic acid.

The genetics section also contains a paper by G. Klein of Stockholm on "Variations and Selection in Tumour Cell Populations"; he writes, "It is also being increasingly realized that the change from a normal to a tumour cell is rarely if ever a single step; usually it is the end result of a series of successive changes. Various steps involved in this biological process, part of which is known under the name of tumour progression. . . ."

In fact, whether carcinogenesis occurs in steps or continuously, or how many steps are involved is still a matter of experimental conditions and of interpretation. Klein does not seem to be too sure of his ground (and with very good reason as the whole subject is exceedingly hypothetical), for his conclusions are a study in diffidence; almost every statement is qualified by a saving clause . . . 'some tentative', 'strongly suggest . . . may', 'no reason to assume', 'some evidence', 'little reason', 'seem to be no less complex', 'probably varies from case to case'.

The papers by D. B. Amos, "Some Iso-Antigenic Systems of the Mouse", by S. E. Luria, "Viruses as Determinants of Cellular Functions", and by Fuerst, "Lysogeny", are related to cancer problems, but on a slightly different level as it were.

The article by Sarah E. Stewart, B. E. Eddy and M. F. Stanton, "Induction of Neoplasms in Mice and Other Mammals by a Tumour Agent carried in Tissue Culture", is of particular interest; these workers report that the mouse polyoma virus is also effective in rabbits and hamsters, and in a foreign strain of mice (Swiss) it can induce leukæmia and tumours of the parotid, kidney, thymus, mesothelium, mamma, subcutaneous connective tissue, bone, hair follicle, thyroid, adrenal, buccal mucosa, lung, sweat gland and stomach. Antibodies to the virus could be detected in animals bearing the tumour, in control mice housed in the same environment as mice with the tumour, and in personnel exposed to the virus.

Stewart's results are confirmed in a paper by Mirand and Moore, who also report that the mouse polyoma virus can induce a variety of tumours in the hamster and rat.

D. W. H. Barnes, M. J. Corf, P. O. P. Ilbery, J. Loutit and F. E. Neal propose to treat leukæmia by destroying all the lymphocytes by radiation and re-populating the system with healthy cells; the resulting combination of tissues and cells derived from two individuals is termed a 'chimera'.

The section on the biology of cancer consists of three papers: the first, by L. H. Gray, contains little directly on cancer, except for a cautious statement that "one particular effect of ionizing radiation on genetic material should be mentioned as conceivably of importance in relation to cancer induction, namely, the transformation of prophage into phage". The use of the word 'conceivably' is appropriate here, for it is conceivable that cancer is induced by a virus which conceivably resembles phage. The epilogue to the conference is a paper, "The Biology of Cancer", by the eminent virologist Sir Macfarlane Burnet. He believes that carcinogenic change can be regarded as "almost entirely" due to somatic mutation or clonal selection. As evidence in support of somatic mutation he describes the observations on Australian long-fleeced sheep. In 30 examples of long-fleeced sheep in large herds of short-woolled breeds (20 million sheep), 1 case showed 44 per cent area involvement of the wool, suggesting that the mutation occurred when the sheep consisted of two cells only; 3 cases showed 23 per cent area, indicating mutation at the 4-celled stage, and 15 cases had 0·2–5·6 per cent area, suggesting mutation at a stage later than 16-cell segmentation. The frequency of mutation per cell is calculated to be $10^{-7 \cdot 15}$ to $10^{-7 \cdot 3}$, which is of the same order as mutation for germ cells.

Burnet has thus, apparently, overcome the most serious theoretical difficulty for somatic mutation, namely, that raised by the multicentric view postulating that carcinogenic induction takes place in a whole region of tissue simultaneously and not in a single cell or small group of cells. But to discuss this fascinating problem adequately would require a full-length review on its own.

I. HIEGER

An Introduction to Medical Genetics

By Dr. J. A. Fraser Roberts. Second edition. Pp. x+263. (London and New York: Oxford University Press, 1959.) 35*s*. net.

THE author looks forward to the day when genetic knowledge is so perfectly incorporated into medicine that specialists in medical genetics are no longer needed. The complexities of human biology would seem to make this a distant and perhaps unrealizable future, and it must also be admitted that little positive work has been done in the past to show the clinician or medical student how genetic principles may be put to use in ordinary clinical practice. Recent discoveries relating blood group frequencies to specific diseases have generated a new interest and the present book, a second edition appearing nineteen years after the first, is an admirable introduction to the subject, illustrated exclusively by medical examples and almost wholly deductive and non-mathematical in treatment. It is designed for the clinician or senior student with a real interest in learning something about medical genetics. The point of view is clinical and based on the affected individual: eugenics and the public health are not discussed. The average medical student may well find the book too demanding, but he should nevertheless be made to read the last chapter, on genetic prognosis. Here is a lucid description of how anxious parents can be accurately helped in one of the most critical decisions they will ever have to make, whether to have more, or even any, children. Precise and sometimes extensive knowledge is an essential prerequisite and in this field also the practitioner should know when to call in the specialist.

Very recent advances in human cytogenetics, which it was possible to refer to in a postscript, have already led to spectacular discoveries, and new observations are being reported almost monthly. After sufficient time for their proper digestion a third edition will surely be called for. The opportunity might then be taken to consider how the actions of doctors affect the genetics of the human race and of particular individuals, not only through the mutagenic effect of the medical uses of radiation, and perhaps of drugs, too, but also through the effects of medical treatment in preserving individuals carrying deleterious genes so that they reach the age of marriage and reproduction.

R. H. MOLE

The Reach of Science

By Prof. Henryk Mehlberg. Pp. xii+356. (Toronto: University of Toronto Press; London: Oxford University Press, 1958.) 45*s*. net.

THIS book is an able study in the philosophy of science. If it seems, in part, a little heavy-handed, the reader must accept that as something to be paid for the author's careful approach, and his concern to avoid misunderstandings. There are three main parts: the concept of scientific knowledge, the method of science, and the universality of science. It is a little difficult to state exactly where the writer stands, but he is evidently a liberal upholder of the "logical inherent universality of science" rather than of the rigid positivism stemming from Comte, who, in the event, has not proved a very constructive influence in research.

Prof. Mehlberg makes a good point in bringing under one critical comment both historicism and psychologism. The errors are parallel; in the first case to see in history the sole explanation of something, in the second to assign to subjectivism an excessive share in the unravelling of causes.

The urge to believe that "whatever is knowable is scientifically knowable" is excellent so far as it goes. It is hard to credit nevertheless that the author intends to press his thesis to the limit, in view of countless lives lived both rewardingly and beneficently without so much as a shred of 'knowledge' as thus defined.

F. I. G. RAWLINS

The World of Learning, 1959–60

Tenth edition. Pp. xiii+1221. (London: Europa Publications, Ltd., 1960.) 140*s*. net.

"THE World of Learning" continues in its now established form and hence remains a most valuable comprehensive compilation of academic organizations throughout the world. It includes details of Unesco, giving its origin, aims, functions and activities, and followed by alphabetical treatment of the academic institutes of each of the member countries. It includes learned societies, research institutes, libraries and archives, museums and art galleries, universities, colleges and technical institutes. The entry for each institute contains its address, the names of the leading officials, and in most cases a list of professors is provided. The compilation ends with a thorough sixty-four page index of all the institutes covered. It is regretted, however, that the editors have still not been able to gain the full co-operation of U.S.S.R. institutes, and the total contribution by the U.S.S.R. remains at twenty-eight pages. The work loses some of its usefulness by still not having a name index.

Chemical Process Principles

By Prof. Olaf A. Hougen, Prof. Kenneth M. Watson and Prof. Roland A. Ragatz. Part 2: Thermodynamics. Second edition. Pp. xviii+505–1072+xix–lvi. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 78*s*. net.

THIS is a completely revised edition of a book first published in 1947. After an introductory—but not elementary—chapter on thermodynamic principles, the authors present an extensive chapter on the properties of pure fluids, mainly based on the Lyderson–Greenkorn–Hougen three-parameter modification of the theorem of corresponding states. The rest of the book can be divided into three parts. In the first part the authors discuss the aspects of thermodynamics that are of particular interest to mechanical engineers, such as fluid-flow, power production, propulsion, and refrigeration. The second part is concerned with solutions, vapour-liquid equilibria, and separation processes. The last three chapters deal with chemical equilibria in simple and complex reactions. This edition is enlarged as well as improved. Stress is laid on fundamentals, and it has been skilfully brought up to date. It is a comprehensive work at a level far more advanced than most currently available text-books, and will hold an important place in the university class-room as well as on the reference shelf. If it has a fault, it is that of obscurity, particularly in the first chapter. This is no primer, and the unversed reader will be well advised to choose another book. The informed reader, on the other hand, will find it a valuable addition to his collection.

L. E. MARC DE CHAZAL

EVOLUTIONARY ORIGIN OF SEXUAL DIFFERENTIATION AND THE SEX-RATIO

By DR. H. KALMUS and DR. C. A. B. SMITH
The Galton Laboratory, University College, London

STUDIES of sex ratio usually start from the assumption that it is specifically advantageous for a species to divide itself into two sexes in equal numbers. They then proceed to special explanations why this ratio should break down or be imperfectly realized in particular instances. The purpose of this article is to investigate: (1) why and when a 1 : 1 sex ratio might be advantageous; (2) how it might have arisen.

Advantages of Sexual Differentiation

Experience suggests that inbreeding in a population is usually disadvantageous, and often markedly so. One of the prerequisites for outbreeding is cross-fertilization, and this also provides a large number of different gene permutations through genetic recombination. Such genetical diversity can be important when there are abrupt changes in environmental conditions, and without it the species may not be able to survive. A possible further function of recombination is the replacement of deleterious mutants. Without such replacement, mutants which are only slightly disadvantageous could slowly accumulate by chance in small isolated populations, and in time the species might die out. These three advantages of cross-fertilization suggest why it should be biologically important.

Although it is possible to have cross-fertilization without sexual differentiation (a condition called isogamy), we show in what follows that it is greatly assisted by such differentiation. We suggest that this is the fundamental reason for the evolution of sex in a population, and why it should have arisen repeatedly in the history of a single species.

Fertilization also serves the propagation of a species. Self-fertilization is much simpler and a less-hazardous procedure than cross-fertilization. Hence, unless there is a really effective barrier to self-fertilization, it is likely to be very much more common than crossing, especially in a species which is rare and widely scattered, and this could result in a harmful degree of inbreeding.

There is accordingly a conflict in many species between the advantages of cross-fertilization on one hand, with its avoidance of inbreeding, and self-fertilization or clonal development on the other hand, with their much greater ease of propagation. Survival of the species may depend on some compromise.

Another pair of contradictory tendencies closely connected with our problem are the respective advantages of being large and relatively secure, or of being small, numerous and mobile. In multicellular organisms compromise solutions are reached which combine both these tendencies, either by the sequence in time of large soma and small gametes or spores, or by the simultaneous production of large and small gametes in the same species.

Advantages of Numerical Sex-Equality

One aspect of such developments is the establishment of certain numerical equilibria, of which, as we shall show, the sex-ratio is an example. Let us start by considering a situation in which cross-fertilization is guaranteed by self-sterility. For example, in many unicellular species two gametes from the same clone cannot unite to form zygotes, but those from different sub-strains may be able to do so even when they are alike in outward appearance. If there are only two such sub-strains, suppose they occur with respective numbers n_1 and n_2: then the number of opportunities of such a mating is proportional to the number of pairs of individuals chosen one from the one strain and one from the other, and this number is n_1n_2. Now if the total number of individuals $(n_1 + n_2)$ is assumed to be effectively determined by environmental conditions, we (will) get maximum propagation when n_1n_2 has its maximum value for given $(n_1 + n_2)$. But:

$$n_1n_2 = \tfrac{1}{4}(n_1+n_2)^2 - \tfrac{1}{4}(n_1 - n_2)^2$$

and hence n_1n_2 is greatest when $\frac{1}{4}(n_1 - n_2)^2$ is least, that is, when $n_1 - n_2 = 0$, and the two sub-strains occur in equal numbers. (Similarly, with any number of sub-strains which are cross-fertile but self-sterile, the optimal situation is that in which all strains occur in equal proportions.) Mechanisms which ensure numerical equality of the two kinds of gametes will therefore confer a selective advantage: and we may expect in such cases numerical equality of morphologically similar types of gametes. Situations of this kind are observed among other cases in green flagellates (Klebs[1]) and also in the infusoria (Sonneborn[2]) where nuclei are exchanged between two mating types.

The products of isogamy in algae and of conjugation in infusoria do not undergo long and complex developmental changes and therefore do not need much reserve substances. On the other hand, such substances occur more or less abundantly in the zygotes of many higher plants and animals. If such species also require a high degree of genetical recombination, and hence cross-fertilization, the maximum propagation will be achieved by providing the greatest possible number of zygotes with sufficient reserves. Kalmus[3] has shown that under certain plausible conditions this will happen if there is an unequal distribution of reserve material to two different kinds ('small' and 'large') of mobile aquatic gametes, but in such a way that the reserve as a whole is about equally divided between a large number of the small gametes and a small number of the large ones. In organisms having external fertilization, such as echinoderms, bivalves, fish and others, the total masses of spermatozoa and ova are indeed found to be approximately equal. A similar situation is the comparable bulk of pollen and ovarial material in some wind-pollinated plants.

In monœcious plants and hermaphroditic animals the proportion of sperm and ova (pollen and ovules) is regulated by physiological means in each individual, and questions of sex ratio do not arise. The problem is somewhat different in bisexual animals and plants where the proportion of sperms and ova depends on the ratio of males to females in the population. The assimilatory powers of males and females are not very different in many species, and each can produce about the same volume of sex products. Therefore the optimal situation of near equality of bulk of spermatozoa and ova can be safeguarded by near equality of the numbers of individuals in the two sexes[3]. This occurs in non-copulating species of the following animal groups: Coelenterata, Scolecida, Mollusca, Brachiopoda, Enteropneusta, Echinodermata, Tunicata, Ascidia, Cyclostomata, Pisces and Amphibia. In plants, comparable relations exist among Myxomycetes, Phycomycetes as well as among the diœcious flowering plants.

In the case of animals with internal fertilization which have two sexes (copulating, gonochoristic forms) we shall require the chances of encounter of a male and female to be a maximum; we have already shown that this occurs when the two sexes have equal frequencies, assuming the total numbers to be limited by other factors.

Inequality in the numbers of the sexes can also be disadvantageous in another way. If the population contains, let us say, only a small number of females, then half the genes in the next generation must be derived from these females, however many males there may be. It follows that the genetical diversity of the population will thereby be restricted; in fact, there will be a large number of pairs of half-sibs in the next generation, and so presumably a large number of matings of related individuals: and this will lead to inbreeding. Sewall Wright has devised a measure of this restriction of genetical variation in a small population which he calls the 'effective size' of the population. If there are n_1 males and n_2 females, and the population breeds at random, the effective size is[4]:

$$N = \frac{4n_1n_2}{n_1 + n_1} = n_1 + n_2 - \frac{(n_1 - n_2)^2}{n_1 + n_2}$$

The greater the 'effective size' the smaller the degree of inbreeding, other things being equal; hence the optimal situation occurs when the effective size N is a maximum. For a given total size $n_1 + n_2$ this will occur when $(n_1 - n_2)^2$ is least, that is, when $n_1 = n_2$, and there is a 1 : 1 sex ratio. This effect will be most important in small populations, for example, if a species is divided up into small, relatively isolated groups.

In all situations considered above we see that the observed sex-ratios show a general agreement with those expected on the theory that the function of sex is to reduce inbreeding so far as possible. In the case of species which rear their young, a further reason for expecting equality of sex-ratio at the time of sexual maturity has been given by Fisher[5] in terms of the effort required to raise offspring of the two sexes.

Evolution of the Sexual Differentiation

We now turn from the consideration of the final population sex-ratio to the mechanisms through which sexual diversity and the numerical equality of the sexes may have evolved. A survey of the animal[6] and plant[7] kingdoms shows that sex-differentiation has vanished and probably arisen many times during evolution, and it is safe to assume that no two instances were quite the same. Let us again assume that a species requires the fusion of two genetically diverse types of gametes for its continued existence, and that fertilization will be most successful if the reserve material is stored mainly in one type[3]. Some barrier is required to prevent gametes from the same individual from combining, and this must be powerful, or it will be frustrated by the much greater probability of encounter of such gametes as compared with those from different individuals. Three possible devices are as follows: (1) Self-sterility mechanisms, for example, self-incompatibility. These are sometimes rather precarious arrangements, found in fungi, other plants and a few animals. (2) Proterandry or protogyny, where individuals produce male and female sex products at different times in succession. (3) The differentiation of two types (males and females), one producing small gametes, the other large ones.

In certain fish[8] and mosquitoes[9] single allelic differences or possibly short regions in a chromosome seem to determine sex. In most other organisms which have been investigated there have evolved different and more complex schemes of genetical sex-determination[6]. One difficulty which such mechanisms encounter during their evolution is that of apportioning three genotypes AA, Aa and aa to two sexes with equal frequency.

One theoretical possibility would be to have both homozygotes AA and aa of one sex, and the heterozygote Aa of the other sex. This has not been found, although Whiting and Whiting[10] discovered a somewhat similar mechanism of sex determination in the hymenopteran *Habrobracon judlandis*; there, heterozygosity at a number of loci on different chromosomes results in female development. Males are normally haploid, but can also be produced by homozygosity at some of these loci.

Another possibility is that of a homogametic sex, genetically aa, and a heterogametic sex, Aa; in this context A, a can denote either allelic genes or complete chromosomes (Y and X). This kind of sex determination is of frequent occurrence. It could arise through the gradual elimination of the type AA.

Let us suppose that in a diploid population homozygous for gene a, and producing only small gametes, there arises a dominant gene A which results in larger gametes with more reserve material being formed. These gametes which will carry A will thus provide the zygotes with more reserves, and thus be advantageous; hence the gene A may be expected to spread through the population. This spread will, however, be checked by the difficulty of union between these large, relatively static gametes, so that the advantage will only remain while there are a sufficient number of small gametes also present. Hence this situation may be expected to lead to an equilibrium in which both dominant and recessive types persist, and most fertile unions are between large and small gametes. From such a mating system in which there is already a tendency towards sexual differentiation, natural selection may be expected to develop a more complete sexuality in the course of time.

Another conceivable origin of sex-differentiation would be the appearance of a dominant mutation A with the property that types AA and Aa produce large gametes, and aa produces small gametes. Let us further suppose that there is dissortative mating, that is, a preference for the mating types dominant × recessive rather than dominant × dominant or recessive × recessive. Then the calculations of Li[4] suggest that even with only a moderate degree of dissortation, the population will approach an equilibrium in which the proportions of dominants and recessives are equal, and only a small proportion of the dominants are homozygotes *AA*. Now the structure of such a population differs only little from one with completely dissortative mating, with only the two types *Aa*, *aa*, present in equal numbers and only the single type of mating *Aa* × *aa*. This in turn suggests that it may be comparatively easy for selection to change from moderate to complete dissortation; this involves little disturbance to the population as a whole, but provides it with the advantages of sexual differentiation.

It seems worth noting, as pointed out to us by Prof. L. S. Penrose, that a dissortative mating can lead to an equilibrium also when the homozygote *AA* is lethal, whereas without dissortative mating this would lead to a gradual elimination of the gene *A*. If, therefore, a dissortative mating system arises during the development of sexual differentiation, it becomes possible for the *AA* type to tend to lethality without destroying the system, thus emphasizing the differentiation into the two types *Aa* and *aa*. This can lead ultimately to situations like the human one, in which the *YY* chromosomal zygote is presumably lethal.

Other mechanisms of ensuring numerical equality of the sexes are of course conceivable. It should, however, be pointed out that most of the tendencies which have been postulated in this article do not apply to the primary sex ratio, but to numerical sex equality at maturity. It has been frequently claimed but also denied that the primary sex ratio, that is the sex-ratio at conception in man, is very high and it is a fact that the secondary sex-ratio, namely, that at birth, shows regularly a significant excess of males[11]. However, the survival of females is greater through most of post-embryonic life and women reach a higher age than men. This situation results in near equality of the sexes during the reproductive ages.

[1] Klebs, G., "Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen" (Jena, 1896).

[2] Sonneborn, T. M., "The Species Problem", 155 (American Association for the Advancement of Science, 1957).

[3] Kalmus, H., *Biol. Zentralblatt*, **52**, 716 (1932).

[4] Li, C. C., "Population Genetics" (Univ. of Chicago Press, 1955).

[5] Fisher, R. A., "The Genetical Theory of Natural Selection" (Oxford University Press, 1930).

[6] White, M. J. D., "Animal Cytology and Evolution", 2nd ed. (Cambridge University Press, 1954).

[7] Darlington, C. D., "The Evolution of Genetic Systems", 2nd ed. (Oliver and Boyd, Edinburgh, 1958).

[8] Kosswig, C., *Z. Indukt. Abst. u. Vererbl.*, **70**, 377 (1935).

[9] Gilchrist, B. M., and Haldane, J. B. S., *Hereditas*, **33**, 175 (1947).

[10] Whiting, P. W., *Quart. Rev. Biol.*, **20**, 231 (1945).

[11] Stern, C., "Principles of Human Genetics" (W. H. Freeman, San Francisco, 1949).

BIOLOGICAL EQUILIBRIA IN HUMAN CANCER

By DR. KENNETH W. STARR, C.M.G., O.B.E.
Hon. Director, New South Wales State Cancer Council

NO human race is immune from cancer and the cancerous spectrum is encountered variously in all populations. Humanity justifiably regards the disease with dread because of the insufferable pain and abject dilapidation which attend its fierce mortality. Several unfashionable studies[1–5] have established the fact that most patients who contract the disease eventually die from it, and Lancaster[6] avers dramatically that in the younger age-group in Australia there has been no improvement for more than a hundred years; in fact, some deterioration has occurred in melanoma and leukæmia. The disease therefore is "no ballet dance of bloodless categories" but a poignant human problem.

It may be remarked with disaffection that a perceptible estrangement exists between the experimental and clinical disciplines in oncology. Experimental science finds difficulty in disciplining the uncontrollable variables of the human patient, and studies in man are notably disconcerting and imprecise. Accordingly, scientists dispose for their purposes of a vast array of susceptible animal colonies and artificial carcinogens with which, by exogenous administration, tumours are induced and transplanted. In this fashion, the honoured tradition of Percival Pott[7] and of Yamigawa and Itchikawa[8] is projected into modern cancer research. It is then assumed that the tumours studied by these "exquisite techniques, masterfully applied" are comparable in genesis, evolution, and pathology with human cancer. This assumption requires examination.

With regard to carcinogenesis, the scientist (Peyton Rous[9]) declaims: "Now we know that neoplastic changes are not spontaneous, but are induced by extraneous agents and conditions in the generality of instances and almost certainly in them all. It has become 'rule of thumb' on finding a tumour to look for the agent bringing it on". To the clinician, such an attitude is not only unacceptable, it is also unintelligible. With the exception of a few solar and industrial cancers, the only "rule of thumb" applicable to the lethal cancers which he daily treats is his uniform and unmitigated ignorance of their ætiology.

Most experimental carcinogens are mutagenic, and the clinician is further asked to believe that human cancer results from a somatic mutation. Consequently, "there is little ground for optimism about cancer" and "we should look forward not only to failure but to a sharp increase in the incidence of the disease"[10]. Ignoring the threnody, it may be observed that cancer rates, cancer predilection for both organ and site unrelated to mass, and cancer behaviour cause difficulties for this hypothesis. Recognized mutation rates in human populations rarely exceed 1 per 10,000 of population, while cancer attains a much higher rate (further augmented by unrecorded 'silent' and precancerous complements). Cancers in man favour certain zones of certain organs comprising about 20 per cent of the body mass while ignoring adjacent zones and other massive tissues (the voluntary muscles, bones, liver and small gut are rare sites). Certain systems (especially the alimentary) produce about 5 per cent of multiple tumours. Cancer of the female breast shows several anomalies. It is slowly increasing in this century[11], shows hereditary associations[12], is bilateral in 3 per cent of patients, is consistently more frequent on the left side, and in almost half the cases affects the upper and outer quadrant[13]. The theory of somatic mutation is unsatisfying when confronted with the combination of site and organ predilection unrelated to mass, bilaterality, laterality, multiplicity and variable frequency. An alternative genetic hypothesis appears essential.

From their studies of spontaneous carcinogenesis in human explants, Levan and Biesele[14] have postulated chromosome fracture in a tissue of high mitotic index. The human small gut is 23 ft. in length, and is remarkable for its very high mitotic index and nucleoprotein turnover. Cancer, however, is practically unknown there.

Steiner[15,16], in his superb surveys, finds several incompatibilities. He contrasts the long latent period and independent stages of human cancer with the more rapid appearance of cancer following chemical and other mutagenic carcinogenesis. He notes, too, that many phenomena of experimental carcinogenesis are absent in human cancer (cocarcinogenesis, summation, synergism, inhibition, conditional carcinogenesis, and anticarcinogenesis by noncarcinogenic substances). Further, he marks the following cancers as essentially human in character because they have no counterparts in type and behaviour among the induced tumours of animals: cancers of the stomach, colon, rectum, pancreas, lung (bronchogenic), œsophagus, uterus, salivary gland and breast ("a different disease"). This list comprises the majority of cancers which the clinician encounters.

Spontaneous human and animal cancers are notably resistant to chemotherapy, effective against experimental cancers[17]. The elimination of industrial cancers—a great triumph of modern preventive medicine—has not affected total cancer incidence because known carcinogens are rare clinically. To all these considerations, Greene's[18] experience in the transplantation of human tumours is complementary—"the highly individualised primary neoplasm develops to attain 'independence' and then to transcend the species barrier. This profound biological transformation is not due to sudden mutations affecting normal cells but to a developmental process". Willis[11] agrees with this.

The complexity of the genesis and evolution of human cancer becomes even more apparent when the biological equilibria in which it is involved with other vital processes are studied.

The Genetic Equilibrium

"It must be difficult always to remember", wrote Darwin in his "Origin of Species", "that the increase of every creature is constantly being checked by unperceived hostile agencies". Although modern science has increased the life-span, death comes as it must to all men, chiefly through disease. The pattern of disease varies in each population. In oncology the Mendelian population is chiefly racial, for it is found that certain races favour certain cancers and shun others. The cancer-rates, too, vary among the races; low rates are chiefly found among primitive races—the less-variable wild organism (Waddington)—and high rates in advanced cultures. It is a genetic truism that these Mendelian populations with "the common gene pool" (Dobzhansky) and "an exceedingly heterogenous aggregate of largely heterozygous genotypes"[19] survive by virtue of their heterogeneity. Moreover, this heterogeneity is not related to single genes but to "polygenic groups" mutually involved in a "totality of interaction" (Dubinin).

In 1825, Benjamin Gompertz[20], of Northampton and of Portuguese extraction, presented a communication before the Royal Society asserting that the "force of mortality" and the age of human populations manifested a straight-line relationship in the logarithmic graph. This function has been merely of academic interest for more than a century, and its current resurrection in relation to human cancer is indeed a scientific romance. It has now been sufficiently demonstrated in countless millions of human beings in many populations that the Gompertz function is valid[5]. The simplicity of this two-dimensional graph is startling considering its import, and it has recently been shown that it is maintained before adulthood, if violent deaths are excluded[21]. The force and authenticity of this human demographic study is in some contrast with the restricted information from population studies in animals which "vary according to strain, sex, laboratory conditions and numerous other factors. The number of animals, too, is usually too small to provide good curves"[21].

When cancer mortality is plotted against age in the logarithmic graph it is found that a straight-line relationship is sustained at a higher intensity and the Gompertz function is applicable[4,5,22–25]. At any age, therefore, the cancer mortality is a function of total mortality, and the exponential processes are in equilibrium[5].

The gradient of the exponential graph for total mortality shows a doubling rate each 7–8·5 years, a specific character of the human species and therefore genetically determined. Strong genetic influences consequently subtend the genesis, evolution and consummation of human cancer. The number of cancer deaths in these surveys exceeds 15 millions, and it is accordingly difficult to understand why these telling facts do not dominate all cancer research.

With the possible exception of leukæmia, the straight-line behaviour of the cancerous sub-population relative to the Gompertz function is incompatible with the virus theory of cancer[25]. This casts some doubt on Stanley's zealous asseveration—"it is difficult to escape the conclusion that viruses may be the ætiological agent for most, if not all, cancer, including cancer in man, and represents by far the most intellectually satisfying hypothesis consistent with the presently known facts"[26]. The function emphasizes the genetic relationships of human cancer and creates considerable difficulties for any hypothesis based on exogenous carcinogenesis.

The Pathological Equilibrium

Each Mendelian population in man manifests its own disease-pattern, and some of the component diseases obey the Gompertz function. The pattern appears to be determined early in life[5], and accordingly has strong genetic affinities. Cardiovascular degeneration is so widely encountered in clinical experience that it is regarded as an 'average' disease within this pattern.

The process of neoplasia produces benign lesions (such as nævi, universal in whites), border-line lesions (which may behave in either a benign or a malignant fashion), 'silent' and 'histological' lesions discovered post-mortem or microscopically, and finally malignant lesions distinguished for their lethality. Moreover, certain diatheses (diabetes mellitus) are associated with a higher cancer incidence. Cancer, too, is a complication of certain components of the disease-pattern (gastric ulcer, ulcerative colitis, achlorhydria, megalocytic anæmia, etc.). 'Silent' or histological cancers are being reported with increasing frequency, especially in the thyroid, bronchus and prostate. In the last-named instance it is asserted that 'histological cancer' can be demonstrated in more than half of all patients dying after eighty years of age.

While neoplasia therefore is an 'average' disease of the population, cancer is not. Moreover, Hardin Jones[5] finds that total disease and cancer incidence are interrelated, and he emphasizes the narrow margin of variation in the "threshold of manifestation" (Law) of cancer compared with the wide margin in 'average' diseases. The intensity of the age-specific mortality of cancer equals that of the senile population of more than seventy years of age. From these points of view it is evident that the cancerous sub-populations of the various races resemble each other more than their parent populations[5], and the behaviour of these sub-populations is comparable with that of a new biological species[27].

Despite the manifold sources from which the cancerous sub-population may be recruited, it is a remarkable fact that the cancer mortality in any population is predictable, fairly constant and varies within narrow limits. Reference to the year-books of the various nations (and since 1952 to the "Demographic Year Book" of the United Nations) will reveal that the cancerous sub-population is a fairly constant proportion of the parent population. Deaths from cancer vary between 0·03 and 0·3 per cent, the higher rates being encountered where superior public health services prevail. In this regard the Commonwealth Statistician records[28] that in Australia "there has been no increase in cancer mortality since 1921 and in some age groups it has actually declined". Soper[29] refers to a similar state in Switzerland. The manner in which this constant and distinctive biological group of lethal cancers is 'selected' from the neoplastic spectrum and disease-pattern of the parent race, strongly suggests Darwinian natural selection, operating in a Mendelian population.

The Ontogenetic Equilibrium

The paucity of induced tumours available for experimental study is in some contrast with the bewildering array and variable frequencies of human cancers. Moreover, subtle nuances of malignancy are encountered varying from 'histological' cancer with metastases but benign behaviour (papillary cystadenocarcinoma of the thyroid gland) to lethal malignancy without a detectable primary (melanoma malignum) or without metastases (glioblastoma multiforme). Willis[11] holds the view that this protean character of cancer demolishes the theory of somatic mutation. It is likely, too, that failure to appreciate these aspects of clinical cancer may explain the tendency in the scientific literature to regard cancer as a generic disease differing from the normal only in a single enzymic or other biochemical aberration and eradicable by a single chemotherapeutic nostrum.

Nevertheless, apart from occasional morphological and behaviouristic difficulties, the basis of orderly taxonomy in histopathology is genetic (histogenesis)[11].

Human cancers do not occur uniformly in equal numbers and similar types during each year of the life-span. Some cancers are very frequent, others rare. In populations under the action of natural selection, organisms tend to cluster about mean values for all characters[19]. A similar phenomenon is discerned as a peak incidence of various groups of cancer at certain ages. When such a chart is prepared (Fig. 1) it is apparent that the physiological epochs (childhood, adolescence, maturity, menopause, senescence and especially puberty) are also involved in these incidences. Thus the "threshold of cancer manifestation" may be related to the "ontogenetic differentiation"[33] of the host.

The racial phenotype is the distinctive characteristic of Mendelian populations in man and is profoundly influenced by both hereditary and environmental (including cultural) factors. In the same fashion, the physiological development of the host modified by environment appears to modulate the clinical presentation of human cancers, and considerable racial variations are observed.

Thus, heredity manifests itself in hereditary cancers, 'cancer families', cancer diatheses, and certain pathological symbioses (such as the association of stomach cancer with achlorhydria, megalocytic anæmia, certain blood groups, and a genodermatosis, acanthosis nigricans). Cancer afflicts the sexes equally, and sex has a profound effect not only on the cancer of the reproductive organs but also in an unexplained fashion on certain somatic cancers (bronchogenic carcinoma, pharyngeal cancer). On the other hand, monozygotic twins do not manifest total concordance, just as the frequency of similarity is not identical in mono- and dizygotic twins (Gorer and Oliver[30]). Migrant studies, too, confirm this blending of hereditary and environmental factors. These studies (for example, the African Negro in the Americas), while never conclusive, suggest that cancers of the parent population first predominate, being supplanted in succeeding generations by indigenous cancers, and do not recur (a Lamarckian twist).

In 1927, the Registrar-General of the United Kingdom[31] reported the relationship of various cancers to occupation and social stratum and similar studies have since incorporated geographical, edaphic, social (marriage, housing, diet, etc.), and personal (obesity, hygiene, pregnancy, etc.) influences.

Another aspect of human cancer emphasized by the peak incidences is that the clinical appearance of the cancer is an index of the duration of the latent period. It will be noted that certain cancers do not appear in certain decades (for example, carcinomata of the stomach, colon, and rectum never appear before the tenth year, those of the breast and pancreas never before the twentieth year, and those of the prostate, gall-bladder and mouth rarely before the thirtieth year)[14]. The 'scatter' of the age incidence is less marked too at the extremes of life (in childhood, the nephroblastoma, neuroblastoma, embryoma and leukæmia, and in the aged, œsophageal and prostatic cancer). The cancers of these latter epochs are characteristic exanthems. It appears, therefore, that the latent period is a fairly stable cycle in human cancer. This suggestion is supported by Strong's[32] studies in mouse populations on the compensatory responses evoked by fluctuations in the maternal age, litter size and latent period. So stable is the latter characteristic that homœostasis was only restored to the biological equilibrium by the development of new cancers in different organs, the total cancer incidence remaining constant.

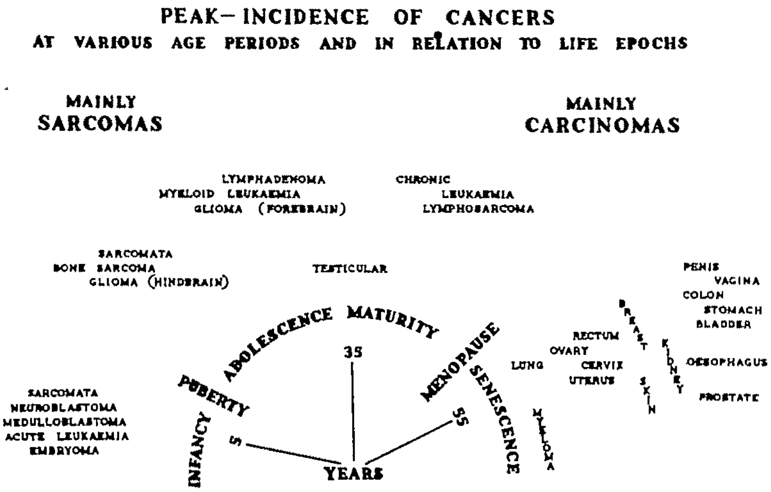


Fig. 1. Peak incidences of human cancers charted against age and physiological epochs (data from Potter's "Pathology of the Fœtus and Newborn" and Harnett's "Cancer Survey of London")

In this equilibrium between the ontogeny of the host and the manifestation and behaviour of human cancer, an oncological paraphrase of Loeb's law[33] may be discerned: "the human organism, its constituent parts and their associated cancers each has its own characteristic time-curve".

The Oncological Equilibrium

An equilibrium of the fourth order exists among the cancers themselves. Mendelian populations under the action of natural selection compensate extreme deviations of one trait with some form of deviation of another[19,34]. The cancers themselves behave in this fashion, and the equilibrium is of considerable epidemiological and demographic interest. If fluctuations occur in the frequency of certain cancers, homœostasis is then achieved by compensatory fluctuations in the frequency of other cancers.

It is now twenty years since Cramer[35] published his law: "There appears to be a general law, that when in a given population the incidence of cancer in any one particular organ is markedly increased when compared with another, there is then a compensatory decrease in the incidence in a number of other organs".

In 1909, the Registrar-General of the United Kingdom directed attention to the catastrophic increase in males, since 1870, of cancer of the tongue (228 per cent). Contemporary clinical opinion held that unless radical measures to curtail tobacco smoking were enforced, a further increase among males and females could be expected to reach a maximum by 1950[36]. Of course, despite increased tobacco consumption, the incidence of tongue cancer is now halved. To-day, clinicians are deeply concerned with the avalanche of bronchogenic carcinoma in males and tobacco is again under criticism. Case[37] has used cohort analysis to show that in the United Kingdom, coincident with this marked increase in lung cancer, a compensatory fall in several other cancers (especially oropharyngeal) has occurred.

The Clinical Equilibrium

This equilibrium is a further manifestation of the cancer-host relationship. It is of paramount importance to the clinician and to the research worker, who believes with Homburger that "at the core of the cancer problem is the patient afflicted with the disease". It is the clinico-pathological equilibrium known as 'latency' or 'dormancy'.

In most cases the appearance of a cancer is a prelude to a continuously disturbed equilibrium in favour of the cancer until the host dies. This is not always the case. Rarely the equilibrium is disturbed in favour of the host and the tumour spontaneously regresses or disappears (notably melanoma malignum, retinoblastoma, neuroblastoma, choriocarcinoma testis, myosarcoma uteri and certain angiomata and hepatomata). Quite frequently encountered is an equilibrium of considerable stability. Every clinician is familiar with the patient who, having had a cancer of a certain organ (often the breast) removed one or more decades previously, now has a metastasis in a remote organ. Periods of 10–30 years are far from uncommon. Many observers have reported the circumstances which may suddenly upset this latter equilibrium, to result in cancerous recrudescence and death. Thus surgical operations, pregnancy, illness and accidents[38] are all known to be involved. Many forms of therapy in autonomous cancer achieve temporary benefit until homœostasis invalidates them. However, the symptomless state of latency is obviously a therapeutic goal.

This equilibrium also presents certain distinctive human features having no counterpart in experimental oncology. This difference relates to the decay of the afflicted sub-population. In animal studies the death-rate augments as the disease progresses and cancerous tissue preponderates in the body mass. The human patient may perish, however, with a relatively small tumour from metastatic, mechanical, or metabolic complications. The mode of decay here shows a straight-line relationship between the logarithmic scale of survival and the linear measure of time-duration of the disease. "It is a remarkable fact that the death-rate for all kinds of human cancer remains nearly fixed from the moment when the cancer is identified"[5]. Consequently, the termination of human cancer is no fortuitous affair but the orderly decay of a biological process from "unperceived hostile agencies".

Biology of Human Cancer

Cancer is usually represented as an anarchic and disorderly process, but Darwinian and Mendelian regulation permeates its biology and the Gompertz function is its commandment. Intricate biological equilibria, rising to the fifth order, ensure its specific integrity, the ratio and longevity of its constituent lesions, its inexorable autonomy and constant lethality.

Heterogeneity is the vital elixir of Mendelian populations under the action of natural selection. Cancer is the lethal element in the neoplastic component of the disease-pattern, and consequently is an appanage of that heterogeneity.

From these points of view, the cancerous patient is a phenodeviant in antagonistic symbiosis with a lethal parasite. This processional system emerges from the anlagen of the embryo, and after a variable latent period crosses the thresholds of manifestation and autonomy to encompass the death of the host. Throughout its course the cancer is embedded in a reticulum of biological equilibria, genetic and environmental pressures, and homœostatic reactions. The resultant of these forces determines the number, site, nature and behaviour of the lesions.

It is apparent that experimental and clinical cancer are not identical diseases. The principal divarication between the oncological disciplines pertains to carcinogenesis. The genesis of experimental cancer is mainly exogenous and mutagenic, and a 'cause' is specified. Human cancer, on the other hand, arises in a complex genetic phenomenon and evolves with the ontogeny of the host. No 'cause' can be postulated until the physiology of gene action and of normal ontogeny have been reduced to precise physicochemical terms (Lerner).

The "Novum Organum" (LXXXI) lays it down that "it is not possible to run a course aright when the goal itself has not been rightly placed". The prevention of human cancer is probably eugenic, but neither science nor society can yet confront and assimilate this proposal. The goals in contemporary clinical oncology are therefore readily defined if the present cure-rate is to be augmented. First, to devise a test which will distinguish the cancerous sub-population and permit the cure of their precancerous and cancerous lesions before autonomy supervenes. Second, to reduce ineradicable autonomous cancer to 'latency'.

These proposals demand novel studies in human metabolism; but there is some evidence to show that they are now within the ambit of modern scientific techniques. Success in this ambition would suppress this *genius ater* which pervades society and rob cancer of its terrors.

[1] Boag, J. W., *J. Roy. Statist. Soc.*, B, 15 (1949).
[2] Bond, W. H., *et al.*, *Brit. Med. J.*, i, 643 (1958).
[3] Douglas, J. R. S., *Med. J. Aust.*, i, 536 (1957).
[4] Metcalfe, D., *Med. J. Aust.*, i, 877 (1955).
[5] Jones, Hardin, *Ann. New York Acad. Sci.*, 18, 298 (1956).
[6] Lancaster, H. O., *Med. J. Aust.*, ii, 351 (1958) and personal communication.
[7] Pott, Percival, "Chirurgical Observations" (London, 1775).
[8] Yamigawa and Itchikawa, *J. Canc. Res.*, 3, 1 (1918).
[9] Rous, Peyton, *Nature*, 183, 1357 (1959).
[10] Burnet, F. M., *Brit. Med. J.*, i, 779 (1957).
[11] Willis, E. A., "Pathology of Tumours", 197 (Butterworth, London, 1948).
[12] Editorial, *Brit. Med. J.*, i, 683 (1959).
[13] Harnett, W. L., "Survey of Cancer in London" (British Empire Cancer Campaign, London, 1952).
[14] Levan, A., and Biesele, J., *Ann. New York Acad. Sci.*, 71, 1058 (1958).
[15] Steiner, P., *Archiv Path.*, 55, 227 (1953).
[16] Steiner, P., "Cancer and Geography" (Williams and Wilkins, Baltimore, 1954).
[17] Druckrey, H. D., *Deutsch. Med. Wschr.*, 83, 543 (1958).
[18] Greene, H. S. N., *Ann. New York Acad. Sci.*, 71, 177 (1958).
[19] Lerner, I. M., "Genetic Homœostasis" (Oliver and Boyd, Edinburgh, 1953).
[20] Gompertz, B., *Phil. Trans. Roy. Soc.*, 513 (1825).
[21] Failla, G., *Ann. New York Acad. Sci.*, 71, 1125 (1958).
[22] Holloman, J., and Fisher, J., *Cancer*, 4, 916 (1951).
[23] Nordling, C. O., *Brit. J. Cancer*, 7, 68 (1953).
[24] Armytage, P., and Doll, R., *Brit. J. Cancer*, 8, 1 (1954).
[25] Burnet, F. M., *Acta Uni. Int. Cancer*, 15, 31 (1959).
[26] Stanley, W. M., *Ann. New York Acad. Sci.*, 71, 1111 (1958).
[27] Huxley, Julian, "Biological Aspects of Cancer" (Geo. Allen and Unwin, London, 1957).
[28] Aust. Commonwealth Year Book, Part 5, 418 (1954).
[29] Soper, G., "Encyclop. Brittan.", fourteenth ed., 732 (London).
[30] Symposium, "The Genetic Concept of Cancer", 71 (*Ann. New York Acad. Sci.*, 1958).
[31] Decennial Supplement, Dept. of Registrar General (U.K.) (H.M.S.O., London, 1927).
[32] Strong, L. C., *Science*, 125, 595 (1957).
[33] Loeb, L., *Biol. Symp.*, xi, 197 (1945).
[34] Fisher, R. A., "Genetical Theory of Natural Selection" (Clarendon Press, Oxford, 1930).
[35] Cramer, W. O., *J. Amer. Med. Assoc.*, 119, 309 (1942).
[36] Power, D., *Brit. J. Surg.*, 6, 336 (1919).
[37] Case, R. A. M., *Brit. J. Prev. and Soc. Med.*, 10, 191 (1956).
[38] Gordon Taylor, G., *Brit. Med. J.*, ii, 455 (1959).

A FORERUNNER OF TWENTIETH CENTURY PHYSICS

A RE-VIEW OF LARMOR'S "AETHER AND MATTER"

By LANCELOT LAW WHYTE

IN 1900 there appeared a work which, though little read to-day, is of considerable retrospective interest, for it records the ideas of a brilliant theoretical physicist immediately prior to Planck's discovery of the quantum constant and Einstein's formulation of the special theory of relativity.

"Aether and Matter", by Joseph Larmor, F.R.S. (1857–1942, later Sir Joseph Larmor, member of Parliament, Lucasian professor of mathematics at Cambridge, 1903–32) was issued by the Cambridge University Press as an Adams Prize Essay. A thousand copies were printed, which were sold by 1912. It has never been re-printed or translated, and is now rare; I purchased a damaged copy in 1921 for 3*s*. 6*d*. and another in 1953 for £1 10*s*. 0*d*. The most important references to the book are in the original reviews, the obituary notices at Larmor's death in 1942, and Whittaker's "History of the Theories of Aether and Electricity" (2 vols. 1951, 1953), where there are twenty-six references to Larmor, including six to "Aether and Matter".

The full title of the book reads: "Aether and Matter, a Development of the Dynamical Relations of the Aether to Material Systems on the Basis of the Atomic Constitution of Matter, including a Discussion of the Influence of the Earth's Motion on Optical Phenomena". The book is a study of the relations of micro-discontinuity to macro-continuity, of atomic matter to the electromagnetic aether, on a classical pre-1900 basis. The text was written by 1898, but parts of it had already been published in the *Phil. Trans. Roy. Soc.* and elsewhere between 1894 and 1897. Thus the ideas expressed in it were formulated some years before the decisive discoveries which opened the quantum and relativity physics of our century. "Aether and Matter" expresses the point of view of an able mind taking advantage of the facts and theories as at 1894/98.

It is not surprising that Larmor's book has been forgotten. Though Larmor was a profound thinker, he never achieved any outstanding basic result and his work had relatively little influence on the advance of fundamental theory. Much of what was most useful in "Aether and Matter" (the 'Larmor rotation', and other contributions to electron theory) had already been published elsewhere, and by 1905 it was largely out of date, owing to the work of Lorentz, Planck and Einstein. Moreover, Larmor's careful study of the historical development of his subject, leaving none of its difficulties concealed, makes heavy reading for those who have benefited by the clarifications achieved since. Even the best minds have found "Aether and Matter" indigestible; though Bohr took from it the 'Larmor rotation', which he made famous by applying it to quantized electron orbits[1].

None the less, parts of the book are fascinating, for both historical and contemporary reasons. First, he gives a masterly analysis of the history of ideas[2] relating atomic matter to the macroscopic electric continuum; and secondly, he shows (though he did not know this himself) how far his mind could reach out towards issues which are still obscure sixty years later, on the basis of the facts and theories of 1898 daringly interpreted in terms of fundamental physical ideas. This second aspect is the one with which I am here concerned: "Aether and Matter" as evidence that a perceptive application of basic ideas can point beyond established theories.

There is no need to describe the facts and theories of 1898. The fundamental ideas which Larmor employed in interpreting them can conveniently be expressed in five antitheses: atomic discontinuity/macroscopic continuity, matter/electricity, scale-fixed molecules/scale-free similarity in the macro-realm, chiral/non-chiral phenomena, and reversibility/irreversibility. By using these ideas to analyse the physics of the time, Larmor was led to identify the following issues, and to make comments on them which are still valid: the need for a characteristic length providing definiteness of scale in atomic theory; the existence of pure numbers of importance for fundamental theory; the role of chiral properties; the compatibility of molecular indeterminacy with molar determinacy.

It is the fact that Larmor could use basic principles to see so far ahead that has led me back to "Aether and Matter" many times during the thirty years since these same pure numbers and the presence of natural lengths in atomic theory began to receive widespread attention. For while in 1960 we tend to consider these issues in terms of the characteristic discoveries of the twentieth century (Planck's constant, relativistic invariance, quantized fields, new particles, etc.) in 1900 Larmor reached them from very general considerations, which in some sense may lie deeper. Thus something can be learnt from his achievement in recognizing the importance of these four issues.

I will now consider each of them in turn.

Need for Definiteness of Scale

Larmor was the first[3], known to me, to enunciate (pp. 189/193) the principle that to account for the definiteness of scale of material bodies and of their radiations atomic theory must contain at least one constant with the dimensions of a length, or the equivalent. These are not his words, but they express his idea. (Eddington, in his "Fundamental Theory", 1946, p. 16, called such systems 'scale-fixed', as against the scale-free systems lacking any such length.) Larmor regarded this necessity for scale-fixed atomic expressions as one aspect of the more general problem of reconciling the discreteness of material structure with the continuity of fields, which was the main theme of his book. For convenience I shall call the above recognition 'Larmor's principle'.

He used the method of dynamical similarity to show that the use of point electrons and electric actions depending only on e^2/m (for example, not on velocities) led to a "deficiency of definite scale", any steady system of such electrons being alterable to any other linear scale, in accordance with the similarity property of all scale-free systems[*]. But "this indefiniteness of linear scale in a material body cannot exist". Larmor reasoned that this indefiniteness might be eliminated in various ways, by introducing into the laws (*a*) a finite size of the electron; (*b*) other residual terms important at small distances; or (*c*) actions dependent on electron velocities—all of which methods are now in use in relativistic theories, though they may not be directly relevant to the structure of material bodies.

He did not anticipate the main scale-fixing method which proved necessary: the introduction of a new constant h, representing discreteness of action or angular momentum, which yielded two classes of scale-fixing constants: (*a*) in combination with $(k.T)$ and c, a statistically unique wave-length λ_m, which is a function of the temperature, through the use of the dimensionless group $(hc/\lambda k.T)$; and (*b*) in combination with e^2, m and c, a series of basic lengths, defining (with numerical factors) the scale of atoms, molecules, and characteristic optical and other wave-lengths.

Yet the fact that Larmor did not anticipate the dimensions of the necessary constant does not lessen the interest of his principle that a scale-fixing constant absent in 1898 is indispensable. For both relativity theory (by employing combinations with c, for example, e^2/mc^2) and quantum theory (by introducing h and powers of the fine-structure constant) have 'incidentally'—as we may think—achieved precisely what Larmor asserted was necessary[4]. Both theories introduced scale-fixing natural lengths into fundamental theory, and all the empirical data by which these theories are supported represent scale-fixed phenomena. All the quantum and the relativistic modifications of classical theories are necessarily scale-fixed, since by combining either h or c with the 'classical' constants GM, e, m, natural lengths are introduced into the laws.

Thus in a special, but instructive sense, Larmor might be called the unconscious father of twentieth-century physics. For Larmor did not know in what manner his principle would be satisfied, nor apparently did either Planck or Einstein know (for they never referred to this interesting fact) that the two theories they had initiated both satisfied a single principle formulated by Larmor: that fundamental theory must be scale-fixed. Indeed, twentieth-century physics has 'out-Larmor-ed Larmor'. He said: introduce a scale-fixing length. Physics has done this not once, but many times: by discovering h, by employing relativistic corrections, and finally by discovering particles to which a series of theoretically arbitrary masses have to be ascribed in order to fix the linear scale of their respective fields and orbits. So the question arises: Why does contemporary fundamental theory employ not merely the one length that is necessary but very many, the ratios of which are (*a*) powers of the fine-structure constant, and (*b*) the pure numbers relating the mass spectrum of the elementary particles? This leads us to the next point.

---

[*] The following notation is used: e, electron charge; m, electron mass; M, proton mass; c, velocity of light; h, Planck's constant; G, gravitational constant; K, Boltzmann's constant; T, absolute temperature. Also V_e, characteristic electron velocities in atoms; L_a, diameter of any atom or molecule; λ, wave-length of any characteristic optical radiation; λ_m, wave-length of the maximum in the black-body radiation law; α, fine-structure constant.

Fundamental Pure Numbers

It has been clear to most, from Newton onwards, that physics is primarily concerned with numerical ratios, and Larmor's interest in the dimensional aspects of fundamental theory, including the known existence of certain universal constants (e^2, m, c, G) and the suspected existence of others (mass of positive particle, characteristic electron velocities in atoms), led him to a remarkable achievement: the identification of what are to-day recognized as functions of three fundamental pure numbers: (1) the fine-structure constant; (2) the ratio electron/proton mass; (3) the ratio gravitational/electric actions.

Larmor did not, of course, anticipate all the fundamental pure numbers now known, such as those of the particle mass spectrum, the ratios of the lives of the particles discovered since 1932, or those arising in nuclear and high-energy systems. But he identified, and used in arguments which are still valid, functions of the above three numbers ten years before Einstein (1909) directed attention to the importance of the dimensionless group e^2/hc, and twenty-five years before many workers—Eddington, Dirac, Milne, Jordan, and others—took up the study of these fundamental empirical numbers (1925 onwards). This achievement deserves attention, not only for the sake of justice and the historical record, but also because of the challenging question which arises in one case: How could Larmor identify an expression of the fine-structure constant before h was discovered?

The Fine-Structure Constant

At any time from 1817 onwards, when Thomas Young had made observational estimates of both magnitudes, it was possible for a physicist to meditate on the ratio of the wave-lengths of the radiation from material systems to the diameters of the 'molecules' of which they were composed. For example, Cauchy suggested that the order of magnitude of the sizes of 'molecules' might be inferred from dispersion properties, but this proved wrong. After 1880, when the conception of electrical particles was being established and the empirical data were more reliable, increasing attention was paid to this ratio[5]. But Larmor was probably the first to consider it in the light of dimensional arguments applied to the theory of electrons moving in an electromagnetic continuum.

Larmor stated (p. 233) that "the very striking fact that the wave-lengths of free radiant vibrations of molecules [in which he includes atoms] are such large multiples of their diameters has always invited explanation. . . . On the dynamical conception here employed [radiation from rapidly moving electrons], it involves that the orbital velocities of the electrons are about of the same order of smallness, exceeding 10^{-3}, compared with the velocity of radiation, as are the molecular dimensions compared with the wave-lengths". Or:

$$V_e/c \doteqdot l_a/\lambda$$

which corresponds to the quantum mechanical relation:

$$A \, . \, V_e/c = \frac{B \, . \, h^2/4\pi^2 me^2}{C \, . \, h^3 c/8\pi^3 me^4} = \alpha$$

where A, B, C, are numerical factors which are functions of quantum numbers.

Thus Larmor correctly recognized the existence of a fundamental pure number, involved in electronic systems, which (with small numerical factors) must determine the ratios both of characteristic lengths and of characteristic velocities. The experimental facts led him to estimate this geometrical and kinematic ratio as of the order of 10^{-3}. Moreover, he gave the correct reason why V_e/c must be small, since "the energy of orbital groups moving with greater speeds would be through time sensibly dissipated through radiation, so that such groups could not be permanent". In fact, condensing Bohr's statement in 1932, the concept of stationary states only works because $\alpha \ll 1$, and the transition coefficients therefore small enough to be negligible in a first approximation.

Elsewhere (p. 346), Larmor argues that the internal energy function of the atom may be separated from the energy of the radiation, "for a disturbance in the aether can travel over about 10^3 diameters of the molecule during the period of a single vibration".

The radiative model on which Larmor based this analysis was that of systems of orbital negative electrons the net radiation of which was determined by the total resultant electric polarity of the atom. Though this model has been discarded, the dimensional relations underlying Larmor's argument remain valid. We call the above ratio the 'fine-structure constant' for reasons connected with relativistic dynamics, but from another point of view the associations of this name may be misleading. For Larmor's argument emphasizes that α may be regarded as a geometrical and kinematic ratio, a ratio of lengths and of velocities, into which mass enters only secondarily when it is necessary to compare radiative (electron and photon) processes with nuclear and other particle processes. Larmor's model gave the correct dimensional relations, but no model is yet known which can account for the empirical value of this ratio. While Larmor's principle asserts that a natural length is necessary in atomic theory, it does not explain why one is not sufficient.

My conclusion is that it was possible for Larmor to identify the fine-structure constant before h was discovered because this constant has geometrical and kinematic, as well as dynamical, consequences. This suggests the possibility that a geometrical and kinematic interpretation of the constant may one day help to throw light on its origin and value.

Ratio Electron/Proton Mass

In a discussion of the Zeeman effect (p. 341) Larmor first assumes, for simplicity, that e/m has the same constant value for all the electrical particles involved, and then shows that approximately the same result will be obtained if there are additional particles for which e/m is small in comparison with the value for all the others. "We may for example suppose the charges to be the same for all the ions, and the effective masses of the positive ones to be large compared with those of the negative ones . . . the velocities of the positive ones will be the smaller, inversely as the ratio of their masses."

During the 1890's values for e/m were becoming available from various sources, first indirectly and in 1897 from direct measurements ; e had been estimated from 1870 onwards ; and the masses of atoms had been determined from 1875 onwards. Thus it was natural during the 1890's to infer that positive charges were associated with much larger masses than that of the negative electron. But it seems that Larmor was one of the first to develop dimensional arguments employing the ratio electron/proton mass. Indeed, he formulated the conditions under which the motions of heavier particles can be neglected relatively to those of electrons ; for example, in calculations of the Zeeman effect, in which the influence of the magnetic field is treated as equivalent to a uniform ('Larmor') rotation of the system.

The Ratio Gravitational/Electric Actions

Larmor was interested in the weakness of gravitational relative to electrical actions and in the bearing of this on the problem of a unified theory of the two realms. In this connexion he posed the question, "Are the linear equations of the Aether exact ?" (p. 186). Clerk Maxwell's equations are linear, indeed "they must be so if all kinds of radiations are to travel with the same speed in the celestial spaces". But Larmor noted that the theory of the propagation of sound involves the neglect of terms (normally unobservable) of the order of the square of the ratio molecular velocities/velocity of sound. He therefore asked : "Why then should not relatively minute phenomena like gravitation be involved in similar non-linear terms, or terms involving differentials of higher orders . . . which are as insignificant compared with the main ( ) linear terms as is the gravitation between two electric systems compared with their ( ) electric forces ?"

He considers the difficulties in this assumption, and suggests that the smallness of the optical dispersion that would arise from such non-homogeneity of the aether "may be estimated by comparing the electric force between two ions with their gravitational attraction". Larmor's conclusion, on the basis of the facts available to him, was that "there is little to be urged in favour of leaving this loophole for the explanation of gravitation". This in conformity with doubts that he and others (for example, A. N. Whitehead) felt as to whether a heterogeneous continuum, without severe restrictive conditions, can provide a sufficiently stable basis for a theory of systematic measurements, that is, for the observed quantitative consistency between phenomena separated in space and time.

However that may be, we are to-day no more certain than Larmor was whether or not electrical actions correspond to the main terms and gravitational to residual ones in a non-linear field.

Chiral Properties

In a section "On Dynamical and Material Symmetry" (p. 140) Larmor considers the invariance properties of electrical systems under two transformations : time reversal, or the substitution of $-t$ for $+t$, and mirror reflexion, or the substitution of $-x$ for $+x$; invariance under changes of linear scale is treated elsewhere (pp. 176, 189). He is particularly interested in chiral[6] properties, and discusses these in several contexts (pp. 27, 142, 208).

Larmor enters into a detailed analysis of the influence of motion relatively to the aether on chiral properties, and discusses the connexions between chirality, reflexion, sign of electric charge, magnetic fields, and optical rotation properties. Part of his argument was challenged at the time, and it is now largely superseded.

Yet even here Larmor's insight is remarkable. One example (p. 27) will suffice : "The duality arising from the assumption of two kinds of electrons, only differing chirally so that one is the reflexion of the other in a plane mirror, will present nothing strange to those physicists who regard with equanimity even the hypothesis of the possible existence of both positive and negative matter". This was written in 1898.

Atomic Indeterminacy

Larmor divided physics into two related realms : (i) the fundamental 'molecular' phenomena (now called 'atomic') largely obscure to him, where discreteness plays a basic role ; and (ii) the 'mechanical' phenomena of the macroscopic smoothed-out averages of electromagnetic actions in the aether. He believed (at least until 1898) that the true connexion of the two realms would be discovered by interpreting fundamental electrical particles as knots, foci, or small regions of strain in the aether. Though this model for particles may seem naïve to-day, his clarity regarding the logical and mathematical inter-relations of micro- and macro-phenomena is impressive. Throughout the book his main concern is the nature of the relation of discrete actual distributions (mainly electric particles) to continuous macroscopic and directly observable actions (mainly the effects of currents and fields).

An eloquent passage (p. 272) describes the advance of physics from the macro- to the micro-realm "by the gradual reclamation of an empirical fringe surrounding the settled domain of the science". One cannot help thinking of Bohr's Correspondence Principle as one reads : "Here progress has been effected mainly by transferring to the molecule, considered as itself a material system [that is, for Lamor, atomic], dynamical ideas the same as or analogous to those that hold good in the mechanics of sensibly continuous bodies". He was aware of the contemporary ignorance regarding the atomic realm, and believed that the progress that was being made was only possible because the individual molecule is "a nucleus in that universal aethereal *plenum* that is the transmitter of half our impressions" and therefore must in some degree conform to laws based directly on macroscopic observation.

Yet "there can be an unlimited amount of molecular structure and function in a given system, which is unconnected with any mechanical effect occurring in that system treated as continuous matter" (p. 287). "Mechanical determinateness thus need not involve molecular determinateness".

Conclusion

By the time "Aether and Matter" was in print, Larmor had overcome the tendency to demand mechanical models of the aether (medium with rotational elasticity, vortex rings, wheels with bands, etc.) which had been prevalent between 1860 and 1890. Whittaker[7] considered that it was "chiefly under the influence of Larmor [that] it came generally to be recognized that the aether is an immaterial medium *sui generis*, not composed of identifiable elements having definite locations in absolute space".

Larmor's contributions to electro-magnetic and electron theory are fully reported in Whittaker's "History". Here I have been concerned with a different task: to show that Larmor saw far beyond the typical problems of 1900 to issues that are still unresolved. This was possible, I believe, because a radical theoretical analysis, applied with judgment, can sometimes lead beyond contemporary theories and help to open up new problems the solution of which may lie well ahead.

Certainly the main theme of Larmor's book, the relation of basic discreteness to macroscopic continuity, is far from exhausted to-day. There is no golden rule for discovering the new ideas which will prove fertile in relation to this problem, for example, in nuclear processes. But there is a rational method of preparing the ground: to analyse the known facts, and the hitherto successful theories, with as little prejudice as possible in terms of basic principles which appear worthy of confidence. It would be of great value to-day to be able to identify issues lying as far ahead as those Larmor recognized in 1900.

---

[1] See Bohr, N., *Phil. Mag.*, 27, 506 (1914) (see p. 519).

[2] See Larmor's "Mathematical and Physical Papers" (2 vols., 1929). for several additional historical surveys.

[3] I have already discussed Larmor's originality in this respect; see "On the History of Natural Lengths", *Annals of Science*, 10, 20 (1954).

[4] For an analysis of this characteristic of twentieth century physics see Whyte, L. L., *Z. Phys*, 56, 809 (1929), "The Presence of a Universal Constant with the Dimensions of a Length". To ensure that I had understood "Larmor's principle" correctly, I sent him a copy of this paper. For his reply (Sept. 27, 1929), see *Brit. J. Phil. Sci.*, 4, 337 (1954).

[5] Particularly after the discovery of h. For references to papers dealing with it before Bohr, see Bohr, N, *Phil. Mag.*, 26, 1 (1913), especially p. 6.

[6] Larmor adopts this term from Kelvin (1884). For references and an improved definition of 'chirality' (not assuming, as Larmor does, any unique axis or helical properties), see Whyte, L. L., *Nature*, 182, 198 (1958).

[7] Whittaker, E. T., *loc. cit.*, 1, 303. See also, Larmor, J., Brit. Assoc. Reports (1900), p. 618.

OBITUARIES

Dr. Andrew McKellar

ASTROPHYSICISTS have learned with great regret of the death, at the early age of fifty, of a well-known and very popular colleague, Dr. Andrew McKellar, assistant director of the Dominion Astrophysical Observatory, Victoria, B.C. McKellar was first brought into contact with astronomy as a summer student at the Dominion Astrophysical Observatory about thirty years ago, when he was an undergraduate at the University of British Columbia, Vancouver. He proceeded from there to the University of California, Berkeley, where he gained his Ph.D. and laid the foundations of the spectroscopic technique which later served him so well. After two years in the spectroscopic laboratories of the Massachusetts Institute of Technology as a National Research Council Fellow, he returned to Victoria, to become a permanent member of the staff, and spent the rest of his life there.

McKellar was the first to identify molecules in the interstellar gas, a matter of great importance for problems of interstellar matter, especially in relation to the equilibrium between gas and dust. These questions are part of larger problems involving the formation of stars from interstellar matter, about which so much is said and so little understood. McKellar's identification of these molecules was far more than an achievement of the obvious; the molecules are unsaturated, their bands in the conditions of interstellar space are reduced to one or two lines only, and these are usually quite faint.

McKellar was also one of the leading authorities on molecular bands in stellar spectra. He did a great deal of exploratory work in the red and near infra-red, discovering and identifying hitherto unrecognized bands. His most noteworthy achievement in this field, however, was to show that the ratio of abundance of the carbon isotopes carbon-12 and -13, while about 90 in some stars (as on Earth) is about 3½ in certain *R* stars, a significant fact for nuclear physicists and all who are interested in the origin of the elements. While working in the red region he also found that some carbon stars contain considerable quantities of lithium, an element which is normally present in stars only in very small quantities, presumably because it is easily destroyed by nuclear processes in stellar interiors.

Among other work, McKellar made important contributions in the rather difficult field of spectroscopy of comets. He was one of the first to aluminize a large telescope mirror. He took a leading part in the design of spectroscopic equipment at the Dominion Astrophysical Observatory. He was also a leader of the small group concerned with unusual eclipsing binaries such as ζ Aurigae, 31 Cygni, VV Cephei, where a comparatively small hot star is eclipsed by a large and cool supergiant. Absorption lines due to the atmosphere of the cool star appear near the beginning and end of eclipse and can be used to study the outer structure of the supergiant. Apart from the Sun, this is our only fairly direct means of exploring a stellar atmosphere. The results suggest an irregular field of huge and variable prominences, quite unlike the stratified layers of conventional theory.

Perhaps the most important feature of McKellar's work was his ability to obtain significant results without burdening astronomical literature with over-lengthy papers and irrelevant detail. He himself with characteristic modesty attributed this to economy of effort imposed by a very long illness, which he knew must eventually prove fatal. His many friends will miss "Andy's" quiet humour and charm, and will mourn an astronomer who had the gift of courage as well as of scientific insight. He leaves a widow and a son and daughter.

R. O. REDMAN

Mr. J. P. Mills, C.S.I., C.I.E.

James Philip Mills, who died at his home in Sydling St. Nicholas, Dorchester, on May 12, was born in 1890. He was the son of James Edward Mills, was educated at Winchester and Corpus Christi College, Oxford, and entered the Indian Civil Service in 1913. He was allotted to Assam, and in 1916 was posted to the Naga Hills, where he occupied himself at once on an ornithological survey of the district for the Bombay Natural History Society, but was soon caught up in the ethnographical work which constituted his major contribution to science. His monograph on "The Lhota Nagas" was published in 1922, and "The Ao Nagas" followed in 1927. After an absence on leave and a term as deputy commissioner of Cachar (whence he once wrote to me apropos of some controversy with a difficult planter, that he was contemplating a monograph on "Scotsmen and Other Hill Tribes of Cachar"), he returned to the Naga Hills as deputy commissioner, and "The Rengma Nagas" followed ultimately in 1937. Meanwhile, he had been appointed honorary director of ethnography for Assam (1930), and in 1943 he was appointed Advisor to the Governor of Assam for Tribal Areas and States, a post which enabled him to gain a very considerable knowledge of the hill tribes on both frontiers of the province as well as to make practical use of his anthropological knowledge and experience. Before this period he had been lent to the Bengal Government to recommend on the administration of the Chittagong Hill Tracts, and after touring there for two months, during which he covered some five hundred miles mostly on foot, he submitted a most discerning analysis of what was wrong with the existing condition of affairs and what was needed to improve the administration there.

Mills was made C.I.E. in 1941 and C.S.I. in 1947, in which year he retired. In 1948 he was appointed reader in the School of Oriental and African Studies, from which he retired in 1955. The bibliography of the ethnology of Assam which he compiled during this period has never been separately published though used by other bibliographers. In 1942 he was awarded the Rivers Memorial Medal of the Royal Anthropological Institute for his ethnographical work in the Naga Hills, and during 1951–53 he was the president of that society.

Mills made an admirable colleague in administration. Though not of very robust constitution he never spared himself, and was always ready to go anywhere and tackle anything; and his unfailing fund of humour and tolerant good temper endeared him to all who came into contact with him, even the wrongdoers who suffered at his hands. In Assam it is perhaps his many friends in the Ao Naga tribe who will most regret the news of his death.

He married in 1930 Pamela Moira, daughter of J. Foster Vesey-FitzGerald, who with two daughters survives him.

J. H. Hutton

NEWS and VIEWS

Mechanical Engineering at Manchester : Prof. H. Wright Baker

Prof. H. Wright Baker, head of the Mechanical Engineering Department at the Manchester College of Science and Technology, will retire this summer. Prof. Wright Baker was educated at Liverpool College and in the Engineering Department of the Faculty of Science, University of Manchester. After obtaining his first degree, he joined the War Victims Relief Committee and for four years was head of its transport department. He afterwards went back to his University Department as an assistant lecturer, being later promoted to lecturer and senior lecturer under the late Prof. A. H. Gibson. For his extensive researches into piston temperatures in internal combustion engines, he was awarded the D.Sc. degree. Prof. Baker was appointed to his present chair in 1939. During the War, the size of his Department grew steadily to cater for the training of Service personnel as well as of undergraduates. His Department continued to grow after the War to its present large size in accordance with national requirements; and its range of research and teaching activities broadened. During the past decade his interests have been directed towards developing workshop technology as a subject worthy of academic attention. Metrology was singled out as his particular interest, and under his ægis the Royce Laboratory was created and stands as one of the finest of its kind in Britain. Prof. Baker's interest in machine tools has led to special emphasis being placed on teaching and research in production engineering. He is a founder member of the International College of Production Engineering Research. Prof. Baker's publications consist of papers and books on thermodynamics, metrology and education. He has successfully pioneered a 'clearing house' system for students seeking university places in engineering, and his opening of the Bronze Dead Sea Scrolls—a matter of courage and considerable technical skill—is one for which he will long be remembered.

Prof. W. Johnson

Mr. William Johnson has been appointed to the chair in mechanical engineering in the Faculty of Technology of the University of Manchester, as from August 1960. Mr. Johnson was educated at the Central Grammar School for Boys and later at the College of Technology (as it then was) in the Faculty of Technology of the University of Manchester. After graduating in mechanical engineering in 1943, and having become an undergraduate in that Department a year after Prof. H. Wright Baker became the head, Mr. Johnson joined the Army and was afterwards commissioned in the R.E.M.E. He served until late 1947 in various workshops at home and abroad, joining the Home Civil Service as an assistant principal in 1948. Also in 1948 he took an external degree of the University of London in mathematics. In 1950, Mr. Johnson became lecturer in engineering at what was then the Northampton Polytechnic, London, and in 1952 he moved to the University of Sheffield, where he became interested in the theory of plasticity, especially as applied to the forming processes. The results of his researches appeared in a number of reports to the British Iron and Steel Research Association. Mr. Johnson was secretary of the Yorkshire Branch of the Institution of Mechanical Engineers between 1953 and 1956, in which year he was appointed senior lecturer in mechanical engineering in the Faculty of Science at the University of Manchester. His researches during this period in the Faculty of Science were extended, but especially he has made considerable contributions to knowledge about the fundamental mechanics of metal extrusion and forging. Mr. Johnson is editor and founder of the *International Journal of the Mechanical Sciences*.

Botany at Newcastle on Tyne: Prof. Meirion Thomas, F.R.S.

WHEN he retires from the chair of botany at King's College, Newcastle on Tyne, at the end of the present session, Prof. Meirion Thomas will have completed thirty-six years service in the Botanical Department of that institution, first as lecturer during 1924–43, then as reader until 1946 when he was appointed to the chair in succession to Prof. J. W. Heslop Harrison. After serving in the army throughout the First World War, first in the South Wales Borderers, but for most of the time with the Royal Engineers, Prof. Thomas entered Trinity Hall, Cambridge, where he remained until his appointment to the lecturership in Newcastle. At Cambridge, he combined the study of biochemistry and botany with achievement in the field of sport, obtaining his 'blue' in association football. Prof. Thomas is distinguished for his long series of researches in plant metabolism, particularly in regard to the respiratory and allied processes in apple fruit and succulent plants. Many of his papers have appeared in the *New Phytologist*. He was president of Section K (Botany) of the British Association at its Belfast Meeting in 1952 where his presidential address was a masterly review of our knowledge of such metabolic processes in higher plants. Prof. Thomas is also the author of a well-known text-book on plant physiology, the success of which may be judged from the fact that it is now in its fourth edition. His friends will wish him a long and happy retirement. He is to be succeeded by Prof. J. H. Burnett, professor of botany in the University of St. Andrews (see *Nature*, 176, 1002; 1955).

Bacteriology at St. Mary's Hospital: Prof. R. E. O. Williams

DR. R. E. O. WILLIAMS, who has been appointed to the chair of bacteriology at St. Mary's Hospital, has long maintained an interest in both the scientific and the clinical aspects of bacteriology. Dr. Williams was educated at Sherborne School and the University of London. He obtained a B.Sc. at University College in 1937 and read medicine at University College Hospital, qualifying in 1940. He entered the Emergency Medical Service in 1941 and transferred to the Medical Research Council Wound Infection Unit in 1942. In 1946 he joined the Public Health Laboratory Service and was appointed director of the Streptococcal and Staphylococcal Reference Laboratories and of the Air Hygiene Unit in 1949. Dr. Williams has made a special study of hospital cross-infection, and the laboratories in which he has worked and has later directed have made notable contributions to this field. His name is associated particularly with important research into air hygiene and the typing of streptococci and staphylococci. In the latter context the energetic development of phage typing in the epidemiology of staphylococcal infections has been of prime importance and owes a great deal to him and his group. Dr. Williams has published numerous papers on all the facets of bacteriology in which he is interested. He has travelled extensively and is well known to scientific colleagues in many countries.

Royal Society Tercentenary Exhibition

As one of the functions of the Royal Society tercentenary celebrations this year, a conversazione is to be held at Burlington House on the evening of July 23. There will be on this occasion an exhibition in the Diploma Galleries of the Royal Academy of Arts, illustrating British scientific achievements during recent years. The exhibition will differ somewhat from that usually arranged for a Royal Society soirée. There will be fifteen sections, each devoted to some field of science in which British contributions have been of outstanding importance, and in most cases several research centres will be represented in each section. The fields which have been selected are: calculating machines; physics of the Earth, ocean and atmosphere; exploration by radio; fundamental particles; solvent extraction of plutonium; refined chemical separation; metals; molecular structure of biological systems; abnormal hæmoglobins and human chromosomes; natural selection; microbial genetics; antibiotics; vitamins; electrophysiology; physiological and biochemical aspects of plant growth. The exhibition will remain open from 10.30 a.m. to 6 p.m. from Monday, July 25, until Friday, July 29. On Monday, Tuesday and Wednesday, admission will be by ticket only. Schools, colleges, scientific societies and professional institutions are being informed of the exhibition and tickets will be issued to them. On July 28 and 29 the exhibition will be open to the public.

U.S. Expenditure on Academic Research and Development

A PRELIMINARY report on research and development in colleges and universities in the fiscal year 1958 issued by the National Science Foundation shows that during 1954–58 expenditure on research and development in the natural and social sciences at colleges and universities in the United States increased from 409·7 million dollars to 735·8 million dollars, in which period Federal expenditure for research and development in colleges and universities proper increased from 140·7 million to 217·9 million dollars. In 1958 expenditure on research and development in colleges and universities proper amounted to 327·5 million dollars; agriculture experiment stations, including schools of agriculture, to 119·2 million dollars; and in Federal contract research centres, to 289·1 million dollars. At universities and colleges proper 74 per cent of this expenditure was on fundamental research, compared with 35 per cent at agricultural experiment stations and 24 per cent at Federal contract research centres. Of the total 735·8 million dollars, 186·4 million dollars was expended in engineering sciences (26·3 per cent on fundamental research); 262·3 million dollars on physical sciences (49·5 per cent); 251·5 million dollars on biological sciences (61·7 per cent); and 35·6 million dollars on social sciences (56·9 per cent). Of the 327·5 million dollars expended at colleges and universities proper, 67 per cent came from the Federal Government, 12 per cent from the Institution's own funds, 11 per cent from foundations, 8 per cent from industry and 2 per cent from other sources. Total indirect, or overhead, costs of conducting current research are estimated at 28 per cent of direct costs.

Pauli Memorial Room at CERN

At the suggestion of Mrs. Pauli, the personal library of her husband, the late Prof. Wolfgang Pauli, has been transferred to the European Organization for Nuclear Research (CERN) in Geneva. On June 14, following one of the meetings of the sixteenth session of CERN Council, a brief ceremony marked the inauguration of the Pauli Memorial Room, where the volumes composing the library of the great scientist have been housed. This consists of some 700 books dealing with literature and philosophy in addition to theoretical physics. It also includes sets of periodicals and a unique collection of reprints.

Mathematics, Education and Industry

The successful Oxford conference of 1957 on mathematical education and industry was followed up in 1959 by a similar conference at Liverpool, attended by teachers, research workers and industrialists (Mathematics, Education and Industry: a Record of a Conference of Teachers, Research Scientists, and Industrialists, held at the University of Liverpool, April 1959. Pp. 156. London: *Technology*, The Times Publishing Co., Ltd., 1960. 7*s*. 6*d*.). The summary of the papers and discussions now available ranges over a wide field; the teacher has now been told that while the research worker demands a high standard of mathematical technique, the needs of industry at the moment are for clear thought expressed through a fairly elementary technique. On the other hand, the teachers have been able to explain to the research workers and to the industrialists the limitations under which the school teacher of mathematics is obliged to work; in a school of moderate size, sixth-form mathematics cannot be split into a very large number of groups and a common core of work must be accepted, so that special interests cannot be sure of receiving full emphasis. One topic which should be further explored at a later conference is the place of numerical analysis in the school. On the present showing, the research workers and industrialists do not seem to be sure what they would like the schools to do, and the teachers do not seem to have studied available school texts which show what can be done. But on the whole this pamphlet leaves a very pleasing impression of increasing co-operation between the two parties.

National Museum of Canada

Since 1957 the annual reports of the National Museum of Canada have been discontinued, and an administrative report of the Museum appears in the annual report of the Department of Northern Affairs and National Resources. To provide for the publication of short papers, which formerly appeared in the annual reports of the Museum, a series of "Contributions" is now issued. These permit of the grouping of the papers into the various sciences covered by the Museum, and the first three deal with anthropology, botany and zoology (Canada: Department of Northern Affairs and National Resources. National Museum of Canada. Bulletin No. 160: "Contributions to Botany", 1958. Pp. iii+148 (3 plates). 2 dollars. Bulletin No. 162: "Contributions to Anthropology", 1957. Pp. iii+203 (28 plates). 2 dollars. Bulletin No. 166: "Contributions to Zoology", 1958. Pp. ii+59. 1 dollar. Ottawa: Queen's Printer, 1959 and 1960). The "Contributions" are well produced, amply illustrated and attain a high standard in scholarship. Typical papers deal with the salt-marsh vegetation of Churchill, Manitoba, some freshwater fishes from north-eastern Quebec and Labrador, the dentition of rabbits, and a description of Sadlermiut houses excavated on Southampton Island.

The Fauna Preservation Society

The annual report of the Fauna Preservation Society for the year ended December 31, 1959, records a deficiency of £153 on the year, but donations and legacies received during the year amounting to £4,435 have been credited to the General Reserve Fund and membership increased by 348 to 1,799 (pp. 12. London: Fauna Preservation Society, c/o The Zoological Society of London, 1960). This was due considerably to the interest aroused in the preservation of wild life by 'Operation Noah', launched to help the rescue work already begun by the Game Preservation and Hunting Association of Northern Rhodesia. The rescue ship *Erica* has been built and entered into service, and in June the Society undertook the work of the Survival Service Commission of the International Union for Conservation of Nature. A special investigation also was started into the position of the African black rhinoceros to consider whether this rhinoceros should be regarded as an endangered species and special efforts made for its preservation.

The Institute of Professional Civil Servants

The fifteenth annual report of the Institution of Professional Civil Servants, for the year 1959, presented to the annual delegate conference on May 23, characterizes the year as one of frustration, despite the 3·5 per cent pay supplement on salaries up to £2,000 a year, the Coleraine Committee's recommendations for the higher Civil Service, the 10 per cent increase in night-subsistence allowances and the commencement of the review of all subsistence allowances (pp. 64. London: Institution of Professional Civil Servants, 1960). Membership at December 31 was 51,632 compared with 52,239 in the previous year. The Institution continues to devote time and energy to publicizing the need for more scientific professional and technical workers, and for more, and better, planned use of this manpower; but the Pay Research Unit surveys and consideration of the reports on those surveys have involved an enormous time-lag, and this organization is to be reviewed in 1960. Concern is expressed at proposals for dealing with staff structure in the Atomic Energy Authority, and the report also describes negotiations dealing with the use and recruitment of professional engineers and particularly with the possible redundancy among such officers caused by devolution.

Isotope Information Bureau

The Isotope Information Bureau, situated on the ground floor of the London Office of the United Kingdom Atomic Energy Authority in Charles II Street, was opened on June 16 by Sir Roger Makins, chairman of the Authority. The ceremony was attended by Sir Hugh Beaver and Sir Ralph Cochran, representing the Federation of British Industries, and by representatives of the Institute of Directors, the British Institute of Management, the Department of Scientific and Industrial Research and the Board of Trade. Sir Roger, in an address of welcome, said that the Authority felt that the stage had now been reached at which radioisotopes could be regarded as true and tried tools and that industry would gain great benefit from their widespread adoption. He expressed the hope that all those interested in the production and use of isotopes would take the opportunity of visiting the Bureau, where the Authority was putting radioisotopes in the 'shop window'. Sir Hugh Beaver, acting president of the Federation of British Industries, commended the Authority on the excellent work it had done on research and development into isotope uses, and expressed the hope that industry would come forward and make use of the facilities which the Authority could make available in the form of advice and consultancy. The Bureau, which is open to the general public, is to be staffed by scientific personnel from the Authority's Radiochemical Centre at Amersham, who will be able to give on-the-spot advice to industrialists, doctors and research workers. Radioisotopes, the trade in which already amounts to nearly a million pounds, are widely used in industry, medicine, agriculture and research in the United Kingdom, and the Authority's Radiochemical Centre at Amersham supplies isotopes to more than sixty countries in all five continents. Sir Roger remarked that the use of radioisotopes by British industry could easily be increased tenfold.

International Co-operation and the Production of Calcium-47

FOLLOWING a meeting of experts on the production of calcium-47 convened by the International Atomic Energy Agency in Vienna in December 1958, there have been successful efforts to produce this very useful radioisotope in Great Britain and the United States. Agency research contracts have so far been awarded to institutions in France and Sweden to promote research on production as well as practical applications of Ca-47. As reported at a second meeting held in December 1959 in Vienna, limited amounts of this isotope are now available from Amersham and Oak Ridge. Although the present Ca-45 contamination would not permit the use of this product for experiments on normal healthy persons, it is considered satisfactory for diagnostic and research work in patients and for agricultural and other applications. The International Atomic Energy Agency is now developing a programme to assist, through research contracts, users of this isotope to procure it and to co-ordinate further work on applications of Ca-47 as well as its production by methods other than the calcium-46 $(n\gamma)$ – calcium-47 reaction.

Addiction-producing Drugs

IN its tenth report, the Committee on Addiction-producing Drugs which was set up by the World Health Organization recommends that eight new substances derived from different chemical groups and all having morphine-like effects should be subject to international control (Technical Report Series, No. 188. Pp. 16. Geneva: World Health Organization; London: H.M. Stationery Office, 1960. 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollar). These substances are allylprodine, benzethidine, furethidine, lævophenacylmorphan, metazodine, norlævorphanol, phenazocine and piminodine. The Committee feels that the fundamental criterion for the establishment and degree of control is the extent to which drug-induced behavioural disturbances are a risk to the community, for neither the chemical structure *per se* nor any definition, however descriptive, can be a complete guide indicating which substances should be placed under control. Consequently, there is a need for research along various lines in the field of drug-addiction. In particular, to help the World Health Organization in carrying out its functions, the Committee must have at its disposal the results of basic and applied research in this field. So far, insufficient support has been forthcoming for such investigations. The Committee strongly urges that research on drug addiction should be strengthened and expanded, since it continues to be a serious international health problem. The Committee makes certain technical comments concerning the draft of the Single Convention on Narcotic Drugs. It expresses the view, *inter alia*, that only those preparations should be retained as exempted preparations which constitute no risk to public health, and from which the potentially addicting agent is not readily recoverable.

Mud Fauna of the Stour Estuary

ONE of the most striking features of any estuary is the replacement of freshwater animals by marine animals as the river progresses towards the sea. In spite of the presence of numerous estuaries in the British Isles, surprisingly few accounts of their ecology have been published. A study of the River Stour estuary was made by Frances Bull, Helen Honeyman and Susan Knott over a period of three weeks during June 1958 (Transactions of the Suffolk Naturalists' Society, including the Proceedings of the year 1959. Vol. XI, Part III. Pp. 217–288. Ipswich: Miss Janet C. N. Willis, Honorary Secretary, 1 Holly Road, 1960. 7*s*. 6*d*.). The scope of the investigation was limited to burrowing animals and to their distribution in relation to salinity, substrate, and their level on the shore. Although no hard and fast lines can be drawn, the fauna of the estuary roughly falls into three groups, depending on where each species attains a maximum density. It can be inferred that a maximum density implies optimal conditions for the life of the species. There are those species which have their maximum density in the upper reaches of the estuary, although they may occur in limited numbers right down to Shotley. Examples of this group are *Corophium volutator*, *Nereis diversicolor* and *Streblospio shrubsolii*. At the other end of the scale are those species which do not penetrate to the top of the estuary and have a maximum density towards the seaward end. These, for example *Cardium edule* and *Nephthys hombergii*, are generally marine species which have managed to penetrate the estuary. Although they can live in waters of lower salinity than the sea, they appear to be unable to survive the wide fluctuations of the upper reaches. Finally, there are those species with a mid-estuarine maximum, for example *Hetercirrus* sp., *Scoloplos armiger* and *priapulos caudatus*. A striking feature of the distribution of animals in the estuary is that, as soon as salinities become constant between high and low water, and the overall salinity higher, the total number of animal species rises, although the maximum density of any one is usually lowered. At Buck's Horns a total of 866 *Corophium volutator* and 720 *Nereis diversicolor* were collected from four stations, while an odd *Scrobucularia plana* and *Cyathura carinata* were the only other species present. The other extreme is shown by the transect at Shotley, where eighteen different species were found; the maximum number of any one species collected was 137 *Scrobucularia plana* from six stations.

Scottish Geology

TWENTY-ONE years ago the Geological Survey of Great Britain inaugurated a new publication, the *Bulletin*, to accommodate short scientific reports by members of its staff, and since then more than seventy noteworthy papers on British geology have appeared within its covers. The latest number (*Geol. Surv. G. Britain Bull.*, No. 16. Pp. 178+11 pl. London: H.M. Stationery Office, 1960. 20*s*. net) is a compilation of seven contributions to the geology of Scotland. Two of them describe the strata encountered in deep borings sunk by the National Coal Board in the Firth of Forth, off the coast of Fife, to prove the geological structure beyond the present limits of undersea mining. A third presents a full discussion of the remarkable and little-understood post-diagenetic replacements of coal seams by limestone, found locally in the Coal Measures of Ayrshire and in some other British coalfields. Other papers are concerned with Carboniferous lamellibranchs, with the classification of Scottish Carboniferous strata, and with the igneous rocks of the Pentland Hills; and the volume concludes with a petrological account of the sea-stack of Rockall, based on specimens collected when it was 'annexed' by H.M.S. *Vidal* in 1955. This almost inaccessible islet of aegerine-granite, 200 miles west-north-west of the Outer Hebrides, is renowned as a geochemical curiosity, and it has given its name to the rare rock-type rockallite, present in the granite as veins and segregations which are outstandingly rich in cerium and zirconium.

Parametric Amplification

A RECENT issue of *Philips Technical Review* contains an article entitled "Experiments in the Field of Parametric Amplification", by B. Bollée and G. de Vries (21, No. 2 (1959–60), obtainable from N. V. Philips' Gloeilampenfabrieken, Eindhoven, Holland). The principle of parametic amplification is described on the basis of the century-old Melde's experiment (*Ann. Physik u. Chemie.*, 109, 193; 1860), in which a taut slightly elastic string is pulled lengthwise at the appropriate frequency—nowadays termed the 'pumping' frequency—causing the string to vibrate transversely at half this frequency. The electrical analogue is a resonant circuit in which the capacitance is varied periodically. One example of a voltage-dependent capacitance is the germanium diode, which has already been used by some workers as the basis of a parametric amplifier. The authors of the article, however, describe a system which uses a magnetostrictive resonator of 'Ferroxcube' as the basis of the variable capacitor. Longitudinal vibrations are produced in the core, which is centrally clamped; the ends of the core are ground to be parallel to each other, and opposite each of them is mounted a parallel, fixed electrode at a spacing of 80μ, giving a total capacitance of 532 *pF*. With a pumping frequency of 22 kc./s., satisfactory 'noise-free' oscillations were obtained at half this frequency, and various theoretical predictions were verified. Another system, briefly described in the article, uses a piezoelectric resonator with a pumping frequency of 3 Mc./s. This gave results similar to those obtained with the magnetostrictive pump.

Index of Crystallographic Supplies

PREPARED under the editorship of Dr. A. J. Rose (Université de Paris, Laboratoire de Minéralogie et Cristallographie), the "Index of Crystallographic Supplies" is the second in the series of indexes undertaken by the Commission on Crystallographic Apparatus of the International Union of Crystallography (Union Internationale de Cristallographie: Commission des Appareils Cristallographiques. Répertoire de Metériel Cristallographique. 2e Édition. Pp. xxvi+126. Paris: Société Francaise de Minéralogie et de Cristallographie, 1959. 1,250 francs; 2.50 dollars). The first, entitled "Index of Manufacturers of Apparatus and Materials used in Crystallography", was compiled by Prof. A. Guinier and published in September 1956. The information contained in the present Index has been taken from manufacturers' catalogues, and no attempt is made to assess the relative merits of the equipment listed. The volume consists of four parts. Part 1 lists equipment and suppliers, classifying the material in eleven groups according to their fields of application and giving brief specifications to help crystallographers in their selection; Part 2, consisting of three chapters, quotes references to publications concerned with the reading and interpreting of patterns, books and text-books, and the names of periodicals with either the word crystallography or mineralogy in their titles or sub-titles; Part 3 consists of classified advertisements; and Part 4 gives the addresses of manufacturers and suppliers. The table of contents is in English, French, German and Russian, and the rest of the text in a mixture of mainly English and French. The Index is being distributed gratis to all crystallographers, but additional copies can be purchased from the International Union.

Organization for European Economic Co-operation: American Awards

THE Organization for European Economic Co-operation and the National Science Foundation recently announced award of the first twenty-seven senior visiting fellowships in science. These awards are designed to improve scientific work at the Fellow's home institution by training the Fellows in specialties that the institution desires to strengthen. The National Science Foundation is administering the fellowship programme for United States citizens. The recipients will study primarily in member countries of the Organization for European Economic Co-operation, and several will visit more than one country. They will work in Australia, Austria, Denmark, France, the Federal Republic of Germany, Italy, The Netherlands, Portugal, Sweden, Switzerland and the United Kingdom. Scientists from the member countries will also study in the United States under this programme, which is supported by the Organization and the United States.

The Biological Engineering Society

A NEW Society, called the Biological Engineering Society, was inaugurated at a meeting held at the Royal College of Surgeons on June 10. The meeting was attended by doctors, physiologists, electronic engineers, mechanical engineers and physicists from many parts of the country. The purpose of the Society is to bring together members of these different disciplines, from hospitals, research institutes and industry, to further the applications of engineering to biological and medical problems. Prof. R. Woolmer, professor of anæsthesia at the Royal College of Surgeons, was elected first president. The Council consists of: Dr. P. Bauwens, Prof. A. V. Hill, Dr. A. Nightingale, Dr. G. Pampiglione, Mr. W. J. Perkins, Mr. B. Shackel, Dr. N. Smyth, Dr. A. M. Uttley, Mr. H. S. Wolff, Dr. B. M. Wright. The acting secretary is Dr. A. Nightingale, Physics Laboratory, St. Thomas's Hospital, S.E.1.

Lady Tata Memorial Trust

THE Trustees of the Lady Tata Memorial Trust, on the recommendation of the (European) Scientific Advisory Committee, have made the following awards for research on leukæmia and allied diseases in the academic year beginning October 1: *Grants for research expenses*, Dr. B. M. Braganca (Indian Cancer Research Centre, Bombay); Dr. J. Pontén (Pathology Institute, Uppsala); Dr. M. Simonsen (Institute of Pathological Anatomy, Copenhagen); Dr. H. J. Woodliff (New Pathological Laboratory, Radcliffe Infirmary, Oxford). *Scholarships*, Dr. L. Chieco-Bianchi (Institute of Pathological Anatomy, Bari); Dr. J. Hastrup (Institute of General Pathology, Aarhus).

University News: London

THE following appointments have been announced: Dr. H. Harris, reader in biochemical genetics at the London Hospital Medical College, to the University chair of biochemistry tenable at King's College; Mr. A. F. Huxley, reader in experimental biophysics in the University of Cambridge, to the Jodrell chair of physiology tenable at University College.

Yale

THE following changes in staff of the Department of Botany in Yale University have been announced: Prof. Paul B. Sears (conservation and ecology) will retire as from July 1, 1960. Prof. Oswald Tippo (anatomy) will leave his post as chairman of the Department to assume duties as provost of the University of Colorado at Boulder as from July 1, 1960. Assistant Prof. Theodore Delevoryas (palæobotany) will leave to accept a post as associate professor in the Department of Botany in the University of Illinois. Assistant Prof. Kenton L. Chambers (cytotaxonomy) will leave to accept a post as associate professor and curator of the Herbarium in Oregon State College. Prof. Arthur W. Galston (plant physiology) has been appointed chairman of the Department as from July 1, 1960. During the academic year 1960–61, when Prof. Galston will be on sabbatical leave at the Commonwealth Scientific and Industrial Research Organization, Canberra, Australia, Prof. Norman H. Giles (cytogenetics) will serve as acting chairman. Dr. Ian M. Sussex (plant morphogenesis), of the Department of Biology, University of Pittsburgh, has been appointed associate professor. He will assume his post on July 1, 1960, and will teach courses in anatomy and developmental morphology. Dr. Diter H. von Wettstein, of the Forest Genetics Institute in Stockholm, has been appointed associate professor as from July 1, 1961. Dr. von Wettstein will set up an electron microscopy laboratory in the Department, and will give courses in electron microscopy and in sub-cellular morphology. Dr. William S. Hillman (plant physiology) has been appointed assistant professor. He will aid in the teaching of advanced plant physiology and in the supervision of graduate students. Dr. John H. Miller (developmental morphology) has been appointed instructor. His primary duties will be to take the elementary biology course. Dr. Derald G. Langham (genetics), formerly head of the Departments of Genetics in Caracas and Maracay, Venezuela, has been appointed lecturer. He will give a course in economic botany.

Announcements

THE following were elected officers of the Royal Statistical Society on June 15: *President*, Prof. M. G. Kendall; *Honorary Secretaries*, Mr. B. Benjamin, Dr. P. Armitage and Mr. B. P. Emmett; *Honorary Treasurer*, Mr. C. T. Saunders.

THE Royal Aeronautical Society Man Powered Aircraft Group has announced that it will make financial contributions to one or more persons or organizations who submit promising projects designed to further the achievement of man-powered flight. Submissions must reach the Royal Aeronautical Society not later than October 31. Further information can be obtained from the Chairman of the Man Powered Aircraft Group Committee, Royal Aeronautical Society, 4 Hamilton Place, London, W.1.

THE Committee on the Problem of Noise, of which Mr. A. H. Wilson is chairman, which was appointed by the Minister for Science "to examine the nature, sources and effects of the problem of noise and to advise what further measures can be taken to mitigate it", is now ready to receive evidence from persons and organizations with special interest or experience in matters relevant to the problem of noise. Anyone wishing to give evidence should first write to the secretary of the Committee, Mr. R. S. Matthews, Ministry of Health, Savile Row, London, W.1.

IN an admirable Library Association Pamphlet (No. 20: The Reproduction of Catalogue Cards. By Philip S. Pargeter. Pp. 48. London: Library Association, 1960. 8*s*. 8*d*.; L.A. Members, 6*s*. 6*d*.), Mr. P. S. Pargeter provides a comprehensive illustrated survey of the various means used for this purpose, including wax-stencil duplicators, spirit duplicators, offset lithography, metal plate, stencil and spirit addressing machines, microphotography, xerography, reflex copying, dyeline processing and automatic typewriter. The advantages and disadvantages of each method are recognized and there is a list of the principal periodical articles consulted.

A COURSE in practical field techniques in physical and cultural geography is to be held in south Devon during August 17–31 under the auspices of the Geographical Association. Further information can be obtained from the Assistant Secretary of the Association, Park Branch Library, Duke Street, Sheffield 2.

AN international congress on "Biophysics" will be held in Stockholm during July 31–August 4, 1961. The meeting will be divided between a series of symposia devoted to special topics in biophysics and to presentations of a number of contributed papers in pure and applied biophysics submitted by the participants. Further information can be obtained from Dr. Bo Lindström at the Department of Medical Physics, Karolinska Institutet, Stockholm 60, Sweden.

THE fifth general assembly of the International Union of Crystallography will be held in Cambridge during August 15–20 at the joint invitation of the University of Cambridge and the Royal Society. These meetings will be followed by symposia during August 22–24, namely, "Thermal Motion in Crystals and Molecules", and "Lattice Defects and the Mechanical Properties of Solids". Further information can be obtained from Dr. W. H. Taylor, Crystallographic Laboratory, Cavendish Laboratory, Cambridge.

NEW BIOLOGY BUILDING OF THE UNIVERSITY COLLEGE OF WALES, ABERYSTWYTH

A NEW Biology Building to accommodate the Departments of Botany and Zoology of the University College of Wales was officially opened by Sir Keith Murray, chairman of the University Grants Committee, at Aberystwyth on April 27.

The Departments of Botany and Zoology had been housed for many years in old-fashioned buildings too small for their needs, so that a move to new quarters was eminently desirable. The new building which now contains these Departments is situated on a hill behind the town, with an excellent view over Cardigan Bay, on the new College site, an area of former farmland which is large enough to take as many new buildings as the College is likely to need in the foreseeable future. The Biology Building is the third one to be erected on this site, the others being a men's hostel and the Institute of Rural Science. The College therefore now has a nucleus of a 'campus' about half a mile from the town. The architects for all these buildings were Sir Percy Thomas and Son, Cardiff.

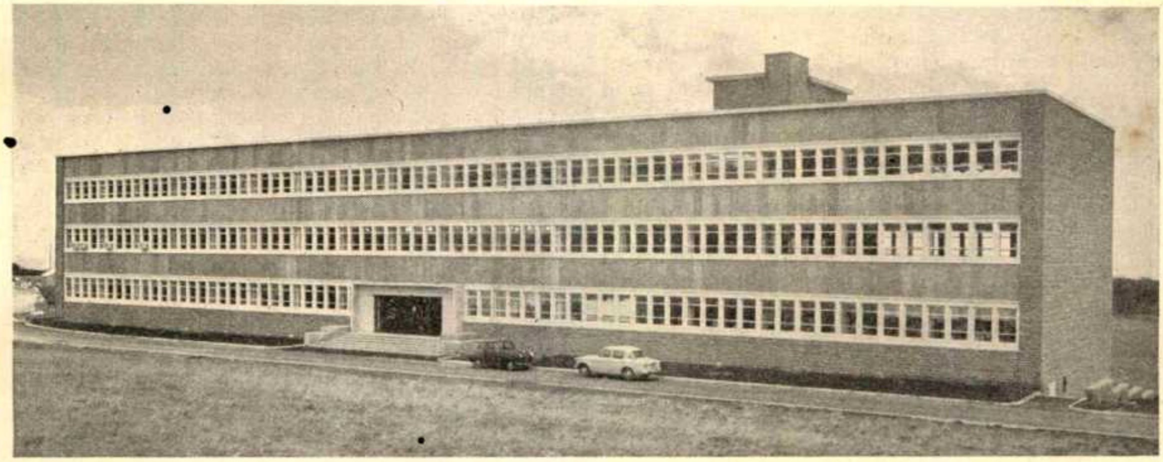


Fig. 1. The Biology Building at the University College of Wales, Aberystwyth

In general plan the building consists of four floors, with a large lecture theatre projecting towards the sea from the middle of the lowest floor. The Botany Department has the north end of each of the four floors, the Zoology Department the south end.

Rooms shared by the two Departments are situated in the centre of the building; this applies to the joint library and staff common room on the first floor. The joint lecture theatre seats 190 and is provided with a projection room and modern equipment for showing sound films and colour transparencies. The present number of students in each of the Departments is about 150.

The planning and design of the new Botany Department was carried out by Prof. Lily Newton, in consultation with the architects and staff. Special attention was given to the provision of adequate teaching laboratories for the second- and third-year classes, and the two large laboratories provided for these classes are excellently equipped for general botanical work. There are also special laboratories for the honours students and for advanced classes in plant physiology. Preparation rooms have been provided on each floor, to serve these laboratories. The botany lecture room accommodates 100 students, and there is a seminar room which is also used as a herbarium.

Specially equipped rooms for teaching and research in mycology, and a general research laboratory, are located on the second floor. The ground floor is allocated to plant physiology and biochemistry, and includes the laboratory for advanced classes in this subject, and several research laboratories. There are special facilities for enzymology, the use of radioactive materials and work on plant hormones. Four large growth rooms, with controlled lighting, temperature and humidity, provide facilities for controlled environment studies. All the physiological laboratories are served with water, gas, electricity and vacuum lines. The accommodation in the basement includes photographic dark rooms, workshop and a laboratory specially equipped for algological work.

In the old building, many lines of research were severely handicapped through shortage of space, poor services and inadequate equipment. The greatly extended accommodation and facilities, and the provision of a considerable amount of modern scientific equipment in the new Department, now meet the requirements for present-day botanical research.

The Zoology Department has been planned on the principle that in a small, rather remote situation it is better to make reasonable provision for several aspects of a subject than to make comprehensive provision for any one particular line of teaching or research at the expense of the others. The Department is therefore equipped to teach comparative anatomy, physiology and embryology, together with genetics and ecology: and for students who reach the honours or postgraduate levels it also teaches entomology, parasitology and marine biology. If there is any special emphasis in the equipment provided, it is in the direction of ensuring that adequate arrangements exist for teaching and research in the field of comparative physiology, because the future of zoology is so much bound up with this that no department can expect to contribute substantially to the progress of the subject unless it is well equipped for such work.

The various rooms in the Department (about sixty) are so arranged that the circulation of large numbers of students is confined in the main to the two lower floors, with the result that senior students and staff have the two upper floors to themselves. Thus the large lecture theatre opens from the basement, and the main students' cloakrooms are on the same level. On the floor above is the large laboratory, with the zoology lecture room opening from the same passage. The floor next above this one is laid out primarily for senior physiological teaching and research, and also has a technicians' common room, a larger common room for the academic staff, and the library. The top floor provides private rooms for the staff and for postgraduate research, as well as the honours laboratory with an adjacent room for section-cutting.

Several other principles have been kept in mind during the planning. Plenty of store-rooms have been provided, and also an adequate number of photographic dark-rooms situated on different floors, so that technicians, research students and academic staff do not need to use the same ones. Further, the teaching laboratories have been supplied with large and well-equipped preparation rooms opening into them, and this much facilitates the handling of teaching material. In connexion with the physiological section of the Department there is an aquarium in which various types of work can be done, and this room has a circulation of sea water through six small tanks and a circulation of fresh water through six others. In the basement there is a museum, and an innovation on the same floor is a visitors' research laboratory in which are four cubicles, each of which can be used by a visiting scientist, as well as general facilities which visitors can share. There are also two constant-temperature rooms: and compressed air is laid on throughout the building. A laboratory properly equipped for the use of radioactive materials has been provided on the roof.

The whole planning of the internal detail of the Zoology Department was done, in consultation with the architects and the staff, by Prof. and Mrs. T. A. Stephenson.

Aberystwyth is in many ways very favourably situated for biological studies, since there are close at hand a wide variety of habitats, which include not only the sea and shore for marine studies, but also inland rivers and lakes, woodlands, bogs, moorland, sand-dunes and salt-marsh. Moreover, there is a large botany garden very close to the new building. In the past the Biological Departments were handicapped by inadequate laboratory accommodation; but with the large new laboratories and the close proximity of a wide variety of natural vegetation and fauna, the College can now offer opportunities for biological teaching and research which compare favourably with those provided elsewhere in the United Kingdom.

T. A. Stephenson
P. F. Wareing

BOUNDARY-LAYER RESEARCH IN FLUIDS

When a body of streamlined shape moves through a fluid, the latter is disturbed, but in the main it is not carried along with the body. On the surface of the body, however, the fluid shares the body's motion, because viscosity prevents any slip occurring. The change in speed between the fluid at the surface adhering to it and the fluid in the external flow takes place in a thin layer, called the boundary layer. Boundary-layer flow has been intensively studied because many important practical effects depend on the nature of this flow. The fluid exerts a frictional retarding force on the body. This drag depends on the way in which the fluid speed varies across the boundary layer, and it tends to decrease as the boundary-layer thickness increases. It is increased if the flow in the boundary layer, instead of being completely smooth or laminar, is turbulent, with a small-scale eddying motion superimposed on the mean motion. Much work has therefore been devoted to the conditions which provoke the transition from laminar to turbulent flow in the boundary layer.

Another important practical problem is boundary-layer separation. Relative to the body, the boundary-layer fluid has less momentum than that in the external flow. Hence if over the surface of the body the pressure rises in the stream direction, the boundary-layer fluid may be brought to rest, because it will tend to be retarded relatively more by the pressure gradients than the fluid in the external flow. A piling-up of low-speed fluid near the surface may therefore occur, which may make the streamlines in the external flow depart markedly from the shape of the body. A low-pressure region over the rear end of the body sometimes results, with a consequent large pressure-drag. Here again turbulent boundary layers behave very differently from laminar ones, being much less prone to separation. In recent years, with the advent of high-speed aircraft and missiles, aerodynamic heating has become of great importance. This is largely a boundary-layer effect, because it is mainly due to the kinetic energy of the free-stream air being converted into heat when, relative to the body, the air is slowed down by friction inside the boundary layer. Associated with their greater frictional drag, turbulent boundary layers tend to produce greater rates of heating than laminar ones.

It can be understood from the foregoing that the study of boundary layers as a special department of fluid mechanics has itself become specialized into several sub-departments. These specialist interests are exemplified by the papers presented at the meeting on "Boundary Layer Research" arranged by Dr. W. P. Jones of the Aerodynamics Division, National Physical Laboratory, on behalf of the N.A.T.O. Advisory Group for Aeronautical Research and Development and held in London during April 25–29. The topics discussed were grouped under the following headings: (1) effects of roughness on boundary-layer stability; (2) boundary-layer control; (3) stability of shear layers; (4) mechanism of transition and boundary-layer stability; (5) three-dimensional boundary layers; (6) turbulent boundary layers; (7) heat transfer.

About forty papers were read by authors from Belgium, France, Germany, Great Britain, Italy, and the United States, and it is obviously out of place to attempt to summarize them all here. It may, however, be profitable to discuss the topics of some of the above headings in broad terms, in the light of the papers presented at the meeting.

The position at which transition to turbulent flow occurs on a smooth surface depends on several factors. If the surface is a flat plate parallel to the flow, it might at first sight be expected that the only factors affecting the distance x_t of the transition position from the leading edge of the plate would be the density ρ, the viscosity μ, and the velocity V of the oncoming flow. Then $\rho V x_t/\mu$, which is a dimensionless quantity of the kind known as a Reynolds number, would take a definite value at transition. However, in practice the Reynolds number of transition is not uniquely defined. It is very dependent on the magnitude of any small disturbances present in the stream or on the nature of any imperfections in the surface. Small wave-like disturbances introduced into the laminar boundary layer by these means can become amplified and distorted until eventually the flow becomes turbulent. These processes have been for many years and still are the subjects of theoretical and experimental investigations, and many papers at the meeting were concerned with them. The initial small wave-like motions can be treated with some success mathematically because the problem can be linearized. The disturbance velocities are superimposed on those of the undisturbed flow, and any products of the disturbance terms in the equations are neglected, the first-order terms only being retained. A further simplification usually introduced is to consider only two-dimensional disturbances, such that the disturbance velocities do not vary along lines perpendicular to the flow across the flat plate on which the boundary layer is formed. The justification for this is that it can be shown that such two-dimensional disturbances are more rapidly amplified than three-dimensional ones. However, three-dimensional disturbances that are not too oblique can be amplified, and this process has recently been studied because experiment has emphasized that the final process of breakdown into turbulent flow is essentially three-dimensional, with disturbance velocities in all directions superimposed on the mean flow. However, the disturbances considered by linear theory, even in its three-dimensional form, are different in character from those which immediately precede the breakdown into turbulent flow, and to help to bridge this gap in our theoretical understanding, other workers have taken into account some of the higher-order non-linear terms in the equations. Another difficult problem has been the extension of the linear small-disturbance theory to high-speed flow. It has recently been discovered that the earlier version of this extension is in some respects unsound, and a more adequate theory is now being developed.

Surfaces such as aircraft wings are never perfectly smooth, and it is therefore important to investigate what effects randomly distributed elements of roughness are likely to have on transition to turbulent flow. This problem is too complicated to study theoretically, and its experimental investigation is not easy, because it is complicated by the large number of factors defining the roughness—the spacing, height, and shape of the excrescences may all vary. For a band of roughness elements of given geometry situated transversely to the flow, transition will be provoked immediately downstream of the band if the roughness size exceeds a certain minimum. This critical size can be defined by a Reynolds number based on the height of the excrescences and on the velocity, density, and viscosity in the oncoming boundary layer at a distance from the wall equal to the height of the excrescences. There is some evidence that such a critical Reynolds number tends to be constant irrespective of the free-stream Mach number (the ratio of the speed to the local speed of sound), and also irrespective of heat transfer between the stream and the surface. If this is so, cooling a surface with distributed roughness would tend to provoke earlier transition, since it would increase the roughness-element Reynolds numbers. This is in contrast with the behaviour of boundary layers on smooth surfaces, where cooling delays transition.

Results of wind-tunnel investigations of transition may not be in all respects valid for free-flight conditions. Turbulence in the free stream outside the boundary layers may be much higher in a wind tunnel than in flight, where small-scale turbulence is usually negligible. In low-speed wind tunnels this free-stream turbulence may be reduced to a low level by the provision of a large settling chamber containing gauze screens through which the air is made to pass upstream of the working section, where the model under test is situated. However, in high-speed wind tunnels the free-stream turbulence cannot be so readily got rid of, since in the main it comes from acoustic radiation from the eddying motions in the turbulent boundary layers on the tunnel walls. A tentative partial explanation of why this radiation is greater at supersonic than at subsonic speeds is as follows. Eddies in the boundary layer move along with the local speed, so that the external flow moves past them. In effect, from the point of view of the external flow an eddy may form a moving local excrescence or depression. When the speed of the relative motion between the external flow and the eddy is less than that of sound, the disturbance generated in the external flow would be expected to be diffuse, tending perhaps to cancel with contributions from other eddies. On the other hand, when the speed of the relative motion exceeds that of sound, the effects of the disturbances are presumably concentrated along shock waves, and they might tend to persist without cancellation in the external flow. If this explanation is correct, it implies that the bulk of the radiated energy comes from the eddies in the inner part of the boundary layer, moving at supersonic speeds relative to the external flow, and not from eddies in the outer part of the boundary layer, where the relative motion is subsonic. In any event, the radiated energy is associated somehow with the turbulent motions in the boundary layer. If the tunnel could be run at sufficiently low pressures it would be possible to have laminar boundary layers on the tunnel walls, which would greatly reduce the free-stream turbulence-level. Under these conditions, however, the tunnel could not readily be used to study transition, because the boundary layers on any model in the tunnel would normally be entirely laminar.

It is still a matter for conjecture as to how similar turbulent boundary layers in supersonic flow are to those in low-speed flow. At high speeds, but not at low speeds, significant temperature and density fluctuations occur, and at first sight it would appear that they must completely alter the nature of the flow. However, it can be argued that the velocity fluctuations are to some extent independent of the thermal effects, and many of the overall characteristics of supersonic turbulent boundary layers are sufficiently similar to the corresponding ones in low-speed flow to encourage the view that there is a fundamental similarity in the underlying processes of energy exchange between the mean motion and the turbulent eddies, at least up to moderate supersonic speeds. The energy radiated to the free stream, discussed above, may not play a very big part in the overall energy balance.

A disturbing feature that has been noticed in tests of supposedly two-dimensional turbulent boundary layers is the presence of three-dimensional effects. Such characteristics as the boundary-layer thickness have been found to be non-uniform for the boundary layer on a flat plate along lines across the plate perpendicular to the flow. These effects are not to be traced to any small imperfections in the leading edge of the plate, but they seem to depend on the condition fo the screens in the settling chamber of the tunnel. It has been shown that characteristics such as the frictional drag, as calculated from the rate of growth of the boundary layer, are considerably affected by taking into account the spanwise variations.

Spanwise variations of a somewhat similar kind have been observed in regions where a laminar boundary layer re-attaches itself to a surface downstream of a region of separation. Liquid which, after being smeared on to the surface, evaporates most rapidly from regions where the skin friction is highest, reveals a streaky pattern with streaks parallel to the flow. This is suggestive of a number of parallel vortices in the boundary layer, with their axes in the direction of the stream. Such vortices are formed when a fluid flows over a concave surface, as has been known for a long time. The laminar boundary layer on such a surface is unstable because if a relatively fast-moving particle of fluid gets displaced nearer to the surface, where the general speed of the fluid is less, it comes into a region where its centrifugal force exceeds the restoring force exerted by the local pressure field, which is such as to balance the local, smaller, centrifugal forces. Thus the motion is unstable, and pairs of counter-rotating vortices result. It would seem at first sight reasonable to expect a similar instability in a re-attachment region, where the streamlines tend to be concave even when the solid surface is flat. However, it was found that the streaky pattern persisted even when the surface on which the re-attachment occurred was made convex. This would presumably damp out any instability of the concave-surface type, so the cause of the streaky patterns remains at present a mystery.

Many other topics were considered at the meeting, but there is no space to describe them here. It will already be evident, however, how abundantly fruitful has proved the concept of the boundary layer, first thought of by Prandtl more than fifty years ago, in 1904. In the decade following that year scientific papers on boundary layers appeared at the rate of about one a year. The current rate has been estimated to be about 160 a year, and this rate is still increasing. Despite all this effort, we are still a long way from understanding many boundary-layer phenomena. The attempt to solve these problems is one of the most interesting tasks of present-day aerodynamics, a task which is likely to take at least another fifty years to complete.

G. E. Gadd

THE BRITISH LEATHER MANUFACTURERS' RESEARCH ASSOCIATION

The British Leather Manufacturers' Research Association held its fortieth annual open days during May 3–5 at Milton Park, Egham, the Surrey mansion where the laboratories of the Association have been established for the past ten years. More than four hundred visitors attended, mostly from the industry, but including representatives of university departments, research associations, government departments and other bodies.

The Association, which was one of the earliest to be established under the Department of Scientific and Industrial Research scheme for co-operative research in industry, has an income of £65,000 p.a., and applies its effort in roughly equal proportions to background research, technological investigations and member services. Studies of the composition of skin have been maintained since Dr. Joane H. Bowes, the Association's chief biochemist, worked out the overall amino-acid composition of collagen some fifteen years ago; in this year's exhibition the decrease with increasing age of the animal in the proportions of serum and other non-collagenous proteins in the skin was shown. The Biochemistry Department is making a fundamental investigation (sponsored by the U.S. Department of Agriculture) on the mechanisms of the deterioration of leather by various agencies such as heat, moisture and perspiration. A survey of the rates of deterioration of different kinds of leather was shown, together with an exhibit of the more fundamental aspects of the work, which involve the use of continuous paper electrophoresis and liquid-phase chromatography, to identify the breakdown products of the protein fibres and the tanning agents, and the use of isotopic labelling, to follow the movement of tanning agents out of the protein phase.

In the Physics Department, under Dr. R. G. Mitton, work on waterproofing of leather was shown. While the intrinsic water-resistance of leather is adequate for many purposes, there are increasing demands for special leathers with improved performance. Results obtained with a variety of treatments designed to improve water-resistance without reducing the porosity of leather were shown. An important objective of the work of the Physics Department is to devise laboratory tests for assessing the complex physical properties of leather in its many uses; a number of test machines constructed in the Association's laboratories were exhibited. Performance trials under controlled conditions also prove valuable. Studies of the mechanical properties of collagen and leather fibres were also displayed. The properties of leather depend on those of its constituent fibres and on their mode of interweaving. An electrobalance for weighing very small fibres and an extensiometer for determining their stress/strain relation in different controlled atmospheres have been constructed at Milton Park for this work.

The Biology Department, under Dr. Mary Dempsey, is pre-eminent in the study of the fibre structure of skin; one of the items on show was the album of photomicrographs ("Hides, Skins and Leather under the Microscope"), published by the Association, which has had a wide circulation among investigators in other fields concerned with the structure of animal skins. Other exhibits showed the influence of abnormal skin conditions such as mycotic dermatitis, hyperpigmentation and melanomia, on the resulting leather.

In the Chemistry Department, under Dr. D. E. Hathway, exhibits summarized the work done during the past five years, which has contributed substantially to the understanding of biogenesis and structure of the condensed and the hydrolysable groups of natural organic tannins; the aromatization of glucose yields gallic acid and other phenolics (including ellagic acid formed by oxidation of gallic); these by esterification with glucose form the hydrolysable tannins, which are converted to condensed tannins by oxidation in the plant. A variety of non-tannin extractives from trees were also shown, for example, taxifolin and dihydropiceatannol from barks of native conifers (supplied by the Forestry Commission) and hydroxystilbenes from the heartwood of *Eucalyptus redunca*. The Chemistry Department is also responsible for work on leather dyeing, and has developed the application to leather of the 'Procion' range of dyestuffs introduced a few years ago by Imperial Chemical Industries, Ltd. These dyes combine with the substrate by a covalent link giving improved fastness in comparison with other types of dye, which in general become attached by less-specific links. The use of a resist, of the same chemical type, to modify the fixation of 'Procion' dyes on leather, was also shown. This material, now manufactured by Imperial Chemical Industries, Ltd., under the designation 'Lissatan *PR*', was first prepared in the Association's laboratories.

Enzyme treatments have been used by the leather industry for many years for softening skins before tanning, and proteolytic enzymes have been used to a very limited extent for loosening hair in the pre-tanning treatments. Mr. K. G. E. Wyatt demonstrated current work by the Association on the proteolytic treatment which, if it can be made practicable for full-scale operation, will have several operational advantages over the customary treatment with milk of lime and sodium sulphide, for hair-loosening. In the Chemical Engineering Department, under Dr. F. E. Humphreys, investigations on drying leather were displayed. The best drying conditions (air temperature, humidity and flow-rate) for combining fuel-economy and satisfactory leather characteristics have been worked out for the more important types of leather, and a simple drying tunnel with air re-circulation, suitable for most kinds of leather, has been devised. In many of the processes of leather manufacture, accurate control of simple physico-chemical factors such as *p*H value, electrolyte concentration and temperature is desirable and the Department is studying methods for making the necessary measurements inside revolving drums; continuous determination of *p*H value of the liquid in a drum was demonstrated.

Following Procter's application of the Gibbs–Donnan theory of membrane equilibrium to the gelatin/acid system, much work has been done by the Association and in other laboratories on the swelling of collagen in water mostly by acid or alkali, but the addition of any electrolyte, one ion of which can be fixed or adsorbed in the collagen phase, will set up a membrane equilibrium or modify an existing one. An application of this was shown by Mr. E. F. Nattrass in the use of a polymeric phosphate, the anion of which combines with collagen, to control the swelling in acid pre-tanning treatment, so that the maximum practicable leather thickness is obtained; but the swelling is kept below the level at which practical difficulties, such as retarded absorption of tanning agent, would occur. K. W. PEPPER

REACTOR FUEL ELEMENT TECHNOLOGY

A COURSE of ten lectures in reactor fuel element technology was given in the Department of Chemical Engineering at the Imperial College of Science and Technology, London, during February and March. The lecture series, which formed part of the postgraduate diploma course in nuclear technology (chemical), was designed to lay emphasis on the industrial problems of reactor fuel element technology and to appeal to scientists and technologists interested in the metallurgical aspects of nuclear power development. All the lecturers, who were from the United Kingdom Atomic Energy Authority, were specialists in their subjects and spoke from personal experience about the problems inherent in fuel element manufacture.

The course was arranged by the reader in nuclear technology (Mr. G. R. Hall) in collaboration with Mr. L. Grainger, chief metallurgist at the Atomic Energy Research Establishment, Harwell.

Mr. Grainger gave the introductory and concluding lectures. He described various types of reactor fuel element, the qualitative requirements of a satisfactory fuel element, and future developments in fuel element design and fabrication. In Mr. Grainger's opinion, progress in fuel element performance was now the most vital factor in the economic utilization of nuclear power; experimental irradiations would determine the rate of advance for some years to come.

Dr. J. F. M. Bishop, deputy head of laboratories at Springfields, discussed the theoretical evaluation of a fuel element. He outlined the general methods of procedure, illustrated by examples, and described the effects of irradiation and other factors which require consideration. The first stage in the evaluation of a fuel element is to see if it will endure for the proposed charge life under the conditions of stress and temperature imposed. If so, the effects of changes induced by irradiation are then considered in detail. During his second lecture, special attention was paid to ratcheting and irradiation creep.

Mr. J. Harper, head of laboratories, Springfields, described the Springfields manufacturing process from ore to machined bars for Calder and Central Electricity Generating Board fuel elements. The emphasis was placed on the metallurgical stages in the process. He pointed out that the efficiency of slag/metal separation in uranium billet production is a major factor in the quality of a fuel rod. Each fuel rod has its case-history recorded on a punched card.

Mr. D. O. Pickman, deputy head of laboratories, Springfields, described the design and manufacture of Calder-type fuel elements, assembly and testing procedure, and out-of-pile proving tests. In the course of his second lecture he reviewed performance experience in Calder and irradiation proving of Central Electricity Generating Board fuel elements. Out of the 90,000 fuel elements loaded up to mid-July 1959, only twenty-seven failures have been observed.

Mr. L. M. Wyatt, late deputy head of laboratories, Culcheth, and now with the Central Electricity Generating Board, described fuel elements for the advanced gas-cooled reactor and fast reactors. He considered the design and expected performance of these uranium dioxide fuels with stainless steel, beryllium and other canning materials. The design of similar fuels for light water and/or heavy water-cooled and moderated reactors was also briefly referred to. In his second lecture, Mr. Wyatt described fast reactor fuels and cans and expected operating conditions. He concluded by briefly comparing British, American and Russian fuel elements. Design drawings of the advanced gas-cooled reactor fuel elements aroused great interest.

Mr. H. Lloyd, leader of the Fuel Element Fabrication Group at Harwell, discussed the fabrication of *Dido*-type fuel elements including the Mark III version, and considered their application to power reactors. Possible variations and improvements in fuel materials and design were mentioned and comparison was made with similar American fuels. Although various power reactors employing plate-type fuel elements have been built in the United States, only design studies have so far been made in Great Britain. Mr. Lloyd displayed samples illustrating various stages in the fabrication of the *Dido* fuel element, and these aroused much interest.

The course was well attended and it was particularly pleasing to see about forty representatives from industry. Each of the lectures provoked a stimulating discussion. Although the lecturers would have liked to answer the questions put to them fully, they were occasionally prevented from doing so by commercial security regulations. This applied mainly to questions concerning throughput and costs.

In view of the interest the lectures aroused, it is hoped to hold a similar series early in 1961.

S. HARTLAND

THE LEVERHULME TRUST

REPORT FOR 1956–58

THE third report of the Leverhulme Trust*, which covers the period 1956–58, in which commitments of £593,000 were undertaken, is the first of a series of triennial reports. Of this sum, 33 per cent was devoted to universities and centres of higher education, 8 per cent to learned societies, 30 per cent to medical research and 12·5 per cent to grants to individual scholars. Of those to British universities, the largest grant, £30,000, was to Liverpool for fellowships in general research, mathematics, physics and town planning. The University of Manchester received £14,900 for research fellowships and studentships at Jodrell Bank Experimental Station, Nuffield College, Oxford, £14,100 for a study of industrial relations with particular reference to the history and problems of the trade union movement, collective bargaining, the appointment and responsibilities of shop stewards and so forth, and St. Antony's College, Oxford, £12,500 for the study directed by Lord Ismay's committee on the changes in the international status of the United Kingdom since the Second World War and of its position as a Colonial power. £6,000 went to Birkbeck College, London, for research by Dr. N. Pevsner on the buildings of England, and £16,950 to the London School of Economics for miscellaneous scholarships and research awards. The University of Leeds received £7,500 for a research fellowship, scholarship and lectureship in the history and philosophy of science; the Institute of Commonwealth Studies, London, £6,000 for research fellowships in economic development in the Colonies; and the University College of Rhodesia and Nyasaland £28,000 to finance inter-collegiate conferences.

Of the grants to learned societies, research institutions, etc., those of £4,500 to the British Association for the Advancement of Science for an inquiry, under Sir Patrick Linstead's direction, into the broadening of the education of those intending to become scientists and technologists, and of £8,400 to Political and Economic Planning for a study of the effects of economic planning on governments and administration may be mentioned; in medical research, the Royal College of Surgeons received £42,000 for research fellowships and scholarships in dental surgery; the Middlesex Hospital Medical School, £35,000 for scholarships at the Institute of Clinical Research; the London School of Hygiene and Tropical Medicine, £14,000 for research in industrial medicine over four years; the London College of Osteopathy, £12,500 for scholarships; the Institute of Laryngology and Otology, £9,100 for research fellowships; King's College Hospital Medical School, University of Durham, £8,700 for a research fellowship and the Department of Education of the Deaf, University of Manchester, £2,000 for research in connexion with the design of hearing aids. St. Mary's Hospital Medical School received £9,500 for biochemical research.

---

* The Leverhulme Trust. The Third Report of the Leverhulme Trustees. Pp. 55. (London: The Leverhulme Trust, 1959.)

SICKLE-CELL ANÆMIA

INVESTIGATIONS into sickle-cell anæmia in Nigerian children by R. G. Hendrickse, of University College, Ibadan, shows significant differences from experiences recorded by American research workers (*Central African Journal of Medicine*, 6, No. 2; February 1960).

In Africa the age at onset of severe symptoms is earlier; anæmia tends to be more severe; the incidence of splenomegaly is higher, and spleens seem to be larger; gross hepatomegaly and evidence of hepatic dysfunction generally occur at an earlier age; limb swellings, especially those involving the hands and feet, are common in the early years of life, whereas they are rarely reported by American authors; radiological evidence of bone involvement is more frequent and the ultimate prognosis appears to be worse.

These differences in general reflect the more rigorous conditions under which children live in Africa, but certain features of the disease may be attributed to specific environmental factors. Spleen sizes are probably related to endemic malaria, and the earlier onset of liver dysfunction may be related to dietary protein deficiency. The characteristic swellings in the hands and feet of African infants may well result from the customary manner in which African mothers carry their babies. The child is placed astride the mother's back, its legs encircling her waist. The position is maintained by a wrapper which covers the child and is tied in front of the mother. In this position the child's limbs are pinioned to the mother and subjected to steady pressure which probably slightly impairs the peripheral circulation. Such impairment, while of no consequence in normal children, may be sufficient in sickle-cell anæmia to provoke intravascular sickling in the extremities, with resultant capillary blockage and reactionary swelling.

While differences in the clinical picture of sickle-cell anæmia in Africa and America may be attributed to environmental factors, the apparent difference in the severity of the disease in different parts of Africa cannot be readily explained in the same way. Differences in the age incidence in the Belgian Congo and Nigeria are of particular interest. In the Belgian Congo more children show signs of the disease between the ages of three months and one year than at any other period. It has been shown that for infants in hyperendemic malarial areas the mean parasite-rate rises from about 2 per cent at three months to 80 per cent at one year. In the Belgian Congo, therefore, it appears that the period during which children acquire their first infection with malaria coincides with the age during which sickle-cell anæmia is most frequently diagnosed. This suggests that malaria should be considered as a possible factor determining the age at which sickle-cell anæmia presents in the Belgian Congo. Another possible explanation of these age relationships is that some of the cases in the Belgian Congo were examples of primary malarial anæmia in persons with the sickle-cell trait. The clinical and hæmatological findings in such cases can closely simulate those encountered in sickle-cell anæmia. None of the cases reported from the Belgian Congo by the Lambotte-Legrandes was confirmed by electrophoretic studies of the hæmoglobin.

The apparent differences in the clinical manifestations of sickle-cell anæmia in different parts of Africa merit closer study. There are no grounds at present for contending that these differences have a genetic basis, though this possibility should be borne in mind.

ORIGIN OF TEKTITES

Solar Furnace Glass

TO explore the suggestion that tektites are formed by fusion of terrestrial material we have fused some rock samples in a solar furnace. These samples were collected from the regions where tektites have been found in Texas and Georgia in the United States. The Texas sandstone was taken from a stratum in the Wellborn formation in which embedded tektites reportedly had been seen. The black top-soil was taken from a location where tektites had been found in Grimes County, Texas. The Georgia sandstone was collected immediately below the top soil near a place where several tektites were discovered.

The sediments were fused in the solar furnace of the U.S. Army Quartermaster and Engineering Center, Natick, Massachusetts[1], made available to us through the courtesy of Mr. Eugene S. Cotton. At the time of the experiment, November 20, 1959, 1000 a.m., E.S.T., the flux of energy at the focus was 83 calories cm.^{2} sec.$^{-1}$, as determined from the rise in temperature of a blackened metal disk. Each specimen was placed in a graphite crucible in the form of a plug. To make the plug the material was crushed, mixed with water, moulded and then baked at a temperature of approximately 150° C. We added 5 per cent by weight of ferric oxide to samples 2 and 3. Sample 1 weighed 100 gm., samples 2–5 weighed 50 gm.

The exposure time of the samples varied from 59 to 240 sec., the Georgia samples being heated for a longer period of time than those from Texas. Immediately after the water-cooled shutter of the solar furnaces opened, vapour could be seen rising from the sediment, while the front surface of the material became luminous and reached white heat in approxi-

Table 1

Sample	Exposure (sec.)	Weight loss (per cent)	Weight glass (gm.)	Fusion (erg/gm.)
(1) Texas sandstone	59	11·1	20·9	$1{\cdot}9 \times 10^{11}$
(2) Texas sandstone	72	13·6	14·9	$1{\cdot}7 \times 10^{11}$
(5) Texas topsoil	70	11·6	10·2	$2{\cdot}3 \times 10^{11}$
(3) Georgia sandstone	120	20·6	14·6	$2{\cdot}9 \times 10^{11}$
(4) Georgia sandstone	240	20·4	28·2	$2{\cdot}9 \times 10^{11}$

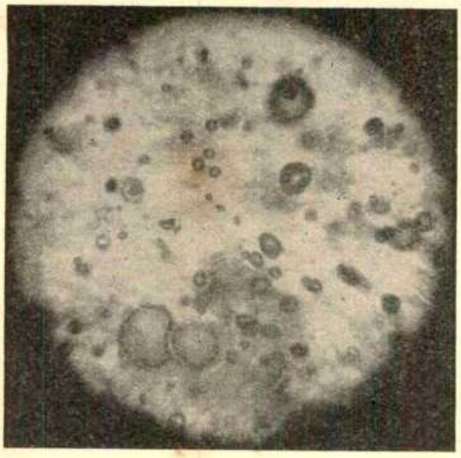


Fig. 1

mately 10 sec. Bubbling began after approximately 20 sec. followed immediately by a forward slumping of the viscous material. In sample 1, where the glass was allowed to pour out of the radiation beam, the drips stiffened and solidified within 2 or 3 sec. The results of the experiment are summarized in Table 1.

It can be seen that the Texas material decreased in weight by 12 per cent and the Georgia material by 20 per cent owing to the vaporization of water and other constituents. The energy required to fuse 1 gm. of glass varied between $1 \cdot 7$ and $2 \cdot 9 \times 10^{11}$ ergs gm.$^{-1}$. After fusion each sample showed a glassy surface with large bubbles, underneath which was a hard porous layer. There was also a considerable quantity of soft, dry material that had not been fused. The specific gravity of the glass droplets, including bubbles, from sample 1 was $1 \cdot 980$ gm.$^{-3}$. The scoriacious layer was considerably lower in density; but no measurements were made on this or the partially fused material.

There is, of course, no definite temperature at which glass melts, and no definite latent heat of fusion. We may define the heat of fusion as the energy required to raise the temperature of 1 gm. of silica glass from 20° C. to 2,000° C., at which temperature the glass would be liquid and incandescent. This heat of fusion may be estimated by extrapolating the tabulated values of specific heat[2] and performing an integration. We find the heat of fusion to be $2 \cdot 1 \times 10^{10}$ erg/gm. The values determined in the solar furnace experiment are ten times higher, the difference being largely due to the losses of heat involved in the fusion process by radiation, conduction, convection and vaporization of material. Nevertheless the effect of heat of fusion as determined here is of considerable interest to any theory of the formation of tektites by external application of heat because it is the value one might expect when radiation and other heat losses occur.

A photomicrograph (reduced to $\frac{1}{2}$) of a thin section of the solar furnace glass, taken with crossed polarization at × 60, is shown in Fig. 1. The glass showed flow lines and bubbles, but we have, as yet, found no evidence for lechatelierite particles. Light was still transmitted through the specimen when viewed with crossed polarization, indicating that the solar furnace glass was under considerable strain. Texas and Philippine tektites, on the other hand, show extinction when viewed with crossed polarization. The tektite glass may have cooled more slowly than solar furnace glass, or may have annealed at ordinary terrestrial temperatures over the long period of time that it had rested in the sediments.

Taking the effective heat of fusion as 2×10^{11} ergs/gm., one finds that approximately 5 min. must elapse before a sphere some 2 cm. in diameter could be fused by passage through the upper atmosphere at a velocity of 10 km./sec. Single tektites could not be fused in the atmosphere, therefore, since an object of this size would decelerate in a matter of a few seconds. There is sufficient energy for tektites to form as drops from the surface of a much larger object, but glass objects have never been recovered from the 590 stone falls already observed[3]. A meteorite with velocity of 20 km./sec. has a kinetic energy of 2×10^{12} ergs/gm. Thus a meteorite of mass m striking the Moon would produce about $10\,m\,(1 - x)$ gm. of glass, where x is the fraction of energy dissipated in shock waves, crater formation and vaporization of the meteorite. A study of terrestrial craters shows that x is close to unity. Only a small quantity of glass would be produced on the Moon and only a portion of this would reach the Earth. Nor do the craters seem to be deep enough for the meteorite to have uncovered molten material below the Moon's crust. It is more probable for an energy of 2×10^{11} ergs/gm. to be supplied by terrestrial phenomena such as volcanic activity or lightning.

This work was made possible by a research grant from National Aeronautics and Space Administration.

GERALD S. HAWKINS
SUMNER H. WOLFSON

Boston University Observatory,
Boston 15, Mass.

[1] *Sky and Telescope*, 18, 4 (1958).

[2] Condon, E. U., and Odishaw, H., "Handbook of Physics" (McGraw-Hill, 1958).

[3] Prior, G. T., and Hey, M. H., "Catalogue of Meteorites" (British Museum, London, 1953).

High-Temperature Fusion of Possible Parent Materials for Tektites

BAKER[1] has recently presented very strong evidence for an extra-terrestrial origin for australites and, by implication, for all true tektites. Once an extra-terrestrial origin is established, then the localized distribution of tektites (particularly the australites) is most readily explained if they have originated close to the Earth[2,3]. In these circumstances, the most likely origin for tektites is that they are portions of the Moon's crust which were fused during large meteorite impacts and then ejected from the lunar surface to fall on the Earth[4].

Certainly as far as their very young ages, most physical properties and terrestrial distributions are concerned, a lunar origin for tektites would seem to be preferred. However, the most serious stumbling block to this theory[3] is the rather unusual composition of tektites, which some authors consider shows that tektites are most likely to be fused sediments[5]. The most probable terrestrial sediment from which tektites might have formed is a shale, and if terrestrial-type shales are the only likely parent materials then a lunar origin would seem to be out of the question. On the other hand, other authors have shown that certain acid igneous (granitic) rocks could well have been suitable parent materials for the formation of tektites[6]. In view of the strong possibility that igneous rocks of granitic composition may exist on the lunar surface, then a lunar origin for tektites would not be unlikely in these circumstances. Clearly it is extremely important to establish what rock types are suitable parent materials for tektites.

Although some types of terrestrial shaly sediments[5] and some types of acid igneous rocks[6] have compositions similar to those of tektites, the composition of the average tektite shows considerable differences from both the average terrestrial shale and the average granite (Table 1), so that neither appears to be an entirely satisfactory parent material. Of course, the assumption that a lunar granitic rock would have the same composition as the average granite found in the Earth's crust at the present day is unlikely to be completely true since many terrestrial granites are probably granitized sediments, and almost certainly all terrestrial granites have assimilated varying amounts of sedimentary and other rocks. However, if there is some material of granitic composition on the lunar surface, it would most likely have formed as a differentiation product during a partial or complete melting of the Moon. There is some geological evidence which suggests that the Earth's primitive continental masses were composed of granitic material formed during an early-stage partial or complete melting of the mantle, although no uncontaminated samples of this material are available for comparison with tektites. In the search for possible parent material for tektites, another approach would be to compare possible lunar surface rocks with acid igneous rocks which are believed to form as the result of differentiation of more basic magmas in the Earth's crust. In these circumstances, perhaps, a suitable rock type would be the acid granophyres often found associated with basic magmas, and which many petrologists believe are acid differentiates of these magmas, although some granophyres may be sedimentary and other rocks mobilized during intrusion of the magmas. Analyses of thirty-five acid granophyres from the available literature have been averaged in Table 1, and in many ways these rocks do appear to be more suitable parents for tektites than the average granite, particularly in that the total iron content of the average granophyre is much closer to that of the average tektite. However, the data in Table 1 also indicate that the sodium monoxide and potassium monoxide contents of the granophyres are higher, and the calcium oxide and magnesium oxide contents lower, than that of the average tektite.

In all comparisons of tektites with the various possible parent materials, the tacit assumption has been made that the process of tektite formation has involved only simple melting, so that both parent rock and tektites would have the same overall composition. However, if tektites have, in fact, formed at the site of large meteorite impacts then temperatures up to 100,000° C., far in excess of simple melting temperatures, have operated over considerable areas around the impact site[10]. Under these conditions it would seem likely that selective volatilization of certain elements could have taken place during the formation of tektite glass, so that parent rock may well have had a composition significantly different from that of the tektite glass. It is reasonable to assume that the relative volatilities of the elements during the formation of tektites would correspond to the boiling points of their normal oxides, or, where boiling points are not available, can be interpolated from their melting points. Consequently, the order of volatility of the major constituents of tektites might be expected to be approximately magnesium oxide, calcium oxide < alumina < silica, ferrous oxide < sodium monoxide, potassium monoxide, so that it might be predicted that tektite glass would be impoverished in sodium monoxide and potassium monoxide, and enriched in magnesium oxide, calcium oxide and possibly also alumina relative to the parent rock. If the concentrations of the major elements have changed in this way during the formation of tektites, then the data in Table 1 indicate that although the average shale is not a suitable parent material for tektites, the acid igneous rocks could perhaps be converted into tektite material.

Table 1. AVERAGE COMPOSITION OF TEKTITES, TERRESTRIAL SHALES, GRANITES, AND ACID GRANOPHYRE DIFFERENTIATES OF BASIC MAGMAS

	I Average tektite	II Average shale	III Average granite	IV Average acid granophyre
SiO_2	73·4	63·9	72·5	73·6
Al_2O_3	12·4	17·0	13·9	12·6
Fe_2O_3	0·6	4·4	0·9	2·1
FeO	4·4	2·7	1·7	1·9
MgO	2·1	2·7	0·5	0·4
CaO	2·5	3·4	1·3	1·2
Na_2O	1·3	1·4	3·1	3·4
K_2O	2·3	3·6	5·4	4·2
TiO_2	0·9	0·7	0·4	0·4
P_2O_5	—	0·2	0·2	0·1
MnO	0·1	tr	0·1	0·1

I, average composition of 62 tektites calculated from data collected by Barnes (ref. 7).

II, average composition of 78 terrestrial shales, recalculated on a water and carbon dioxide free basis from Clarke (ref. 8).

III, average composition of 72 calc-alkaline granites (ref. 9).

IV, average composition of 35 acid granophyre differentiates of basic magmas calculated from published analyses.

To establish whether high-temperature fusion of granitic rocks would form glasses the compositions of which were changed in this way, a powdered granite was subjected to a series of fusions in a solar furnace at temperatures within the range 1,500–3,000° C. A solar furnace was chosen for the experiments because it provides relatively high temperatures simply, quickly and cheaply and with no possibility that the melts could be contaminated by reaction with an enclosing crucible. The granite sample chosen was collected at Fenton, Northern Territory, Australia, crushed to –100 mesh and placed in a large porcelain crucible at the focus of a solar furnace which was situated in the grounds of the University of New South Wales at Broken Hill, New South Wales. Only a small, centrally situated area of the surface of the granite sample was fused during each run, and in this way small glassy buttons, 3 cm. across, 0·8 cm. deep, and weighing about 13 gm., were formed.

The first glassy buttons formed by melting the original granite sample (melting stage 1) were found to contain a considerable amount of unmelted material. To ensure complete melting, a number of melting stage 1 buttons were prepared from the powdered granite, and then these buttons were crushed and their powder used to form a further series of buttons (stage 2). Enough material for a complete rock analysis was kept of each melting stage and the process was continued until samples at each of five stages of melting were prepared, after which no material was available for further heating. Careful analyses were carried out by A. J. Easton on samples of the original granite and glass from melting stages 3, 4 and 5, but since only small amounts of material were available for analysis, only single determinations of each constituent could be made. The uncertainty of a single determination of any constituent is given by the relative deviation of that constituent calculated for the particular analytical method used. These data had previously been determined for each constituent from replicate analyses of a standard granitic rock (for example, silica, 0·2 per cent relative deviation; alumina, 1·4 per cent; ferrous oxide, 0·6 per cent; magnesium oxide, 3·3 per cent; calcium oxide, 3·1 per cent; sodium monoxide, 0·7 per cent; potassium monoxide, 2·0 per cent). On the basis of these uncertainties the results of the analyses of the granite and the glasses (Table 2) are strong evidence for the progressive loss of sodium monoxide and potassium monoxide, relative enrichment in magnesium oxide, calcium oxide and alumina, and little change in silica and ferrous oxide during progressive high-temperature meltings of granitic rock. The elemental fractionations observed in these experiments have taken place at temperatures of only about 2,000° C. so that at the site of meteorite impacts where temperatures up to 100,000° C. have operated there is ample opportunity for extensive fractionation of the constituent elements in the directions established in these experiments. It may be concluded that rocks of general granitic composition, and particularly the acid granophyre differentiates of basic magmas, are suitable parent materials for tektites if they have formed at relatively high temperatures at the site of meteorite impacts. This conclusion is not at all inconsistent with a lunar origin for tektites.

Table 2. CHANGE IN COMPOSITION OF GLASSES FORMED BY THE PROGRESSIVE HIGH-TEMPERATURE FUSION OF A GRANITIC ROCK *

	Granite (Fenton, Northern Territory, Australia)	Glass		
		Stage 3 Melting	Stage 4 Melting	Stage 5 Melting (partial analysis)
SiO_2	75·96	75·77	75·48	—
Al_2O_3	12·52	13·07	13·23	—
FeO	2·27	2·21	2·22	2·23
MgO	0·63	0·70	0·88	—
CaO	0·74	0·79	0·79	—
Na_2O	2·19	2·00	1·99	1·94
K_2O	5·38	5·11	5·05	5·05
TiO_2	0·24	0·25	0·25	0·26
P_2O_5	0·07	0·10	0·11	0·15
MnO	< 0·005	< 0·005	< 0·005	< 0·005

* All analyses recalculated on a water-free basis and total iron recalculated as ferrous oxide. Analyst, A. J. Easton.

These experiments, together with new data on the distribution of certain trace-elements in tektites, will be discussed at greater length in a paper to be published elsewhere. The solar furnace fusions were very kindly carried out by A. Segal, and the co-operation of Prof. C. J. Milner, University of New South Wales, is gratefully acknowledged in making the furnace available for these experiments.

J. F. LOVERING

Department of Geophysics,
Australian National University,
Canberra.

[1] Baker, G., *Nature*, **185**, 291 (1959).
[2] Varsavsky, C. M., *Geochim. et Cosmochim. Acta*, **14**, 291 (1958).
[3] Varsavsky, C. M., Astron. Soc. Pacific, Leaflet No. 365 (1959).
[4] Nininger, H. H., *Bull. Geol. Soc. Amer.*, **51**, 1936 (1940).
[5] Urey, H. C., *Nature*, **183**, 1114 (1959).
[6] Mason, B., *Nature*, **183**, 254 (1959).
[7] Barnes, V. E., Univ. Texas Pub. No. 3945, 477 (1940).
[8] Clarke, F. W., U.S. Geol. Surv. Bull. 770, 631 (1924).
[9] Nockolds, S. R., *Bull. Geol. Soc. Amer.*, **65**, 1007 (1954).
[10] Gilvarry, J. J., and Hill, J. E., *Astrophys. J.*, **124**, 610 (1956).

POLYINOSINIC PLUS POLYCYTIDYLIC ACID: A CRYSTALLINE POLYNUCLEOTIDE COMPLEX

By Dr. DAVID R. DAVIES

National Institute of Mental Health, Bethesda, Maryland

RECENT investigations by Doty *et al.*[1] have demonstrated the existence of secondary structure within the ribonucleic acid molecule in solution. Although it seems evident that the secondary structure is the result of hydrogen bonding between the bases, the structural arrangement of the molecule is not known. X-ray diffraction studies on a variety of natural ribonucleic acids were carried out by Rich and Watson[2]. Although the diffraction patterns obtained were poorly oriented, they were essentially the same regardless of the source of the ribonucleic acid, and were identified as characteristic of helical material. It is presumed that the X-ray diffraction pattern is produced by the same secondary structure as observed in solution.

The synthetic polyribonucleotides, polyinosinic acid (poly I) and polycytidylic acid (poly C) have been shown to interact in solution to form a 1 : 1 complex[3], poly (I + C). X-ray fibre diffraction patterns obtained from 1 : 1 mixtures of the polymers were found to resemble closely those of natural ribonucleic acid. The structure giving rise to these patterns we shall call the *B* form of poly (I + C). Extensive model building has failed to provide a satisfactory explanation for this poly (I + C) diffraction pattern, and it was felt that this was partly because of the poor orientation of the fibres, leading to uncertainties in the dimensions of the molecule.

Attempts have therefore been made to obtain better diffraction patterns of this complex, and in the course of this investigation fibres were obtained which exhibited a new type of pattern (Fig. 1). This differs from the *B* pattern in that the molecules are now packed in a crystalline array with somewhat different spacings. The layer-line spacing for the crystalline material is 35 Å., and the unit screw dimensions consist of a translation of 3·0 Å. and a rotation of 31°. This crystalline form we shall call the *A* form of poly (I + C).

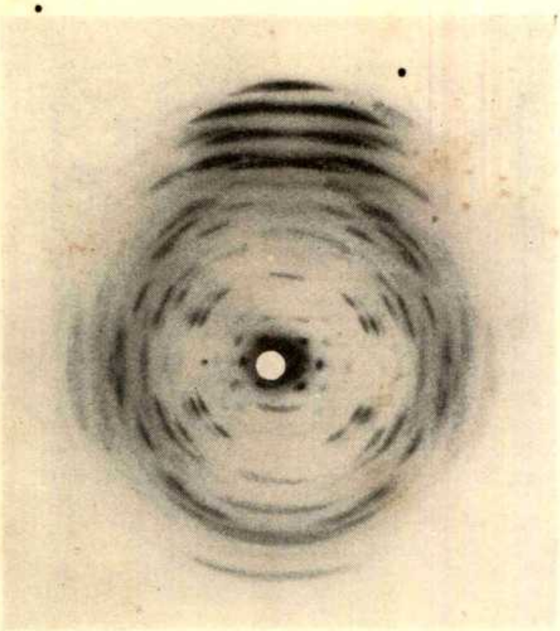


Fig. 1. X-ray diffraction photograph of the *A* form of poly (I + C). The fibre is tilted to show more clearly the upper layer lines on and near the meridian

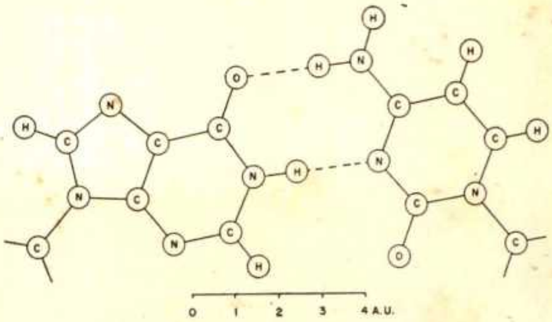


Fig. 2. The arrangement of the bases for the *A* form of poly (I + C)

Poly I was polymerized with polynucleotide phosphorylase isolated by methods previously described[4]. It was dialysed successively against 0·01 *M* versene at *p*H 7·0, 0·01 *M* sodium chloride, and ion-free distilled water. Poly C was a gift from Dr. Leon Heppel. It had been dialysed against distilled water.

The polymers were dried and weighed. 3·0 mgm. of poly C and 3·3 mgm. of poly I were then dissolved in 1 ml. of 0·01 *M* sodium cacodylate buffer at *p*H 6·7. They were mixed thoroughly and the solution lyophilized. Fibres were then pulled from small amounts of the lyophilized material dissolved in distilled water. Examination of these fibres (of thickness around 0·1 mm.) showed them to be highly negatively birefringent with $\Delta n < -0{\cdot}05$.

X-ray diffraction photographs of these fibres were taken in a closed fibre camera with specimen to film distances of 3·0 and 4·0 cm. Helium was blown through the camera to reduce the amount of scattered radiation, and the relative humidity of the helium was controlled by passing it first through a gas dispersion tube placed in a saturated salt solution.

Model building studies indicate that this crystalline diffraction pattern (Fig. 1) can best be interpreted in terms of a deoxyribonucleic acid-like structure. The complex formed is a two-stranded helical structure with the ribose phosphate backbones of the two strands running in opposite directions as in the Watson and Crick structure of deoxyribonucleic acid[5]. The hypoxanthine bases of one strand form two hydrogen bonds with the cytosines of the opposite strand (Fig. 2) compared with three between the guanine–cytosine pair of deoxyribonucleic acid.

The intense non-meridional layer lines with spacings between 3 and 4 Å. suggest that the bases are not perpendicular to the fibre axis, but are tipped at an angle of about 7° to the horizontal. This amount of tipping would still enable the fibre to possess strong negative birefringence.

A peculiar feature of the diffraction pattern is the absence of strong intensity close to the meridian on the second and third layer lines. This may be tentatively accounted for by the presence of sodium cacodylate in the fibres. The strongly scattering cacodylate ion placed regularly in the crystal lattice can account for the observed absence of strong intensity. This region of the diffraction pattern is very sensitive to the ionic content of the fibre. If magnesium chloride is allowed to diffuse into the fibre the main features of the diffraction pattern are retained, but the near meridional region of the second layer line now becomes strong relative to the first layer line, giving an intensity distribution on the first three layer lines which is very similar to that observed for the *A* form of deoxyribonucleic acid.

Fibres of deoxyribonucleic acid show a reversible humidity-controlled transition from the *A* to the *B* form. Since it was suspected that the *A* and *B* forms of poly (I + C) bore a similar relation to each other as the *A* and *B* forms of deoxyribonucleic acid, attempts were made to obtain such a transition from the crystalline poly (I + C) fibres. However, over the range of 20–90 per cent relative humidity there was no major difference in the diffraction pattern. At 98 per cent relative humidity the fibres dissolved and at 0 per cent relative humidity the pattern became amorphous, but could be changed back to the crystalline *A* form on raising the humidity.

However, from poorly oriented fibres it was possible to obtain a non-crystalline pattern which was similar in many respects to the *B* pattern. The innermost regions of these patterns were weak in intensity, and this again might be due to the presence of sodium cacodylate. Well-oriented fibres inevitably crystallized.

The fact that the *A* and *B* forms may be found in fibres pulled under almost identical conditions suggests that the *B* form of poly (I + C) (and therefore, presumably, the helical regions of ribonucleic acid) may have the same configuration of the base pairs as the *A* form. However, direct evidence for the structure of the *B* form is not at present available and will have to await the production of better X-ray fibre patterns of this form. Further investigations are now being carried out to establish reproducible conditions for the production of the two forms of poly (I + C).

I wish to thank Dr. Leon Heppel for the gift of some poly C. I am also indebted to Drs. F. H. C. Crick and Martin Gellert for many stimulating discussions and suggestions.

[1] Doty, P., Boedtker, H., Fresco, J. R., Haselkorn, R., and Litt, M., *Proc. U.S. Nat. Acad. Sci.*, **45**, 482 (1959).

[2] Rich, A., and Watson, J. D., *Proc. U.S. Nat. Acad. Sci.*, **40**, 759 (1954).

[3] Davies, D. R., and Rich, A., *J. Amer. Chem. Soc.*, **80**, 1003 (1958).

[4] Ochoa, S., Special Publication, New York Acad. Sci., **5**, 191 (1957).

[5] Crick, F. H. C., and Watson, J. D., *Proc. Roy. Soc.*, A, **223**, 80 (1954).

A NEW TYPE OF AUTOXIDATION REACTION

Cause of the Instability of Cytochrome c Reductase

THE majority of flavoprotein enzymes are reasonably stable ; two, however, show an exceptional degree of instability, which makes their purification and study difficult. Bach, Dixon and Zerfas[1] found that the lactate dehydrogenase of yeast was so highly unstable as to prevent them from completing its purification, although Appleby and Morton[2] later succeeded in crystallizing it. The cytochrome *c* reductase of heart muscle is likewise very unstable, as has been noted by a number of workers since its first isolation by Mahler, Sarkar, Vernon and Alberty[3].

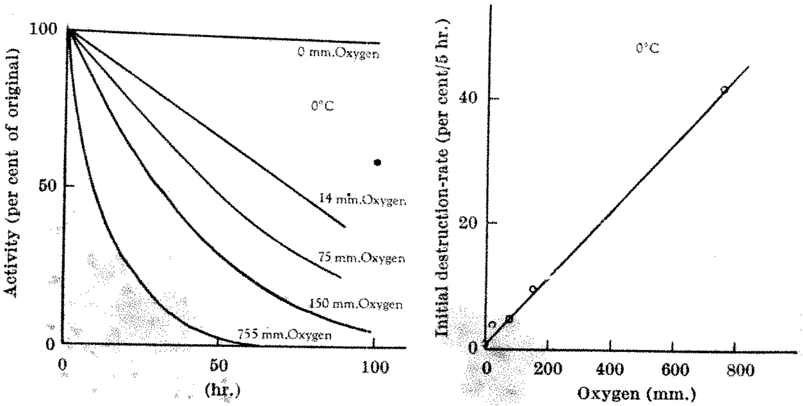
We have investigated the cause of the instability of the cytochrome reductase of pig heart. Simultaneously and independently, Prof. Morton *et al.* have studied the instability of the yeast lactate dehydrogenase, as reported in the following communication. It will be seen that the instability of both enzymes is due to the same cause, namely, a new type of autoxidation of the flavoprotein.

We find that cytochrome reductase, either in crude extract or purified by the method of Mahler *et al.*[3] or by other methods, has a half-life at room temperature of about 5 hr., and even at 0° it is markedly unstable. In unsuccessful attempts to stabilize the enzyme we have tested the effect of adding a considerable number of substances which are known to stabilize other enzymes, or which for various reasons might have been expected to prevent the inactivation. Albumin, glycerol, sucrose, histidine, glutathione, catalase, cytochrome *c*, reduced coenzyme I, cyanide, versene, dipyridyl, ammonium sulphate in high concentrations, tocopherol, chloroacetophenone, ferrous or ferric salts, riboflavin, flavin mononucleotide and flavin-adenine dinucleotide had no significant stabilizing effect ; alterations of *p*H were also ineffective.

The instability was finally traced to a reaction between the enzyme itself and oxygen, resulting in an irreversible inactivation with release of the flavin group from the protein. Removal of oxygen renders the enzyme stable : if a solution of the enzyme is divided into two portions, one is placed in an open test-tube and the other in an evacuated Thunberg tube, and both are kept at 0° for 4 days, the former is found to be inactive while the latter suffers no loss of activity. The inactivation in the presence of oxygen is accompanied by the appearance of the typical fluorescence of free flavin and under certain conditions, with strong solutions of purified enzyme, by the formation of a white protein precipitate.

Fig. 1*a* shows a series of inactivation curves with different oxygen pressures at 0°, from which it is clear that the rate of inactivation is proportional to the oxygen pressure (Fig. 1*b*). Fig. 2 shows the dependence on temperature, with a constant oxygen pressure (air) ; the Q_{10} is about 2·5, showing that the inactivation is not due simply to denaturation of the enzyme.

The results suggest that the protein part of the enzyme contains some autoxidizable group which is connected with the binding of the prosthetic flavin group, that this group exists in the reduced form in the intact enzyme, but that when the group becomes oxidized by oxygen the protein can no longer bind the flavin. The state of oxidation of the flavin group itself seems to be immaterial ; the inactivation occurs at about the same rate in the presence of reduced coenzyme I (which would keep the flavin reduced) as in the presence of cytochrome *c* (which would keep it oxidized).



(*a*) (*b*)

Fig. 1*a* and b. Effect of oxygen pressure on rate of inactivation of cytochrome reductase at 0° C.

The nature of the autoxidizable group remains undetermined. —SH groups come to mind, but such groups in other proteins are not nearly so sensitive to oxygen ; moreover the addition of glutathione (which should keep —SH groups reduced) fails to stabilize the enzyme. The enzyme contains some iron, which might catalyse the autoxidation of —SH groups, but if so cyanide, versene or dipyridyl would be expected to inhibit the inactivation, which is not the case. No uptake of oxygen could be measured during the inactivation, but this was to be expected. Assuming that 1 atom of oxygen is required per molecule of enzyme (m.w. 80,000, with 1 flavin group per molecule), as much as

5 mgm. of the pure enzyme would take up less than 1 μl. oxygen.

The inactivation is not due to the destruction of a factor which is necessary only for the reduction of cytochrome *c*; in other words, it is not merely a conversion of cytochrome reductase into diaphorase as suggested by Mahler[4] as a possible origin of diaphorase. All activity of cytochrome reductase (including its diaphorase activity) disappears in air, while that of diaphorase itself (which has no cytochrome reductase activity) is quite unaffected, as shown in Table 1. The instability of cytochrome reductase towards oxygen contrasts markedly with the stability of the flavoprotein diaphorase, obtained from the same tissue, which suffers no loss of activity on exposure to 4 atmospheres of oxygen for some hours at 38° (ref. 5).

Table 1. COMPARISON OF STABILITIES OF DIAPHORASE AND CYTOCHROME REDUCTASE

(Activities in arbitrary units)

Time of standing in air at room temperature	Diaphorase tested with indophenol	Diaphorase tested with cytochrome *c*	Cytochrome reductase tested with indophenol	Cytochrome reductase tested with cytochrome *c*
0	80	0	725	540
18 hr.	80	0	0	0

In addition to the inactivation by oxygen described above, cytochrome reductase is also inactivated by light, and for this oxygen is not required. Even the ordinary lighting conditions of the bench are sufficient to bring about appreciable inactivation. In all the above experiments the enzyme solutions were kept in darkness.

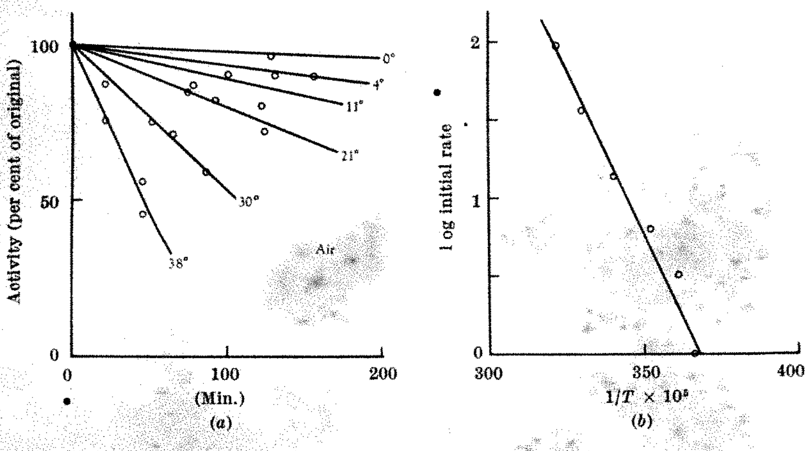


Fig. 2*a*, Inactivation of cytochrome reductase in air at various temperatures; *b*, Arrhenius plot of inactivation of cytochrome reductase in air, from results of Fig. 2*a*. Initial rate is taken as percentage loss in 40 min., corrected for differences in molarity of dissolved oxygen at different temperatures

It is possible that the inactivation of cytochrome reductase by oxygen may be important in connexion with the 'oxygen poisoning' produced by breathing oxygen at pressures exceeding 1 atmosphere, which has been ascribed to damage to the respiratory system of the tissues. Dickens[5] studied the stability to oxygen of several respiratory enzymes, the most sensitive proving to be the succinate dehydrogenase, with a half-life of 3 hr. at 38° with 1 atmosphere of oxygen. This, however, is far less sensitive than cytochrome reductase, which has a half-life of only 6 min. at this temperature and pressure of oxygen.

MALCOLM DIXON
J. M. MAYNARD
P. F. W. MORROW

Department of Biochemistry,
University of Cambridge.

---

[1] Bach, S. J., Dixon, M., and Zerfas, L. G., *Biochem. J.*, **40**, 229 (1946).
[2] Appleby, C. A., and Morton, R. K., *Nature*, **173**, 749 (1954).
[3] Mahler, H. R., Sarkar, N. K., Vernon, L. P., and Alberty, R. A., *J. Biol. Chem.*, **199**, 585 (1952).
[4] Mahler, H. R., "Advances in Enz.", **17**, 233 (1956).
[5] Dickens, F., *Biochem. J.*, **40**, 171 (1946).

Flavin Dissociation and Inactivation of Cytochrome b_2 by Oxygen

CYTOCHROME b_2, the L(+) lactate dehydrogenase of baker's yeast[1], is rapidly inactivated in the presence of air[1-4]. The inactivation occurs in the presence of substrate, and also with added hydrogen peroxide, and is decreased when catalase is added[2,3,5]. Hydrogen peroxide is not formed in any large amounts during short-term aerobic oxidation of lactate by cytochrome b_2 (ref. 5). Cytochrome b_2 is inactivated by cupric ion and by the sulphydryl reagent *p*-chloromercuribenzoate, as well as by oxygen[2]. With all these reagents, the enzyme becomes fluorescent. The fully active enzyme, which contains both riboflavin phosphate and protohæm as prosthetic groups, is not fluorescent[1,3,6]. The inactivation caused by oxygen or by cupric ion is apparently irreversible. Neither monoiodoacetate (10^{-2} *M*)[6] nor iodoacetamide (10^{-3} *M*)[7] causes any substantial inhibition or appearance of fluorescence at neutral *p*H values. It has been proposed that the flavin of cytochrome b_2 is bound to the enzyme by a sulphydryl group of the protein, and that this 'masked' group does not react with iodoacetate or iodoacetamide[2,4]. The following observations give further support to this hypothesis and suggest that inactivation by oxygen is due to rapid oxidation of protein thiol groups to form disulphide bonds. Unless otherwise specified, solutions were equilibrated with commercial 'oxygen-free' nitrogen and all manipulations were carried out in an atmosphere of this gas. Traces of oxygen were probably present.

Cytochrome b_2 sedimented in the 'Spinco' analytical ultracentrifuge as a single component ($S^0_{20,w}$ = 8·36 svedberg units) with a symmetrical boundary. The solution above the boundary was colourless and non-fluorescent. When the same enzyme solution was briefly exposed to air, and re-examined in the ultracentrifuge, two new components ($S_{20,w}$ approx. 11 and 15 svedberg units respectively) were observed in addition to the component mentioned above.

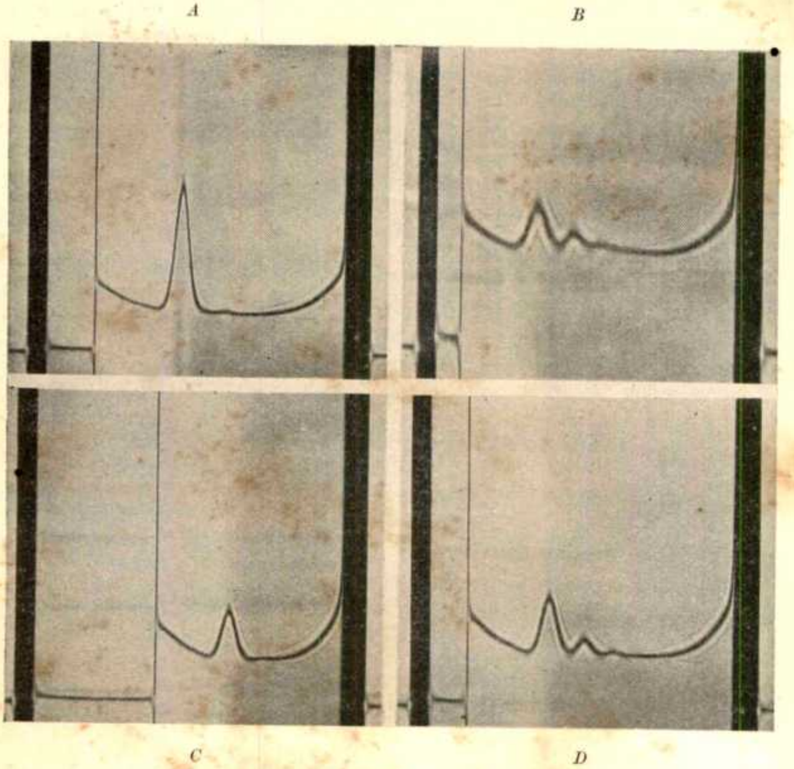


Fig. 1. Sedimentation behaviour of cytochrome b_2. Recrystallized cytochrome b_2 (0·4 to 1×10^{-4} M hæm) in 0·3 M sodium lactate, 0·05 M tetra-sodium-pyrophosphate; ethylene diamine tetra acetate, 10^{-4} M; adjusted to pH 6·8 with hydrochloric acid; ionic strength, 0·63; temperature, 2°–6° C. *A*, Under anaerobic conditions; *B*, the same preparation after brief exposure to air; *C*, preparation treated with 1×10^{-4} M p-chloromercuriphenylsulphonate and then exposed briefly to air; *D*, preparation exposed briefly to air and then p-chloromercuriphenylsulphonate (1×10^{-4} M) added. The photographs were not taken at equivalent times of centrifugation

The supernatant was yellow and had a characteristic flavin fluorescence (Fig. 1).

The addition of p-chloromercuriphenylsulphonate at about 10^{-4} M to a freshly prepared solution of enzyme (approx. $0·7 \times 10^{-4}$ M hæm) resulted in the appearance of strong flavin fluorescence after about 20 min. The enzyme sedimented as a single component with approximately the same sedimentation coefficient as intact cytochrome b_2 at the same concentration, and the supernatant was yellow and strongly fluorescent. When the enzyme treated with p-chloromercuriphenylsulphonate was exposed to air no further sedimenting components were formed (Fig. 1).

Treatment with N-ethyl maleimide (10^{-3} M) for about 45 min. caused about 45 per cent inhibition of the lactate–ferricyanide reductase activity of cytochrome b_2 and a corresponding appearance of flavin fluorescence.

It appears, therefore, that exposure of cytochrome b_2 to oxygen may cause a rapid dissociation of some of the riboflavin phosphate, accompanied by aggregation of the protein. The dissociation of flavin and the prevention of aggregation by p-chloromercuriphenylsulphonate provide further evidence that the flavin is bound to the protein by sulphydryl group(s). The aggregation caused by air is attributed to the formation of intermolecular disulphide bonds, with a concomitant displacement of the flavin group. Although it seems highly likely that the intermolecular disulphide bridge is formed by oxidation of sulphydryl groups previously masked by riboflavin phosphate, this has not yet been established with certainty. There are approximately 18 half-cystine residues/mole of hæm in cytochrome b_2 (ref. 8).

Other workers have recently shown that the flavin adenine dinucleotide prosthetic group of D-amino-acid oxidase is bound by its flavin to the protein via a sulphydryl group[9,10]. In this case, however, there is also bonding between the protein and the adenine portion of flavin adenine dinucleotide. As compared with the few known flavoproteins having riboflavin phosphate as the prosthetic group, many of the flavoproteins containing flavin adenine dinucleotide are rather stable and resist dissociation of their flavin prosthetic group.

Since the apoprotein of D-amino-acid oxidase is fairly readily reactivated by flavin adenine dinucleotide, it is possible that the oxidation of unmasked sulphydryl groups to disulphide bonds is prevented by steric effects. Theorell[11] suggested that the riboflavin phosphate of old yellow enzyme of yeast was bound to the apoprotein by a hydrogen bond involving the isoalloxazine nucleus and a tyrosine residue of the protein. In this enzyme no sulphydryl group was detected. The requirement of a p-chloromercuribenzoate-sensitive thiol group for enzymic activity has been reported for a number of other flavoproteins[12,13].

One of us (J. McD. A.) was supported by a Commonwealth Scientific and Industrial Research Organization senior post-graduate studentship during the course of this work.

J. McD. ARMSTRONG
J. H. COATES
R. K. MORTON

Department of Agricultural Chemistry,
Waite Agricultural Research Institute,
University of Adelaide.

[1] Appleby, C. A., and Morton, R. K., *Nature*, **173**, 749 (1954).

[2] Appleby, C. A., and Morton, R. K., *Biochem. J.*, **73**, 539 (1959).

[3] Morton, R. K., Armstrong, J. McD., and Appleby, C. A., Proc. Hæmatin Enzyme Symp., Canberra, 1959 (Pergamon Press, London; in the press).

[4] Armstrong, J. McD., Coates, J. H., and Morton, R. K., Proc. Hæmatin Enzyme Symp., Canberra, 1959 (Pergamon Press, London; in the press).

[5] Boeri, E., and Rippa, M., Proc. Hæmatin Enzyme Symp., Canberra, 1959 (Pergamon Press, London; in the press).

[6] Boeri, E., Cutolo, E., Luzzoti, M., and Tosi, L., *Arch. Biochem. Biophys.*, **56**, 487 (1955).

[7] Armstrong, J. McD. (unpublished work).

[8] Appleby, C. A., Morton, R. K., and Simmonds, D. H., *Biochem. J.*, **75**, 72 (1960).

[9] Yagi, K., and Ozawa, T., *Nature*, **184**, 1227 (1959).

[10] Kubo, H., Yamano, T., Iwatsubo, M., Watari, H., Soyama, T., Shiraishi, J., Sawada, S., Kawashima, N., Mitani, S., and Ito, K., *Bull. Soc. Chim. Biol.*, **40**, 431 (1958).

[11] Theorell, H., *Disc. Faraday Soc.*, **20**, 224 (1955).

[12] Harris, J., and Hellerman, L., in "Inorganic Nitrogen Metabolism", ed. W. D. McElroy and B. Glass, 565 (The Johns Hopkins Press, Baltimore, 1956).

[13] Weber, M. M., and Kaplan, N. O., *Science*, **123**, 844 (1956).

LETTERS TO THE EDITORS

COSMOLOGY

The Interpretation of Cosmology

We have to postulate that every part of the universe interacts, directly or indirectly, with every other part. We are probably justified in assuming that all fundamental interactions are propagated with the speed of light. It follows that we see all other parts of the universe in the state in which they influence our own part of the universe now. Therefore we can in principle predict the immediate future behaviour of our own part of the universe.

The situation is quite different as regards any remote part P of the universe. We see no other part of the universe in the state in which it influences P. For example, if P is 10^9 light-years away and Q is a part of the universe 10^9 light years away in the opposite direction, then, if the universe is static, whatever influence Q has on P when we observe P depends upon the state of Q at a time 2×10^9 years before Q was in the state in which we observe Q. But the universe is not static, and so we know nothing from observation about the state of Q when Q influenced the state of P in which we observe P.

Were the universe a finite system, we could overcome the situation by continuing our observations for a sufficiently long, but finite, time and then making predictions for still later times. But we almost certainly have to regard the universe as unbounded. Therefore, even in principle, we cannot predict the behaviour of a remote part of the universe with as much assurance as we can predict that of a nearer part.

This reveals a feature that ought to be built into any satisfactory theory of cosmology. Moreover, it agrees completely with our intuitive notion that we should be able to make predictions about sufficiently small parts of the universe, sufficiently near in space and time, but that we should be able to do no more than describe when we come to deal with regions so large that the uniqueness of the universe becomes relevant.

It thus appears that there is an uncertainty in cosmology, which may be said to be occasioned by the fact that the speed of light is not infinite, that is complementary to the uncertainty in atomic physics, which may be said to be occasioned by the fact that the quantum of action is not zero.

This feature is not in fact incorporated in current cosmological theory. But, if what has been said is significant, we seem to be driven to infer that the unavoidable uncertainty in any prediction about the part of the universe out to any particular distance is measured by $1 + z$, where z is the cosmological red-shift at that distance. (The usual definition is $1 + z$ = wave-length observed ÷ wave-length emitted.)

Now the difference between the predictions of evolutionary and steady-static cosmologies is only in factors $(1 + z)$, as was recently shown explicitly by P. S. Florides and me[1]. Thus an immediate consequence of the present view is that the difference between these theories loses any meaning. In fact, all problems concerning the creation of matter as hitherto formulated appear to lose significance. It is suggested that this is basically why all efforts to reach a decision between the two types of theory by observational tests have failed.

Following these ideas, the 'cosmological principle' would now assert that the universe as seen by a distant observer is like the universe as seen by us only to within a factor of uncertainty $(1 + z)$ in the description. Thus we should be asserting almost nothing about what the universe is like at great distances (in space or time). This provides a view of cosmology that essentially leaves room for endless observational surprises. It seems more satisfactory than the recent trend towards a belief that the nature of the 'whole' universe has already been discovered.

W. H. McCrea

Royal Holloway College
(University of London),
Englefield Green,
Surrey.

May 26.

---

[1] Florides, P. S., and McCrea, W. H., *Z. Astrophys.*, **48**, 52 (1959).

ASTROPHYSICS

Solar Limb Surges accompanied by X-Ray Emission

Sudden enhancements of atmospherics are recorded during solar flares[1]. The extra ionization of the lower D region at these times is brought about by X-rays emitted from the disturbed solar region[2].

The simultaneous observations in H_α line and records of atmospherics (27 kc./s.) carried out at our observatory indicate a pronounced coincidence in time

Table 1

	Limb surge		Sudden enhancements of atmospherics (disturbance of D region)			
Date	Time (U.T.)	Position	Time (U.T.)	Importance	Reliability	Note
May 8, 1959	6.58—(7.26)+7.53—(8.02)	N. 16 E. 90	7.18—7.25—7.47	2	5	1
May 13, 1959	8.56—9.01—(9.23)	S. 12 E. 90	8.56—9.02—(9.27)	2+	5	2
May 13, 1959	(9.25)—(9.36)— ?	S. 12 E. 90	9.28—9.40—(10.30)	2	5	3
June 9, 1959 (4)	$\sim$ 16.52 $\sim$ 17.40	N. 18 E. 90	16.38—16.56—(18.30)	2+	5	4
July 10, 1959	(15.02)—15.05—(15.30)	S. 20 E. 90	14.56—15.08—(15.50)	1+	4	
July 11, 1959	12.47—12.48—13.35	N. 15 W. 90	(11.30)—12.40+13.50—(14.17)	1+	3	5
Aug. 8, 1959	14.05—14.09+14.36— ?	N. 13 W. 90	(14.00)—14.22—(14.48)	1	4	6

Second column: beginning (approximate)—maximum—end of surge. Fourth column: beginning—maximum—end of sudden enhancements of atmospherics. Sixth column: degrees of reliability; fifth the highest reliability. Seventh column: notes refer to eventual accompanying radio events. (1) 231 Mc./s. (Ondřejov), 200 Mc./s. (ref. 5); (2) 536 Mc./s. (0); (3) 536 Mc./s. (0); (4) 69,760 Mc./s. (ref. 4), 9,400 Mc./s. (ref. 6), 2,930 Mc./s. (ref. 5); 2,800 Mc./s. (ref. 4), 1,500 Mc./s. (ref. 6), 545 Mc./s. (ref. 5), 200 Mc./s. (ref. 5); (5) 808 Mc./s. (0); (6) 200 Mc./s. (ref. 5).

of sudden enhancements of atmospherics with surge appearances[3]. Projected on the disk the surges are, as a rule, connected with some bright H_α event in the underlying chromosphere (flare, plage brightening). We selected from our observations only those limb surges the disturbed underlying chromospheric region of which was behind the limb on the back side of the Sun. From these limb surges we excluded those coinciding in time with some other H_α event on the Sun, in order to eliminate ambiguity. The list of the remaining limb surges accompanied by sudden enhancements of atmospherics and eventually by radio radiation is given in Table 1.

We conclude that the sudden enhancements of atmospherics accompanying the limb surges could be interpreted as X-ray radiation emitted by the adjacent region of the solar corona.

J. KLECZEK
L. KŘIVSKÝ

Astronomical Institute,
Ondřejov,
Czechoslovakia.
Feb. 19.

[1] Ellison, M. A., *J. Brit. Astro. Assoc.*, **69**, 127 (1959).

[2] Friedman, H., Joint Discussion on Astro. Observations by Artificial Satellites, Tenth Gen. Assoc. Intern. Astro. Union, Moscow (1958).

[3] Křivský, L., and Letfus, V., *Bull. Astro. Inst. Czechosl.*, **11**, 53 (1960).

[4] Coates, R. J., Covington, A. E., and Edelson, S., *Astron. J.*, **64**, 326 (1959).

[5] Solar Geophysical Data, Netherlands *PTT*.

[6] Beobachtungsergebnisse Heinrich-Hertz-Institut.

Rocket and Satellite Observations of the Solar Ultra-violet Spectrum

THE Lyman lines of hydrogen, as well as the corresponding lines of He I and He II, are of interest both as tools for analysing the solar atmosphere and as energy sources for the terrestrial ionosphere. So far, interest in these lines has centred mainly around the Lyman-α lines because of their greater strength.

Rocket and satellite programmes are under way for the continuous monitoring of the energy-flux and the accurate determination of the profiles of the Lyman-α lines. It is the purpose of this communication to direct attention to the unusual importance of parallel observations of the Lyman-β lines.

In the Doppler core of a line, the source-function, S, may be written in the form:

$$S = \frac{\gamma B}{\rho + \beta}$$

where B is the Planck-function, γ is slowly dependent upon electron density and kinetic temperature, and β and ρ are dependent upon the opacity as well as electron density and temperature. Our interest here lies in the evaluation of ρ, which represents the net rate of radiative transitions in the line normalized to unity in the case of no absorptions.

The evaluation of ρ requires integration of the equation of radiative transfer[1]. At $\tau \approx 1$, $\rho \gg \beta$. However, the explicit value of ρ depends markedly on the temperature gradient in the regions of the atmosphere for which $1 \lesssim \tau \lesssim (3\beta)^{-1/2}$. In the case of the Lyman-α lines, $(3\beta)^{-1/2} \gtrsim 10^2$ for H and He I and $\gtrsim 10^4$ for He II. On the other hand, for the Lyman-β lines $(3\beta)^{-1/2} \approx 2$. Thus, the intensities near the centres of the Lyman-α lines are influenced by the temperature structure throughout a large range in τ, whereas the intensities near the centres of the Lyman-β lines are determined primarily by the 'local' conditions at $\tau = 1$ in the solar atmosphere. For this reason, data for the Lyman-β lines present a much stronger supplement to Lyman-α data than if the two lines behaved in the same way, and the analysis of one line will be greatly facilitated if data for the other line are available.

A more detailed report of this work will appear elsewhere.

R. GRANT ATHAY

High Altitude Observatory,
University of Colorado,
Boulder, Colorado.

[1] Jefferies, J. T., and Thomas, R. N., *Astrophys. J.*, **127**, 667 (1958).

PHYSICS

Silver-activated Nitrocellulose as Recording Material for X-Ray Microscopy

ELECTRON optical enlargement of X-ray absorption micrographs has been discussed by Pattee[1] and Asunmaa[2]. A contact micrograph is recorded on a thin layer of material sensitive to X-rays in which the absorbed radiation promotes physical or chemical changes that modify the areal electron density. For example, there may be a decomposition resulting in soluble products which are afterwards removed. A relief image with details of submicroscopic scale then shows an electron optical contrast. For electron optical enlargement of an X-ray absorption micrograph (instead of a replica of it) certain conditions are necessary, particularly if the electron micrograph is to reproduce the quantitative properties of the X-ray absorption images[2].

Most film materials thin enough for recording X-ray images with good resolution and suitable for use in transmission electron microscopy as specimens with so-called characteristic thickness are radiographically slow. Recording speed can be increased by additional absorbents and by selection of radiation-induced reactions with considerable quantum yield.

Nitrocellulose activated by a radiation trap (inorganic crystals or organic degradative dyes in alkaline or acidic media) meets the requirements for recording speed and has been found to possess other suitable properties such as reduced sensitivity after development of the X-ray record. The irradiated areas of the film are efficiently destroyed, because of the sensitivity of the β-glucosidic bond of cellulose to ultra-violet and X-ray energy, and because of the autocatalytic degradation of the cellulose nitrate, which is accelerated by radiation, to form products of low molecular weight through depolymerization, denitration and hydrolytic degradation. A subsequent fractionated extraction removes the main part of the degradation products from the polymer matrix and the small molecules diffuse readily in the solvated solid. X-ray absorption by the polymer is favoured by the uniform distribution of compounds sensitive to radiation, namely, tetrazolium chloride in previous experiments[2], or submicroscopic silver halide crystals in a so-called Goldberg emulsion, known for its fine grain in photographic processes[4] and now utilized for its nitrocellulose component.

Goldberg emulsion was produced by mixing lithium chloride and silver nitrate solutions to form silver chloride dispersed in an acidic medium of 2 per cent nitrocellulose (10·8–12·2 per cent nitrogen) in a mixture of ethanol and ether. Uniform films, about 1000 Å. thick, were cast and irradiated on a glass surface under atmospheric conditions as well as in high vacuum through test objects in direct contact with the recording film. The X-rays originated in a 10–30-μ focal spot 2 mm. from the recording material in a microfocus X-ray tube or from an electron beam ('Hitachi *HU*-10') using its diffraction stage as target holder and 20 kV. acceleration. Exposures ranging from 10 min. to 1 hr. were used, dependent on the spectrum and intensity of the X-rays. Mainly aluminium K and nickel L radiation were used.

Radiolytically reduced metallic silver gave a direct visible image, but this optical contrast does not correspond to differences in electron scattering. The electron optical contrast was produced by treatment of the film with a 2 per cent solution of sodium cyanide in 20 per cent methanol. The silver and the silver salts were removed as water-soluble cyanide complex compounds. Lithium chloride and the main fraction of the degradation products were dissolved away through the methanol-swollen film. The remaining solvent-resistant polymer produced a relief image with differences in mass thicknesses. This relief film was less sensitive to subsequent electron bombardment than the corresponding image recorded on pure nitrocellulose.

The X-ray records were magnified in an electron microscope using a low-intensity 50-kV. or a 30-kV. electron beam ('Hitachi *HU*-10'). The rendering of the edges of the X-ray records of metallic objects (bars of a 1,500/in. silver grid) and of silica diatoms was fairly sharp in the electron micrographs (Figs. 1 and 2), showing that the X-ray effect was well confined on film areas receiving radiation. An energy transfer along a polymer chain to its most sensitive links thus did not limit the resolution. Gradations of photographic density in Fig. 2 correspond to graduated X-ray dosage; this makes X-ray absorptiometry possible, if suitable calibration can be employed. Fig. 3 shows an electron optical enlargement of an X-ray absorption micrograph of one diatom hole. The submicroscopic net bars, respectively about 600 Å. and 300 Å. wide (as illustrated in Fig. 4), are resolved, so a resolution better than 600 Å. is obviously attained. These dimensions are still more than one order of magnitude larger than the electron optical resolving power applied, and the net bar images therefore are suitable for the study of scattering contrasts (*Streuabsorption*[5]).

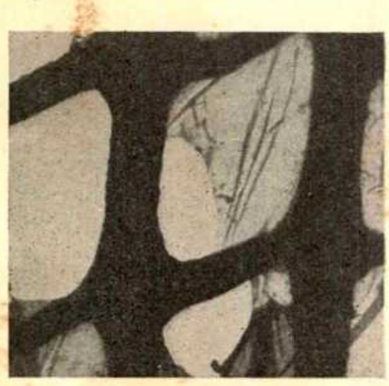


Fig. 1. Electron optical enlargement of an X-ray absorption micrograph of a 1,500/in. silver grid. Over-exposed to X-rays, supporting film broken

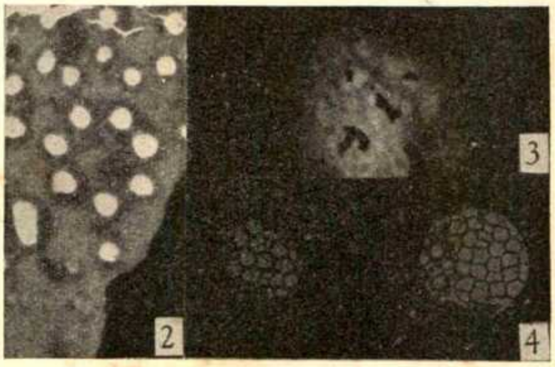


Fig. 2. Electron optical enlargement (× 1,600) of an X-ray absorption micrograph of a part of a diatom. Note the graduated X-ray effect

Fig. 3. Electron optical enlargement (× 19,000) of an X-ray absorption micrograph of a submicroscopic net in the hole of a diatom

Fig. 4. Electron micrograph (× 6,400) of submicroscopic net structures in diatom holes

The acceleration of the irradiation-induced reaction by the inorganic components is probably produced by photoelectrons and by re-radiation when silver ions trap electrons which have been liberated by X-ray absorption. Since oxidation is negligible, the method can be applied to irradiation in air as well as in high vacuum. The reduced sensitivity to radiation of the final record is probably produced by an initial overall polymerization during the induction period of the main irradiation reaction. There has been no attempt to measure the submicroscopic distortion which 'development' and irradiation processes may cause in the dimensions of the record.

I thank Prof. P. Kirkpatrick and Dr. P. V. Laakso for their interest.

This work was supported by the Office of Naval Research under Contract *Nonr*-225(42).

SAARA K. ASUNMAA

W. W. Hansen Laboratories of Physics,
Stanford University,
Stanford, California.

[1] Pattee, jun., H. H., Stockholm X-ray Symposium 1959 (Elsevier Pub. Co., Amsterdam) (in the press).

[2] Asunmaa, S. K., Stockholm X-ray Symposium.

[3] Ladd, W. A., and Ladd, M. W., "X-ray Microscopy", 383, edit. by Cosslett *et al.* (Academic Press, New York, 1957).

[4] Goldberg, E., *Z. tech. Phys.*, **7**, 500 (1926).

[5] v. Borries, B., and Lenz, F., Electron Microscopy, Proceedings of Stockholm Conference, 1956, p. 60 (Academic Press, New York, 1957).

Intrinsic Recombination Radiation in Diamond

DETAILED observations have been recently reported of radiation emission in germanium and silicon, which has been interpreted in terms of exciton recombination with emission and absorption of phonons[1,2]. In view of the similarities between these substances and diamond, it is of interest to look for analogous emission in the latter.

The visible luminescence spectrum of diamond consists mainly of a broad blue band, having its maximum at about 4400 Å. (2·8 eV.) and a complex, green–red system. The distribution of energy between these two regions depends markedly on the specimen, and the emission is thought to be connected with vacancies and substitutional impurities. Recent ultra-

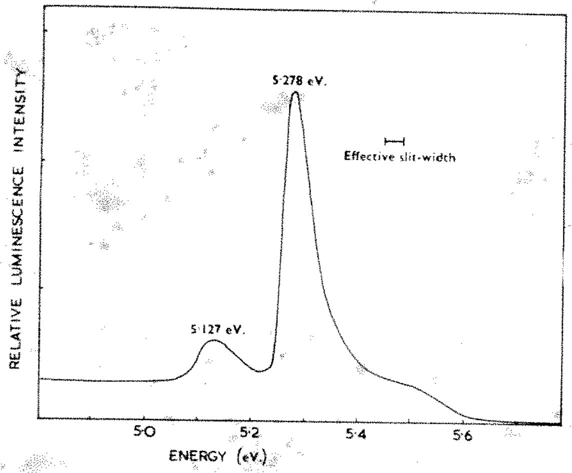


Fig. 1. Spectrum of intrinsic recombination radiation from diamond

violet absorption measurements[3] indicate that the threshold energy for indirect transitions between the valence and conduction bands is approximately 5·4 eV. at room temperature. This is some five times greater than the energy-gap for silicon, and it is to be expected that intrinsic radiative recombination will be an improbable process when compared with recombination via the centres mentioned above[4].

We have observed ultra-violet emission from a strongly blue-luminescent diamond which showed weak, ultra-violet transmission up to a quantum energy of 5·50 eV. The luminescence was stimulated by direct carrier injection, using an alternating potential of 150 volts at 50 c./s. applied between electrodes of colloidal graphite painted on to opposite faces of the crystal, which were 1·5 mm. apart. The diamond was mounted directly over the entrance slit of a Hilger medium quartz spectrometer. The spectrum was detected by a specially selected, low-noise, quartz-window photo-multiplier (*EMI*. 6256*B*) and recorded on a Brown strip-chart recorder.

The radiation emitted has a maximum energy of about 5·6 eV., and intensity maxima occur at energies of 5·278 ± 0·002 eV. and 5·125 ± 0·005 eV. The peak intensity at 5·278 eV. is of the order of 0·1 per cent of the intensity at the maximum of the blue band at 4400 Å. In view of the large effective slit-width employed, extrapolation of the low-energy sides of the intensity maxima to the energy axis is uncertain. The energies obtained in this way should be those associated with transitions involving recombination of excitons having zero velocity, with phonon emission. Analysis of the shape of the 5·278-eV. peak, using the method of Haynes *et al.*[1], indicates that the recombination probability for the excitons is proportional to $1/v^n$, where v is the exciton velocity and n lies between 1 and 2.

The visible luminescence appeared to be concentrated in a small region of diameter approximately 100μ, situated close to the crystal surface on the side facing the spectrometer slit, and it is presumed that the ultra-violet emission also originated at this point. Unfortunately, no other diamond was available which showed intense electroluminescence at voltages sufficiently low for measurements to be carried out at atmospheric pressure without interference from air discharges. However, it is hoped to carry out further investigations in the near future, using an electron beam to excite the free carriers. Attempts to assign phonon energies to the transitions will be delayed until these measurements and more unambiguous ultra-violet absorption data are available.

J. C. Male
J. R. Prior

Wheatstone Laboratory,
King's College,
Strand,
London, W.C.2.

[1] Haynes, J. R., *et al.*, *J. Phys. Chem. Solids*, **8**, 392 (1959).
[2] Haynes, J. R., *Phys. Rev. Letters*, **4**, 361 (1960).
[3] Clark, C. D., *J. Phys. Chem. Solids*, **8**, 481 (1958).
[4] Rose, A., "Photo-conductivity Conference", 15 (J. Wiley, 1955).

Detection of Negative Ions formed by Charge Transfer

We have reported recently the results of a series of measurements of the electron loss cross-section for hydrogen atoms of 5–40 keV. energy in various gases[1,2]. The method employed is capable of some precision, and the cross-sections obtained are accurate, we believe, to within 2–3 per cent. As a result we have been able to determine that in hydrogen and in carbon monoxide the cross-section does not vary smoothly with energy, but has a number of large fluctuations. In the carbon monoxide cross-section, for example, there are nine maxima in the region 8–40 keV. The magnitude of the oscillations is of the order of 10^{-16} cm.^{2} in a total cross-section of the order of 1–5 × 10^{-16} cm.^{2}.

On the other hand, the cross-section shows no such variation for argon. Thus it seems likely that the sudden increases which occur in the cross-section for electron loss are associated with a process which leaves the electron attached to the target molecule or a fragment of it after the collision rather than in a free state. The lack of resonances in argon indicates that this is the cause of the increases rather than some other inelastic process such as excitation of the target molecule, which might also reduce the chance that the electron emerge from the collision still attached to the incident proton.

Furthermore, we have constructed a model of a collision process which results in the formation of a negative ion of the target gas, and seems to give rather impressive numerical results. According to this model, an extra electron-loss channel is opened leading to the formation of negative ions when the target molecule has a positive electron affinity. As a hydrogen atom approaches a molecule the electron to be captured first makes a transition to the continuum. This leaves it travelling toward the target molecule and somewhat faster than the proton with a velocity $V_H + \Delta V$, where V_H is the initial velocity of the hydrogen atom in the laboratory. The kinetic energy of the electron in the laboratory is then $m_e(V_H + \Delta V)^2/2$, and it behaves in the rest of the collision just as a free electron. There is a high probability that it can be captured if this energy is sufficient to produce a negative ion state of the target molecule in accordance with the operation of the Franck–Condon principle. The cross-section should, however, be very much larger than the analogous free-electron process because of the proximity of the proton. Energy and momentum balance can readily be achieved.

Table 1. THRESHOLDS OF ELECTRON-LOSS CROSS-SECTION PEAKS AND CORRESPONDING ELECTRON-ENERGY COMPARED WITH EXPECTED APPEARANCE POTENTIALS FOR NEGATIVE IONS

Hydrogen energy (keV.)	Electron energy (eV.)	Appearance potentials (eV.)	
8·10	6·59		
12·55	9·71	9·66	$C(^3P) + O^-$
14·45	11·03	10 92	$C(^1D) + O^-$
16·6	12·5	12 84	$C(^1S) + O^-$
23·50	17·15	17·11	$C^* + O^-$
28·77	20 65	20·93	$C^+(^3P) + O^- + e$
32 4	23·30	23 40 or 23·63	$C^- + O^+ + e$
35·40	25 25		
36·9	26 12	26·26	$C^+(^4P) + O^- + e$

It was found that if ΔV was assumed to be a linearly increasing function of V_H—and the same function for hydrogen, carbon monoxide and water impurities in the hydrogen experiment—almost all the cross-section peaks could be associated with the various possible negative ion states of hydrogen, water and carbon monoxide. Table 1, reproduced here from a previous communication[2] for the sake of completeness, shows the predicted appearance potentials of various negative ion states of carbon monoxide, and the observed thresholds in terms of the energy of the hydrogen atom and the associated electron-energy computed on the basis of our model. A particularly notable feature of Table 1 is that the peak in the cross-section near 10 keV. must correspond to the formation of the bound molecular ion CO^- since the electron-energy is less than 9·66 eV., the dissociation energy of CO^-. It is to be remarked also that only one peak appears to correspond to the formation of C^-, namely, that at an energy of the hydrogen atom of 33·82 keV.

We have constructed a simple mass-spectrometer designed to detect whatever ions are produced in a gas through which a fast atomic or ionic beam is passed. We have found that negative ions are in fact formed in certain gases by fast hydrogen atoms. These gases are hydrogen, carbon monoxide, water and oxygen. No negative ions could be detected in helium, argon or nitrogen. In hydrogen we have detected H^-; in carbon monoxide, C^-, O^- and CO^-; in water, H^- and O^-; and in oxygen, O^-. The cross-sections for the formation of negative ions appear to be very large, as we expected. In fact in CO we have found them to be of the order of 10^{-16} cm.^{2} at the maxima and to vary in the same way as the cross-section for electron-loss for the hydrogen atoms; that is, maxima and minima occur for the same hydrogen atom energies. The relative variation is much larger in the cross-section for formation of negative ion. There are, of course, other processes which contribute to the cross-section for electron-loss.

In Table 2 we present an analysis of the ions found at various atomic beam-energies. The relative rate of formation for the various species is obtained by an extrapolation to zero carbon monoxide pressure. At most energies it was found that a weakly bound CO^- was formed which inevitably broke up into C and O^- before reaching the magnet of the mass spectrometer. This species is denoted by the symbol $CO^- \rightarrow O^-$ in Table 2. On the other hand, as predicted, the predominant ion in the 12-keV. peak is a firmly bound CO^- ion. C^- is found at one energy only, namely, at 33·82 keV., again as predicted. The total cross-sections for formation of negative ions are given where they have been measured.

Table 2. NEGATIVE IONS FORMED BY THE PASSAGE OF HYDROGEN ATOMS THROUGH CARBON MONOXIDE AT VARIOUS ENERGIES

The relative rates of production of the various species and the cross-sections for formation of negative ions where they have been measured are also given

Hydrogen energy (keV.)	Ionic species		Cross-section (cm.^{2})
12.00	CO^- (98 per cent)	O^-	1 0 × 10^{-16}
13·07	O^-	$CO^- \rightarrow O^-$	
13 75	O^- (98 per cent)	$CO^- \rightarrow O^-$	1·1 × 10^{-16}
14·34	O^- (91 per cent)	CO^-	0·22 × 10^{-16}
16·29	O^- (90 per cent)	$CO^- \rightarrow O^-$	1 26 × 10^{-16}
17 42	O^- (82 per cent)	$CO^- \rightarrow O^-$	0 33 × 10^{-16}
30 71	$m_{\text{eff}} = 20$	$CO^- \rightarrow O^-$	
33 82	$m_{\text{eff.}} = 20$	$CO^- \rightarrow O^-, C^-$	

It appears that this process is by far the most effective yet found for formation of negative ions. It ought to play an important part in the upper atmosphere—particularly during auroræ—and in stellar atmospheres. It should be noticed that such processes as:

$$H + O \rightarrow O^- + H^+$$

would also appear to be possible because of the presence of the proton. Finally, the results of the ion analysis appear to confirm the validity of the model we have presented. The nature of the events leading to the formation of the loosely bound CO^- species remains, however, unknown.

The work reported here was supported in part by the Office of Naval Research and the Office of Ordnance Research, U.S. Army.

T. M. DONAHUE*
F. HUSHFAR

Physics Department,
University of Pittsburgh,
Pittsburgh, Pennsylvania.

---

* John Simon Guggenheim Fellow, Service d'Aeronomie, Observatoire de Meudon, S.-et-O., France.

[1] Curran, R., and Donahue, T. M., *Phys. Rev.* (to be published); *Bull. Amer. Phys. Soc.*, Ser. II, **4**, 234 (1958).

[2] Donahue, T. M., and Hushfar, F., *Phys. Rev. Letters*, **3**, 470 (1959).

GEOLOGY

West-Pacific Stratigraphic Correlation

THE development of reliable methods of world-wide stratigraphic correlation involves the gradual replacement of empirical and traditional 'index fossils' by zonal index species selected on the basis of carefully analysed factors concerning their evolution and distribution. This approach favours abundant fossils to which statistical methods of population study can be applied, such as Foraminifera; rapidly evolving lineages, such as larger Foraminifera; and widespread forms, relatively independent of facies, such as planktonic organisms. It also necessitates a major effort to clarify stratigraphic terminology and classification which is expected to be significantly advanced soon as a result of the work of the Commission on Stratigraphy of the International Geological Congress. The framework of the conventional stratigraphic subdivisions of geological time, dating back to the time when geological knowledge began to accumulate long ago in Europe, is found to lack precision and to suffer from other deficiencies when attempts are made to accommodate in it the results of precise stratigraphic correlation in previously unknown parts of the world. Patient co-operative work of stratigraphers and palæontologists in different continents is required in order to overcome the difficulties and misunderstandings resulting from an over-extension of weakly founded terms and concepts. As Gignoux[1] has stated, it is essential first to establish local stratigraphic sequences (on a rock stratigraphic and zonal biostratigraphic basis, I might now add) and to generalize them only cautiously.

"Much of the correlation of mid-Tertiary Indo-Pacific foraminiferal assemblages depends at present on the recognition of the *Globigerinatella insueta—Globigerinoides bispherícus* zone. Its significance for the Pacific region was first recognized by Todd *et al.*[2], who found it represented on Saipan. The subsequent publication of the geology of Saipan by Cloud *et al.*[3] now enables the stratigraphic relations of this fauna to be examined more closely[4]." In a recent contribution to a stratigraphic handbook[5] I mentioned briefly an alternative view of the relations of this zone fauna from the Mariana Islands which links the Tertiary of the West Pacific with that of the West Indies. It appears now that the original assumptions have led to confusion in the interpretation of important further discoveries. A brief discussion of the problem and its solution is therefore here presented. The *G. insueta*-fauna was found in tuffs (later named the Fina-Sisu formation) which were stated to dip beneath sub-horizontal limestones (Tagpochau Limestone) that contain larger Foraminifera considered to be of Tertiary *e* (early Miocene) age. The fauna found in the vicinity of the tuff outcrops, as quoted in the original paper by Todd *et al.* and later described by Cole[6], does not contain restricted *e*-stage species. Only *Cycloclypeus eidae* Tan, "*Eorupertia semiornata* (Howchin)" (not figured from this locality), *Lepidocyclina sumatrensis* (Brady), *L. verbeeki* Newton and Holland, *Miogypsina thecideaeformis* Rutten, *Gypsina mariannensis* Hanzawa and *Marginopora vertebralis* (Quoy and Gaimard) occur at the relevant localities. This is definitely not an *e*-stage but an *f*-stage assemblage, in terms of the letter-classification of the Indonesian Tertiary. Older faunas were found elsewhere in the Tagpochau Limestone, and for this reason Cole placed the entire formation in the *e*-stage which he considered as Lower Miocene. The tuffs representing the zone of *Globigerinatella insueta* were accordingly placed in the Oligocene. This dating agreed with the then accepted correlation of this unit in the zonal sequence of the West Indies, but disagreed with subsequent revisions of the dating of the Tertiary of the West Indies by Eames, Drooger and others, according to whom the *insueta*-zone is either upper Aquitanian[7] or upper Vindobonian. This disagreement disappears if the Fina-Sisu tuffs in the southern part of Saipan are considered, as they should be on the evidence of published data, as overlain not by the basal part of the Tagpochau Limestone (this was assumed implicitly by Todd *et al.*) but by its highest portion which is to be placed in the *f*-stage. Interbedding of tuff and limestone is an alternative which does not appear to be inconsistent with the detailed map[3].

A close association of the planktonic Foraminifera of the *G. bispherica* zone with *f*-stage larger Foraminifera has just been described by Cole, Todd and Johnson[8] from Yap in the Caroline Islands. The previous assignment of these two groups of fossils to different zones, stages and even series on Saipan made it necessary for the authors to consider carefully possible alternatives, but these did not include a revision of the field relations, and their concluding statement (p. 91) reads as follows: "These rejected possibilities leave us with scarcely anything more than the conclusion that we cannot explain the conflicting evidence of age from the larger and smaller Foraminifera on Yap". Actually, the evidence from Saipan as re-interpreted here, together with new data from Australia and old records from Borneo[9], indicate that the distinctive benthonic larger Foraminifera characterizing the *f*-stage and the planktonic smaller Foraminifera of the *G. bisphericus* zone (= upper *Globigerinatella insueta* zone) are closely associated throughout this region. They also indicate the post-Aquitanian age of these assemblages[4]. A discussion of the discrepancy between this dating and the placing of the same zone in the Aquitanian[7] must await publication of fuller details.

M. F. GLAESSNER

University of Adelaide.
South Australia.
May 19.

---

[1] Gignoux, M., "Géologie stratigraphique", fourth ed., 599, footnote 2 (Paris, 1950).

[2] Todd, R., Cloud, P. E., Low, D., and Schmidt, R. G., *Amer. J. Sci.*, **252**, 678 (1954).

[3] Cloud, P. E., Schmidt, R. G., and Burke, H. W., U.S. Geol. Survey, Prof. Paper 280-*A* (1956).

[4] Glaessner, M. F., *J. Geol. Soc. India*, 1, 58 (1959).

[5] Glaessner, M. F., in "Handb. d. Stratigraphischen Geologie", edit. by Lotze, F., **3** (1), Tertiary, first part, 303 (1959).

[6] Cole, W. S., U.S. Geol. Survey, Prof. Paper 280-*I*, 321 (1957).

[7] Eames, F. E., Banner, F. T., Blow, W. H., and Clarke, W. J., *Nature*, **185**, 447 (1960).

[8] Cole, W. S., Todd, R., and Johnson, C. G., *Bull. Amer. Paleont.*, **41**, 77 (1960).

[9] Koch, R., *Ecologae geol. Helv.*, 19, 732 (1926).

GEOCHEMISTRY

Exposure Ages for Iron Meteorites

THE rare gases in iron meteorites induced by cosmic rays can be used to obtain estimates of the exposure ages of the meteorites[1–3]. The rare-gas nuclides are formed by the nuclear reactions induced by high-energy cosmic-ray particles at a presumably constant rate in time and space. The rate is, however, dependent on the depth at which the sample being investigated is below the surface of the meteorite in its flight through space. This depth is dependent on the absorption of the cosmic-ray particles by the meteorite.

In general, in order to estimate an exposure age, one needs a rate of production of a given nuclide and its total content in the meteorite. The activity-level of a radionuclide with a half-life short compared to the exposure age (usually 100–1,000 × 10^6 years) furnishes a measure of the rate of production; while modern mass-spectrometric techniques make possible the measurement of the rare-gas content of meteorites using of the order of 0·1 gm. per sample. However, the present methods being used for detection of radioactive products require of the order of 100 gm. per sample. As a result there are considerably more rare-gas measurements than radioactivity measurements. Recently such rare-gas measurements have been used to estimate exposure ages[1] by assuming all meteorite specimens are in the same cosmic flux. That is, it is assumed that the depth of a sample in the original body in space is never sufficiently large to cause a great variation in the production-rate of cosmic rays. While there is some evidence that this is the case for stone meteorites, it is certainly not the case for the iron meteorites, and any estimate based on a constant production-rate can, in a given case, be in error by more than an order of magnitude. It would clearly be desirable to have a method of estimating the production-rate from the rare-gas contents alone. Helium is formed with good yield by low-energy reactions while a product such as neon or argon is only found by relatively high-energy interactions. For this reason a ratio such as helium-3/argon-38, for example, is dependent on the ratio of high- to low-energy particles producing the interactions. In turn, this ratio is dependent on the depth below the surface. With increasing depth, relatively more low-energy secondaries are formed. In this way a ratio such as helium-3/argon-38 will furnish a measure of the depth.

There is a complication; if the meteorite should contain calcium, the argon-38 would also be produced in good yield by low-energy secondaries. However, one has available in addition to this ratio the ratio helium-3/neon-21 and helium-3/helium-4, both of which should show a similar dependence on the depth below the surface. Again, each of these ratios can be affected by the presence of an impurity. The presence of magnesium will alter neon-21 production markedly, while the presence of lithium or uranium will alter the ratio helium-3/helium-4. If the ratios helium-3/helium-4, helium-3/argon-38 and neon-21/argon-38 are used to derive a scale of depth, then it should be possible to pick out ratios that are anomalous.

It is thus possible to establish a scale of the production-rate of a given nuclide as a function of a rare-gas ratio. For example, the production-rate of helium-3 can be estimated from the ratios helium-3/argon-38 and the measurements of argon-39 and chlorine-36[4-6] for meteorites, the rare-gas contents of which have been determined on adjacent pieces, that is, at the same depth. The relations involved are:

(1) Production-rate of helium-3 = production-rate of chlorine-36 : $(^3\text{He}/^{38}\text{Ar})\dfrac{\sigma(^{38}\text{Ar})}{\sigma(^{36}\text{Cl})}$

(2) Production-rate of helium-3 = production-rate of argon-39 : $(^3\text{He}/^{38}\text{Ar})\dfrac{\sigma(^{38}\text{Ar})}{\sigma(^{39}\text{Ar})}$

where $(^3\text{He}/^{38}\text{Ar})$ represents the ratio of the rare-gas content of the meteorites. The ratios of cross-sections are obtained from the bombardment by high-energy protons of iron (see ref. 7, also Fisher and Schaeffer, unpublished work). These cross-sections are not very sensitive to the energy and so should be practically independent of the depth of the sample in the meteorite.

When the results in the literature are treated in this way, one can obtain the plot shown in Fig. 1. While the data show the usual spread when accumulating results from a number of independent laboratories, there is none the less a definite change in the production-rate with the ratio helium-3/argon-38. It should be possible to use this figure to interpret some of the results on the rare-gas contents of iron meteorites.

Table 1. METEORITES LISTED IN ORDER OF INCREASING DEPTH

Meteorite	Helium-3 $\times 10^{-8}$ (c.c. N.T.P./gm.)	Helium-3 / Helium-4	Helium-3 / Argon-38	Neon-21 / Argon-38
Washington Co.	193 ± 20	0·067	26	0·28
Tucson	13 ± 1	0·09	25	1·5
Forsyth Co.	48 ± 6	0·32	23	0·28
Canon Diablo	95 ± 9	0 30	23	0·23
Smithland	58 ± 4	0·25	22	0 25
Santa Rosa	47 ± 5	0·26	21	0·19
Santa Catherina	57 ± 6	0·25	22	0·19
Tombigbee River	4·7 ± 1	0 14	7·4	0·12

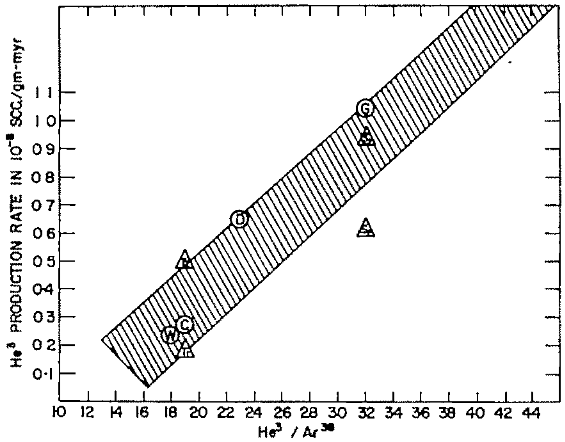


Fig. 1. Production-rate of helium-3 plotted against ratio of helium-3/argon-38. The circles are calculated from chlorine-36 data, the triangles from argon-39 data. *G*, Casas Grandes (ref. 5); S_1, Sikhote-Alin (ref. 5); S_2, Sikhote-Alin (ref. 4); *D*, Canon Diablo (ref. 5); *C*, Carbo (ref. 5); T_1, Treysa (ref. 10), T_2, Treysa (ref. 4); *W*, Williamstown (ref. 5)

Recently the rare-gas contents of several meteorites have been measured[8]. These are listed in Table 1 in order of increasing depth as determined from the ratios helium-3/helium-4, helium-3/argon-38 and neon-21/argon-38.

It can be seen that not all the ratios vary uniformly, and it is suggested that the presence of small amounts of impurities may be influencing the ratios. For example, the low values of the ratios helium-3/helium-4 in the Washington County and Tucson meteorites are probably due to the presence of radiogenic helium from uranium or primordial helium[8,9]; while the high ratio neon-21/argon-38 in Tucson is probably due to the production of neon-21 from magnesium and silicon, which are known to be present to the extent of several per cent in this meteorite.

Table 2. COSMIC-RAY EXPOSURE AGES

Meteorite	Age (million years)	Meteorite	Age (million years)
Toluca*	75	Smithland*	115
Toluca†	110	Treysa‡	1,500
Casas Grandes*	120	Williamstown*	1,900
Arispe*	340	Santa Rosa	120
Odessa*	250	Santa Catherina	140
Sikhote-Alin*	145	Carbo	1,200
Washington Co.	290	Henbury†	1,200
Tucson	20	Imilac†	740
Forsyth Co.	95	Cerros del Buei Mueito†	72
Canon Diablo	190		

* From the data of Schaeffer and Zähringer (see ref. 11).
† From the data of Gentner and Zähringer (see ref. 12).
‡ From the data of Kistner (see ref. 6).

By the use of Fig. 1, the ratio helium-3/argon-38 and the helium-3 content, it is now possible to

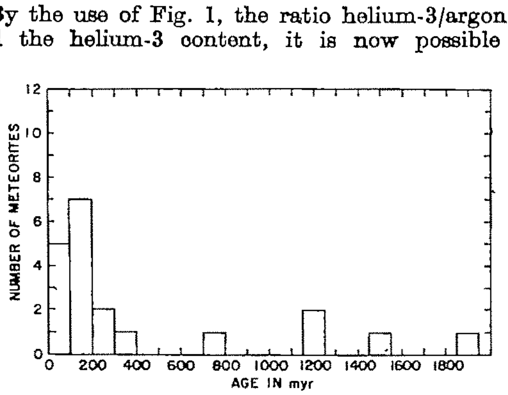


Fig. 2. Cosmic ray exposure ages of the iron meteorites

estimate ages for all the meteorites in Table 1, as well as a number which have been reported in the literature. These are tabulated in Table 2.

The data have been arranged in a histogram in Fig. 2, from which it can be seen that the exposure ages show a variation extending to nearly two thousand million years, with a most probable value near 100–200 million years. This can be interpreted as characteristic of a continual breaking-up process of bodies in space, leading to freshly exposed surfaces.

This work was carried out under the auspices of the U.S. Atomic Energy Commission.

OLIVER A. SCHAEFFER
DAVID E. FISHER

Brookhaven National Laboratory,
Upton,
Long Island,
New York.

[1] Urey, H. C., *J. Geophys. Res.*, **64**, 1721 (1959).
[2] Singer, S. F., *Nuovo Cimento*, **8**, 539 (1958).
[3] Ebert, K. H., and Wanke, H., *Z. Naturforsch.*, **12**, A, 766 (1957).
[4] Fireman, E. L., *Nature*, **181**, 1613 (1958).
[5] Sprenkel, E., Ph.D. thesis (1959) (unpublished).
[6] Kistner, G., Ph.D. thesis (1958).
[7] Schaeffer, O. A., and Zahringer, J., *Phys. Rev.*, **113**, 674 (1959).
[8] Fisher, D. E., and Schaeffer, O. A., *Geochim. Cosmochim. Acta* (in the press).
[9] Schaeffer, O. A., and Fisher, D. E., *Nature*, **183**, 660 (1959).
[10] Wanke, H., and Vilcsek, E., *Z. Naturforsch*, **14**, A, 929 (1959).
[11] Schaeffer, O. A., and Zähringer, J., *Geochim. Cosmochim. Acta* (to be published).
[12] Gentner, W., and Zähringer, J., *Geochim. Cosmochim. Acta*, **11**, 60 (1957).

CHEMISTRY

Effect of Solvent Polarizability on the Ultra-Violet Spectral Shifts of Aromatic Compounds

IT is generally recognized that non-polar solvents cause a long wave-length shift of the optical spectral maxima of absorbing solutes, and that this shift tends to increase with the polarizability of the solvent. Bayliss[1] has proposed that:

$$\Delta\nu(\text{cm.}^{-1}) = \frac{3e^2}{8\pi^2c^2m} \cdot \frac{f}{\nu a^3} \cdot \frac{n^2-1}{2n^2+2} \qquad (1)$$

where $\Delta\nu$ is the long wave-length shift, compared to the dilute vapour spectral position, f is the oscillator strength (that is, the number of 'classical' absorbing electrons), a is the radius of the absorbing molecule, n is the refractive index of the solvent, and the other symbols have their usual significance. Longuet-Higgins and Pople[2] have proposed the relationship:

$$\text{red shift} = \frac{1}{6}\,\alpha_B z\bar{R}^{-6}\left(\frac{1}{4}\,E\alpha_A + M\right) \qquad (2)$$

where the shift is expressed in energy (frequency × h); α_A and α_B are the molecular polarizabilities of the solute and solvent, respectively, and M and E are the dipole moment and energy of the transition. Each solute molecule is regarded as being surrounded by z solvent molecules at a mean distance $\bar{R}$. This relationship predicts that the long wave-length shift will be proportional to $(n^2-1)/(n^2+2)$. Both equations predict that $\Delta\nu(\text{cm.}^{-1})$ or $\Delta\lambda$ ($\Delta\lambda = \lambda_s - \lambda_0$, where the subscripts refer to solvent and vapour respectively; over the very short wave-length range to be considered here, $\Delta\lambda = \Delta\nu\lambda^2$ to a high degree of approximation) will approach zero only in the vapour state, and that in any solvent a substantial shift should be observed. Similar but more elaborate theoretical treatments have been given by Ooshika[3] and McRae[4].

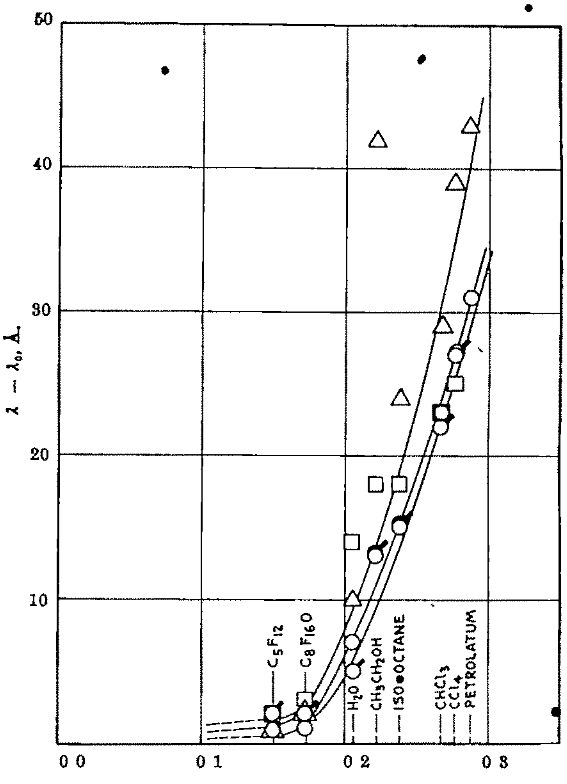


Fig. 1. The long wave-length shift $\lambda_s - \lambda_0$ (Å.), compared to vapour, of the ultra-violet spectral maxima of four aromatic compounds in solvents of refractive index n, plotted as a function of $(n^2-1)/(n^2+2)$; ○, benzene; △, phenol; ♂, fluorobenzene; □, benzotrifluoride

There appear to be very few data on ultra-violet and visible spectral shifts in non-polar solvents which permit a test of these equations. Lauer and Oda[5] found the shift of the benzene spectrum tended to increase with solvent refractive index, but the scatter of their data is too large to permit a test of any definite relationship. In addition, the reported vapour maxima positions are in error. Shepard[6] presented data for a merocyanine dye in four solvents. A linear plot of $\Delta\lambda$ vs. n appeared to pass through the origin; but the extrapolation was rather long. A recalculation of these data by Bayliss[1] gave a plot of $\Delta\nu(\text{cm.}^{-1})$ vs. $(n^2-1)/(2n^2+1)$ which did not pass through the origin; a similar plot for solutions of bromine likewise did not pass through the origin. Phibbs[7] observed that solutions of atomic mercury in water and several organic solvents did not obey Bayliss's relationship. Ham[8] found that complexes of iodine with benzene, mesitylene, and hexamethylbenzene gave shifts which were linear in $(n^2-1)/(2n^2+1)$, and McRae[4] observed similar behaviour for phenol blue, but in both cases the vapour position is indeterminate.

In the course of an investigation of the ultra-violet spectra of proteins and protein models[9], we have had occasion to measure carefully the ultra-violet spectral shifts of benzene, phenol, fluorobenzene, and benzotrifluoride in solvents of varying polarity and polarizability. A particular feature of this study is the inclusion of two solvents of very low polarizability: a cyclic perfluoro-C_8 ether, $C_8F_{16}O$, manufactured by Minnesota Mining and Manufacturing Co. ($n_D^{25} = 1{\cdot}2775$), and perfluoropentane ($n_D^{25} = 1{\cdot}2390$). This enables the relationship of $\lambda_s - \lambda_0$ to n to be extended to considerably lower n than in previous studies. A Cary model 11 spectrophotometer was employed, 1-cm. cells with quartz windows being used for all solutions and a 5-cm. cell for vapour samples. The solution of benzene in petrolatum was measured using quartz plates with 0·015-cm. glass spacers; the refractive index of the petrolatum was 1·4858. The spectrum of a 5 per cent solution of benzene in the cyclic perfluoro-C_8 ether was recorded using a thin liquid film squeezed between quartz plates without spacers.

In Fig. 1 are shown the long wave-length shifts $\lambda_s - \lambda_0$ (in Å.) for benzene (0·0050 *M*, 2529 Å. vapour band), fluorobenzene (0·00115 *M*, 2644 Å. vapour band), phenol (0·00080 *M*, 2685 Å. vapour band[10]) and benzotrifluoride, (0·00390 *M*, 2645 Å. vapour band) in perfluoropentane, cyclic perfluoro-C_8 ether, water, ethanol, *iso*octane, chloroform, carbon tetrachloride and petrolatum, plotted vs. $(n^2 - 1)/(n^2 + 2)$. The refractive indices of the solvents and their positions along the abscissa of Fig. 1 increase in the order given. The spectral shifts for benzene lie on a nearly straight line which appears to extrapolate to an intercept of about 0·18 on the abscissa. Fluorobenzene shows very similar behaviour. Benzotrifluoride, which is quite polar ($\mu_D = 2{\cdot}63$ D.U.) but presumably does not form hydrogen bonds, shows somewhat larger shifts in water and ethanol, for which there appears to be no obvious explanation. Phenol shows a very large shift in ethanol (probably largely the result of hydrogen bonding, with the phenol acting predominantly as the hydrogen donor) but a 'normal' value in water[9] (where it may act equally as donor and acceptor). The slope of the line for phenol is somewhat greater than that for benzene and fluorobenzene, corresponding to its greater oscillator strength. All four give approximately straight lines for the solvents of higher refractive index, but the curve evidently bends sharply below about 0·15–0·17 on the abscissa, since it appears that it must pass through the origin. Therefore, none of the proposed relationships between $\lambda_s - \lambda_0$ (or $\Delta\nu$) and n is even approximately correct, at least for these systems.

The apparently nearly zero polarizability of the fluorocarbon solvents with respect to these aromatic solutes is of some interest, and is probably quite general. Although it is well recognized that the polarizability of fluorocarbons is relatively low, it is clear that it is far from zero. For example, the van der Waals forces between fluorocarbon molecules are large enough so that their boiling points do not differ greatly from those of the corresponding hydrocarbons[11]. The van der Waals forces between fluorocarbon and hydrocarbon molecules are apparently peculiarly low, as judged by their low mutual solubility[12]. The very small spectral shifts may be in part another aspect of this anomalous behaviour. The problem seems to be broader than this, however, for the observed shifts for all the other solvents lie close to the same nearly straight line, which does not have the slope or origin indicated by theory.

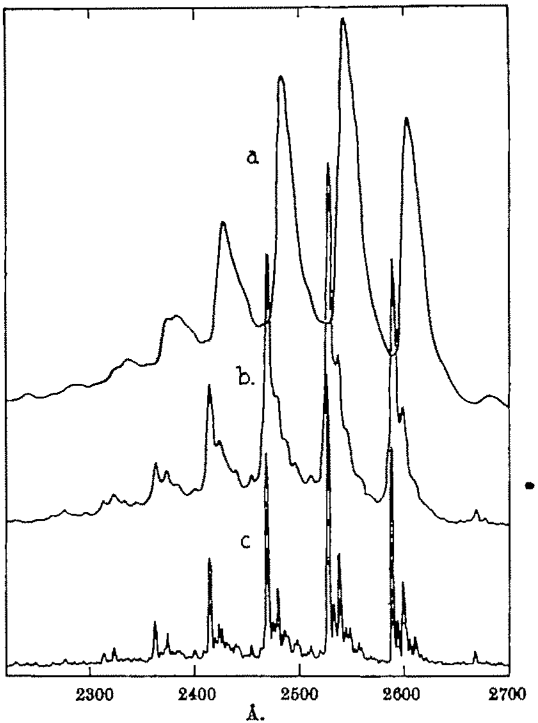


Fig. 2. The ultra-violet spectrum of benzene in *iso*octane (*a*), cyclic perfluoro-C_8 ether (*b*), and vapour (approximately 70 mm.) (*c*)

The fluorocarbon systems represent in an accentuated and striking form an anomaly which is to some degree shared by the other systems.

A possible explanation for these results is that in dilute solutions the solute molecules may exist in part in cavities or holes in the solvent, and that therefore the factor $\bar{R}$ in equation (2) may be larger than expected. Since the shift is predicted to be dependent on $\bar{R}^{-6}$, only a relatively small cavity would need to be postulated. The equilibrium distribution of solute between cavities and the 'true' solvent medium might be imagined to favour the 'true' solvent medium increasingly with increasing solvent polarizability. For fluorocarbons, the solute might then be thought of as being almost entirely in the cavities. We have found, however, that for a 5 per cent solution of benzene in cyclic perfluoro-C_8 ether the spectral maxima are unchanged in position compared to the 500-times more dilute solution represented in Fig. 1. It appears most unlikely that cavities could be provided for these many solute molecules.

In Fig. 2 are compared the spectra of benzene vapour (approximately 70 mm.) and of benzene solutions in cyclic perfluoro-C_8 ether and in *iso*octane. It is of interest experimentally and theoretically that, because of the small interaction between solute and solvent, the spectrum in the fluorocarbon solvent shows a marked increase in resolution over that observed for the hydrocarbon solution; many features of the vibrational fine-structure visible in the vapour spectrum are clearly seen. Fluorocarbon solvents may thus provide vapour spectral positions and considerable fine structure for relatively non-volatile substances for which it would be inconvenient or impossible to obtain a true vapour spectrum.

We wish to acknowledge the able experimental assistance of Mrs. Lucy Klos and Mr. Floyd Vincent.

We are also grateful to Dr. G. V. D. Tiers for several stimulating discussions.

Note added in proof. After this paper had been submitted, Dr. John Foss (University of Oregon) directed our attention to a paper by Sverdlova[13] in which similar data are presented for benzene and chlorobenzene. In general, these data agree with ours; but they are plotted in such a way as to obscure the disagreement with theoretical prediction.

F. A. Bovey
S. S. Yanari

Central Research Laboratories,
Minnesota Mining and Manufacturing Co.,
St. Paul, Minnesota.

[1] Bayliss, N. S., *J. Chem. Phys.*, **18**, 292 (1950).
[2] Longuet-Higgins, H. E., and Pople, J. A., *J. Chem. Phys.*, **27**, 192 (1957).
[3] Ooshika, Y., *J. Phys. Soc. Japan*, **9**, 594 (1954).
[4] McRae, E. G., *J. Phys. Chem.*, **61**, 562 (1957).
[5] Lauer, K., and Oda, R., *Ber.*, **69**, 851 (1936).
[6] Shepard, S. E., *Rev. Mod. Phys.*, **14**, 303 (1942).
[7] Phibbs, M. K., *J. Chem. Phys.*, **19**, 1430 (1951).
[8] Ham, J., *J. Amer. Chem. Soc.*, **76**, 3881 (1954).
[9] Yanari, S. S., and Bovey, F. A., *J. Biol. Chem.* (in the press).
[10] Matsen, F. A., Ginsberg, N., and Robertson, W. W., *J. Chem. Phys.*, **13**, 309 (1945).
[11] Brice, T. J., in "Fluorine Chemistry", edit. by Simons, J. H., 486 (Academic Press, New York, 1950)
[12] Simons, J. H., and Dunlap, *J. Chem. Phys.*, **18**, 345 (1950).
[13] Sverdlova, O., *Optics and Spectroscopy* (U.S.S.R.), **6**, 223 (1959).

Absorption Spectra of Diatomic Radicals containing Boron or Silicon

Various workers have used methods of time-resolved absorption spectroscopy to study the formation and decay of free radicals produced in pulsed electric discharges. These investigations have been confined to the use of a single parent substance which normally flows through the discharge tube at a rate such that the parent substance is not completely replenished before each discharge pulse. In this way the absorption spectra of OH (ref. 1), CN (ref. 2) and of several halides such as BBr, BCl, AlBr, AlCl, AlI and SiCl[3,4] have been observed. The main limitation in this work was low intensity of the background sources used, and a large number of exposures were needed to obtain an adequate record with both high dispersion and good time resolution. The use of a flash tube filled with an inert gas as background source greatly reduces the number of exposures needed to obtain an adequate record and this removes the difficulty of studying systems where the discharge tube has to be refilled after each exposure.

An apparatus of this type has been constructed, and has been used for studying the absorption spectra of free radicals which have not previously been detected in absorption and which would be expected to have appreciable concentrations at the temperatures reached when a pulse electric discharge is passed through a suitable gas mixture at low pressure. In typical experiments a 1–5 μF. condenser at 10 kV. is discharged between tungsten electrodes 25 cm. apart in a 5-cm. diameter glass tube containing the parent mixture at a few mm. mercury pressure. A 100 *J* argon-filled quartz capillary flash tube with a duration of 7 μsec. is used to photograph the absorption spectrum on a 3-metre grating spectrograph. The firing of this lamp is controlled by an electronic delay circuit which is initiated by light from the discharge. With the optical arrangement used, the amount of light reaching the spectrograph from the discharge is small enough by comparison with intensity of the spectroscopic flash to make the use of shuttering unnecessary at wave-lengths above 2800 Å.

To date experiments have been concentrated on systems containing boron or silicon. For the former, either boron trichloride or trimethyl borate has been used, either alone or mixed with oxygen, nitrogen or hydrogen. In these systems, the absorption spectra of BCl ($A^1\Pi - X^1\Sigma$), BH ($A^1\Pi - X^1\Sigma^+$), BN ($^3\Pi - {}^3\Pi$), BO ($A^2\Pi - X^2\Sigma^+$)[5] and the "boric acid fluctuation bands"[6] have been observed. Of these, the observation of the triplet but not the singlet bands of BN (ref. 7) in absorption is of particular interest, since they suggest strongly that BN has a $^3\Pi$ ground-state, whereas the iso-electronic species C_2 has recently been shown to have a $^1\Sigma^+$ ground-state with its configurationally excited $^3\Pi$ state only about 610 cm.$^{-1}$ higher[8]. This difference in behaviour can be attributed to the fact that ground-state B(^2P) and N(^4S) atoms can only give triplet and quintet states, whereas singlet, triplet and quintet states can arise from two normal carbon atoms (^3P). Attempts are being made to observe the gas-phase absorption spectrum of BeO which is iso-electronic with BN and C_2 with the view of determining the relative positions of its lowest singlet and triplet states.

Preliminary experiments with silicon tetrachloride either alone or mixed with hydrogen or nitrogen have yielded the absorption spectra of SiCl ($B^2\Sigma - X^2\Pi$), SiH ($A^2\Delta - X^2\Pi$) and SiN ($B^2\Sigma^+ - X^2\Sigma^+$)[5]. In addition to observing most of the $B^2\Sigma - X^2\Pi$ bands of SiCl listed by Jevons[9], the (2,1) and (3,1) bands have been identified. The identification of these bands and the strong appearance of the (2,0) and (3,0) bands in these experiments confirm Jevons's assignments, about which he expressed some doubt. Under conditions when the $^2\Delta - {}^2\Pi$ band of SiH was most intense, a weak, slightly diffuse system appeared in absorption between 3900 and 3750 Å. This spectrum has been tentatively identified as the $^2\Sigma^- - {}^3\Pi$ transition of SiH to be expected in this region by analogy with CH. An attempt is being made to obtain this spectrum with enough intensity to permit a rotational analysis. No band system of SiH corresponding to the 3143 Å. $^2\Sigma^+ - {}^2\Pi$ transition of CH has yet been detected.

It can be seen that this technique provides a relatively simple method of studying the absorption spectra of species likely to be present at high temperatures without the use of large quantities of material or of elaborate apparatus to produce the high temperatures. A detailed account of this work is being prepared for publication.

I wish to thank Prof. R. G. W. Norrish for helpful discussions and the Government Grants Committee of the Royal Society for a grant, part of which was applied to this work

B. A. Thrush.

Department of Physical Chemistry,
Lensfield, Cambridge.

[1] Oldenberg, O., *J. Phys. Chem.*, **41**, 293 (1937).
[2] White, J. U., *J. Chem. Phys.*, **8**, 79, 459 (1940).
[3] Miescher, E., *Helv. Phys. Acta*, **9**, 693 (1936).
[4] Maeder, D., *Helv. Phys. Acta*, **16**, 503 (1943).
[5] Herzberg, G., "Spectra of Diatomic Molecules", second ed. (Van Nostrand. New York, 1950).
[6] Jevons, W., *Proc. Roy. Soc.*, A, **91**, 120 (1915).
[7] Douglas, A. E., and Herzberg, G., *Canad. J. Res.*, A, **18**, 179 (1940).
[8] Ballik, E. A., and Ramsay, D. A., *J. Chem. Phys.*, **31**, 1128 (1959).
[9] Jevons, W., *Proc. Phys. Soc.*, **48**, 563 (1936).

Analysis of Anæsthetic Mixtures by Gas Chromatography

During anæsthesia, and in respiratory research, there is a need to analyse mixtures of permanent gases and organic vapours on a routine basis. Physical methods are being increasingly used for this type of work, but the equipment required tends to become complex when the analysis of several components is desired. Chromatographic analysis is discontinuous in nature, but, provided that this can be tolerated, the use of gas chromatography offers several advantages of which simplicity and versatility are the most important.

For the separation of oxygen and nitrogen we have employed a column 12 in. long and ¼ in. internal diameter packed with 52–60 *B.S.* mesh Linde *5A* molecular sieve at room temperature. Samples can be analysed at 30-sec. intervals.

Carbon dioxide and nitrous oxide are commonly encountered in respired anæsthetic mixtures since the majority of anæsthetics are based on nitrous oxide and oxygen. None of the common adsorbents, such as silica gel, alumina and charcoal, will give an adequate separation of these gases. However, we have found that a *G.L.C.* column 24 ft. long by ¼ in. internal diameter packed with 28·6 per cent of propylene carbonate on 52–60 *B.S.* mesh 'SIL-O-CEL' firebrick will separate these gases at room temperature. A mixture of oxygen, carbon dioxide and nitrous oxide can be analysed in about 2½ min. on such a column. By overlapping the samples the analysis may be repeated every 2 min. Recently we have found that dimethyl sulphoxide is an even better stationary liquid for this work. A 20-ft. by ¼-in. column containing 20 per cent of dimethyl sulphoxide on 52–60 mesh 'SIL-O-CEL' at 20° C. will separate a mixture of oxygen, nitrous oxide and carbon dioxide in 1 min.

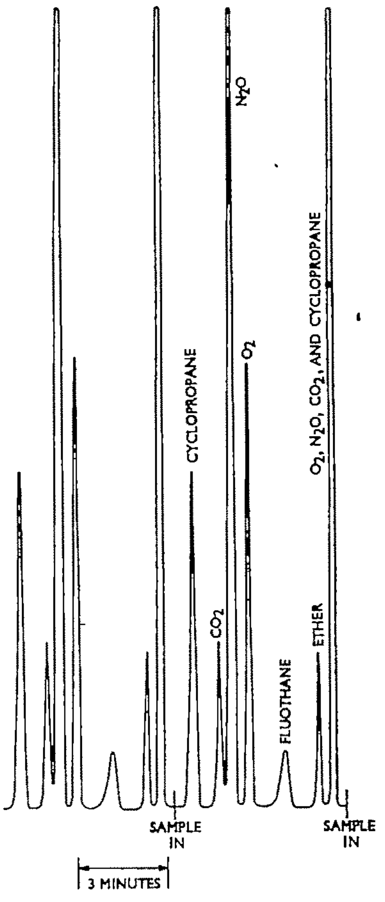


Fig. 1. Chromatogram of a respired anæsthetic mixture. Column 1, 20 ft. × ¼ in. 20 per cent dimethyl sulphoxide on 52–60 mesh 'SIL-O-CEL' at 20° C.; inlet pressure 280 mm. mercury. Column 2, 2 ft. × ¼ in. 15 per cent dinonyl phthalate on 52–60 mesh 'SIL-O-CEL' at 75° C.; inlet pressure 40 mm. mercury. Flow-rate, 30 ml./min. H_2 in both columns

When ether and fluothane are present, a 2-ft. by ¼-in. column containing 15 per cent of dinonyl phthalate on firebrick is used in parallel with the dimethyl sulphoxide column. Automatic valves[1] inject different-sized samples simultaneously into both columns. The dinonyl phthalate column is heated to 75° C., allowing the light gaseous components to pass through unresolved but retaining ether and fluothane long enough to give complete separation. The gases and vapours from the two columns pass through opposite channels of a thermistor thermal conductivity detector. The recorder in the bridge circuit is modified so that a negative signal actuates a reversing switch and consequently all the peaks on the recorder chart are in the same direction. Fig. 1 shows the separation of a respired anæsthetic mixture analysed in this way in approximately 4½ min.

We wish to thank Prof. R. F. Woomer, of the Royal College of Surgeons, and the Directors of "Shell" Research, Ltd., for their encouragement, and for permission to publish this communication. We also wish to thank colleagues at the Koninklijke/Shell-Laboratorium, Amsterdam, who suggested the use of dimethyl sulphoxide as a stationary liquid.

E. R. Adlard

"Shell" Research, Ltd.,
Thornton Research Centre,
Chester.

D. W. Hill

Research Department of Anæsthetics,
Royal College of Surgeons of England,
London, W.C.2.

[1] Hill, D. W., and Hook, J. R. (unpublished work).

RADIATION CHEMISTRY

Radiative Life-time of the Pyrene Dimer and the Possible Role of Excited Dimers in Energy Transfer Processes

The absorption spectra of certain dye solutions exhibit a marked dependence on concentration over a range in which the corresponding fluorescence spectrum remains unchanged; this is attributed to absorption by non-fluorescent dimeric complexes at higher concentration which reduces the overall fluorescence yield of the solution[1]. The relative intensities of absorption by the dye in its monomeric and dimeric forms suggest that the radiative lifetimes of the corresponding excited species are both of the order of 10^{-8}–10^{-9} sec. (ref. 2).

On the other hand, Förster and Kasper[3] have observed that, whereas the absorption spectrum remains unchanged, the violet fluorescence of dilute solutions of pyrene is replaced by a blue emission at higher concentrations; in this case the excited dimer responsible for the blue fluorescence is formed

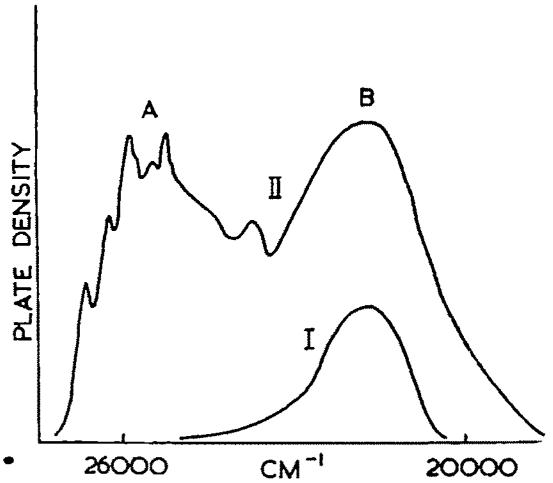


Fig 1. Spectrum of slow fluorescence of pyrene in solution photographed through phosphoroscope (I), and of total fluorescence (II) consisting of violet (monomer) and blue (dimer) bands *A* and *B*

collisionally from excited and unexcited pyrene molecules and, according to cryoscopic data, does not exist in the ground-state. Since measurement of the delay between absorption and emission observed in the vapours of pyrene and other aromatic hydrocarbons indicates that excited dimers formed in this way have a life-time of the order of 10^{-3} sec. even at temperatures of more than 200° C. (ref. 4), it would not be surprising if the radiative life-time of the pyrene dimer in solution were at least of the same order.

We thoroughly outgassed a $10^{-3} M$ solution of pyrene (Light's, white puriss.) in B.D.H. spectroscopically pure *cyclo*hexane in a 'Pyrex' cell and, using the flash photometric technique, observed a first-order emission component with a life-time of $1 \cdot 8 \pm 0 \cdot 2 \times 10^{-3}$ sec. To confirm that this component originates from the excited pyrene dimer, the fluorescence of the same solution in the same cell was excited by a 250-W. high-pressure mercury arc and photographed through a locally constructed phosphoroscope on a small Hilger quartz spectrograph. Fig. 1 shows a microdensitometer tracing of the exposed plate together with the total unsectored emission excited by the mercury 313 mμ line in the same solution.

A theoretical treatment[5] of the optical properties of dimers of this type shows that the radiative transition between excited and unexcited states is orbitally forbidden if the complex has a centre of symmetry, which accounts for the magnitude of the radiative life-time observed here. Consequently the corresponding absorption would be extremely difficult to detect even if the dimer exists to an appreciable extent in its ground-state, and the independence of the absorption spectrum of concentration is clearly no criterion for the non-existence of excited dimers at higher concentrations. On the contrary, an absorption spectrum independent of concentration indicates that any excited dimers formed are of the long-lived variety which will not be detected in emission or absorption if non-radiative processes leading to self-quenching compete successfully with fluorescence. In this case the evidence for their existence must be based on self-quenching itself[6], extremely efficient sensitization, a case of which has recently been suggested[7], or perhaps the appearance of unidentified bands observed in flash absorption spectroscopy of which a recently reported case may be an example[8]. Their reversible formation in the vapour phase at pressures as low as 0·5 mm. (~ 10^{-5} mol./litre) satisfactorily accounts for the negative temperature-coefficient of self-quenching[9] and the phenomenon of delayed fluorescence[4].

The observation of an emission of this duration in concentrated pyrene solutions illustrates the remarkable resistance of the emitting species to collisional deactivation by the monomer or by solvent molecules. These properties of the collisionally formed excited dimer which has virtually the life-time of a triplet state and the multiplicity of a singlet state[5] are those of an ideal sensitizer, and it is not unlikely that it plays an important part in the physical processes associated with photosynthesis and with phenomena dependent on concentration observed in aromatic solutions. Since it is not a primary product of absorption and does not apparently exist in the ground-state, we suggest the term 'excimer' be used to distinguish it from the short-lived dimer excited directly in solutions exhibiting an absorption spectrum dependent on concentration.

We wish to express our thanks to Prof. G. J. Hoijtink and Dr. R. N. Dixon for enlightening discussions, and to the Royal Society for a grant-in-aid and the Safety in Mines Research Establishment for the loan of a spectrograph. One of us (E. H.) is grateful to the Department of Scientific and Industrial Research for the award of a maintenance grant.

B. STEVENS
E. HUTTON

Department of Chemistry,
University, Sheffield 10.

[1] Levschin, V. L., *Acta Physicochim.*, 1, 685; 2, 331 (1935).
[2] Rabinowitch, E., and Epstein, L. F., *J. Amer. Chem. Soc.*, **63**, 69 (1941).
[3] Förster, Th., and Kasper, K., *Z. Elektrochem.*, **59**, 977 (1955).
[4] Williams, R., *J. Chem. Phys.*, **28**, 577 (1958).
[5] Hoijtink, G. J., paper presented at Symposium on Fast Reactions in Solution, Hahnenklee (Sept. 1959).
[6] Dammers-de Klerk, A., *Mol Phys.*, 1, 141 (1958).
[7] Stevens, B., Hutton, E., and Porter, G., *Nature*, **185**, 917 (1960).
[8] Kato, S., Watanabe, T., Nagaki, S., and Koizumi, M., *Bull. Chem. Soc. Japan*, **33**, 262 (1960).
[9] Hardtl, K. H., and Scharmann, A., *A. Naturforsch.*, **12**, *a*, 715 (1957).

BIOCHEMISTRY

Effects of Fatty Acids on the ^{32}P-Adenosine Triphosphate Exchange Reaction in Rat Liver Mitochondria

ATTENTION has been focused in recent years on the effects of fatty acids on phosphate metabolism. In 1956 it was shown[1] that decanoate uncouples oxidation from phosphorylation in rat kidney and brain mitochondria. It was also shown, in the same year[2], that fatty acids stimulate the latent adenosine triphosphatase activity of rat liver mitochondria, myristic acid being the most effective. Results of recent work[3] have shown that the phosphorus-32 turnover in Ehrlich ascites cells is markedly decreased in the presence of potassium decanoate; however, that of rat liver slices is more sensitive to decanoate than is the process of oxidative phosphorylation in rat liver mitochondria[4]. In isolated rat kidney and brain mitochondria, 0·6 mM decanoate is needed to decrease the P : O ratio by 50 per cent[1], and preliminary experiments with rat liver mitochondria have indicated that decanoate is approximately as active in this system.[4] In work with rat liver slices, 1·33 mM decanoate inhibited phosphorus-32 turnover in adenosine triphosphate by 75 per cent, but the oxidation of decanoate-1-^{14}C proceeded at a high and constant rate for 3 hr. at this concentration, indicating that there was still sufficient adenosine triphosphate for the initial activation step. It was therefore of interest to determine if the decrease in the rate of labelling of adenosine triphosphate with phosphorus-32 in liver slices is due to a decreased rate of synthesis of the triphosphate, or whether it is due to the fact that labelling takes place by a process which is particularly sensitive to the presence of fatty acids. The adenosine triphosphate–phosphorus-32 exchange reaction[5] might constitute such a process, and the effects of fatty acids on this reaction were investigated.

The methods used were essentially those described by Dawkins, Judah and Rees[6], and a summary of the results obtained is given in Table 1. At low concentrations, all the fatty acids investigated cause an increased rate of labelling of adenosine triphosphate with phosphorus-32, and at somewhat higher concentrations they give rise to increasing inhibitory effects. Decanoate, at a concentration of 0·05 mM, brings about a 57 per cent stimulation of the rate of exchange of phosphorus-32 with adenosine triphosphate. Increase in decanoate concentration to 0·2 mM leads to a decrease of 42 per cent. It appears, therefore, that the process of labelling of adenosine triphosphate with phosphorus-32 in rat liver mitochondria is more sensitive to decanoate than is the oxidative synthesis of adenosine triphosphate. This is in agreement with the observations reported above that the process of labelling of adenosine triphosphate in rat liver slices is more sensitive to decanoate than is oxidation of this fatty acid, a process which is known to be dependent on the continued oxidative synthesis of adenosine triphosphate. The labelling of adenosine triphosphate by phosphorus-32 in rat liver slices, therefore, probably occurs more rapidly by the adenosine triphosphate–phosphorus-32 exchange reaction than by true synthesis of the triphosphate, and it is the former process which is inhibited on addition of relatively low concentrations of decanoate to rat liver slices in the presence of phosphate-^{32}P.

Incubations were carried out for 20 min. at 20° C. in the medium described by Dawkins *et al.*[6] with mitochondria equivalent to 125 mgm. wet weight of rat liver tissue. Under these conditions, the exchange reaction in the control vessels followed a linear course for a period of more than 30 min. The reaction was terminated by the addition of 2 ml. of 10 per cent trichloracetic acid to the 2 ml. incubation medium. The radioactivity present in the adenosine triphosphate was determined as described by Dawkins *et al.*[6]. All figures in Table 1 refer to percentages of the control values obtained in the absence of added fatty acid and are averages of 2–6 separate determinations. The average value for the control in fourteen experiments was 28·0 µmoles ^{32}P-phosphate exchanged in 20 min./gm. original wet weight of liver.

Table 1. EFFECTS OF VARIOUS FATTY ACIDS AT DIFFERENT CONCENTRATIONS ON THE ADENOSINE TRIPHOSPHATE – PHOSPHORUS-32 EXCHANGE REACTION IN ISOLATED RAT LIVER MITOCHONDRIA

Fatty acid concentration (mM)	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}
0	100	100	100	100	100	100	100	100	100	100	100
0·005								112	111	118	
0·01						115	127	100	118	119	
0·015					150						
0·02						139	112	83	105	145	
0·03				189	189	129	112	68	95	106	
0·04						107		18	54	93	
0·05				204	157		54		54		115
0·075				141			11				
0·08						33		5		66	78
0·1					114		9				
0·15			161		64	14			12	36	47
0·2				123	58						
0·25		124	183								
0·3	164	190	178	90	15						
0·45			161								
0·5	204	160	116	52							
0·6				32							
0·75		105	105								
0·9			76								
1·0	193	55	39								

The greatest inhibitory effect on the exchange reaction occurs with the C_{13} fatty acid, the effects of the C_{14}, C_{15} and C_{16} fatty acids being approximately equivalent to the C_{12}, C_{11} and C_{10} fatty acids respectively (Table 1). This may be correlated with the observation of Pressman and Lardy[2] that optimal stimulation of latent adenosine triphosphatase activity occurs with myristic acid (C_{14}).

The present results are of further interest in view of the recent report that the '*U*-factor', which is present in normal tissues and is capable of uncoupling oxidation from phosphorylation, has the properties of a fatty acid[7]. A rapid and extensive swelling of rat liver mitochondria is brought about on addition of 3 µM oleate[7]. It is possible that the increased rate of labelling of adenosine triphosphate in the present experiments at the lower concentrations of fatty acids (5 µM in the case of tridecanoate) may be due to an increase in mitochondrial permeability to phosphate or adenosine triphosphate consequent upon the swelling of the mitochondria under these conditions.

K. AHMED*
P. G. SCHOLEFIELD†

The McGill-Montreal General Hospital Research Institute,
3619 University St.,
Montreal, P.Q.

* Colombo Plan Fellow.

† Research Associate of the National Cancer Institute of Canada.

[1] Scholefield, P. G., *Can. J. Biochem. Physiol.*, **34**, 1227 (1956).

[2] Pressman, B. C., and Lardy, H. A., *Biochim. Biophys. Acta*, **21**, 458 (1956).

[3] Creaser, E. H., and Scholefield, P. G., *Cancer Res.*, **20**, 257 (1960).

[4] Ahmed, K., and Scholefield, P. G., *Proc. Can. Fed. Biol. Soc.*, **2**, 3 (1959).

[5] Boyer, P. D., Falcone, A. B., and Harrison, W. H., *Nature*, **174**, 401 (1954).

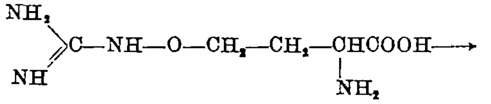
[6] Dawkins, M. J. R., Judah, J. D., and Rees, K. R., *Biochem. J.*, **73**, 16 (1959).

[7] Lehninger, A. L., and Remmert, L. F., *J. Biol. Chem.*, **234**, 2459 (1959).

Chemical Degradation of Canavanine to Canaline

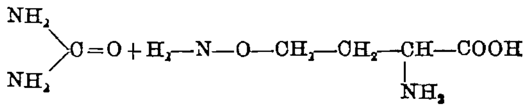
THE biologically interesting amino-acid, canaline, has been obtained by enzymatic cleavage of canavanine, a naturally occurring constituent of the Jack bean[1].

No chemical method capable of effecting this step has, however, been reported so far. While arginine, a close structural relative of canavanine, is impervious to acid hydrolysis, the latter undergoes cleavage to homoserine lactone (α-aminobutyrolactone) on heating with strong acids[2]. Canavanine, on the other hand, exhibits extraordinary stability in alkaline medium[3] while arginine is decomposed to ornithine by alkaline hydrolysis. In view of recent interest in canaline, it appeared desirable to re-examine the possibility of chemical degradation of the commercially available canavanine to canaline.



$$(NH_2)(NH{=})C\text{—}NH\text{—}O\text{—}CH_2\text{—}CH_2\text{—}CH(NH_2)COOH \longrightarrow$$

Canavanine



$$(NH_2)_2C{=}O + H_2\text{—}N\text{—}O\text{—}CH_2\text{—}CH_2\text{—}CH(NH_2)\text{—}COOH$$

Canaline

Accordingly, an attempt was made to force this reaction by vigorous alkaline hydrolysis. 1·37 gm. D,L-canavanine sulphate was heated with 25 per cent barium hydroxide for 48 hr. under refluxing conditions. The excess barium hydroxide was removed by addition of ammonium carbonate and filtration of the resulting barium carbonate. The reaction mixture was then evaporated to dryness in order to remove excess ammonia and redissolved in 100 ml. boiling water containing two mole equivalents of picric acid. The solution was allowed to cool to 25° and the beautifully crystalline dipicrate of canavanine (2 gm.) which had separated was filtered. On standing overnight, the mother liquors deposited a second crop of crystalline material (0·55 gm.) which was identified as D,L-canaline dipicrate, m.p. 189–191° after recrystallization from water. Analysis: calc. for $C_{16}H_{17}N_8O_{17}$: N, 18·92 per cent; found N, 19·0 per cent.

Treatment of canavanine with barium hydroxide under refluxing conditions for five days did not improve the yield of canaline. In order to prepare the free amino-acid, canaline dipicrate was dissolved in 70 volumes of hot water containing 2·5 mole equivalents of sulphuric acid. The picric acid was now removed from the solution by two successive extractions with nitrobenzene and ether. An excess of 'Dowex-3 *X*-4' resin (free amine form) was added to the colourless solution, the mixture filtered and the filtrate evaporated to dryness under reduced pressure. The residue when triturated with *iso*propanol yielded a solid which upon recrystallization from *iso*propanol–water gave D,L-canaline, m.p. 195–198° dec. Analysis: calc. for $C_4H_{10}N_2O_3$: N, 20·89 per cent; found N, 20·82 per cent.

Paper chromatograms of this product obtained by the small-scale technique of Rockland and Underwood[4] gave R_F values of 0·67 in the methyl-butynol–formic acid–water (69·5 : 1 : 29·5) system[5] and 0·78 in the ethanol–acetic acid–water (65 : 1 : 34) system and indicated the presence of a trace of impurity. L-Canaline obtained by enzymatic cleavage of L-canavanine exhibited chromatographic behaviour indistinguishable from that of the above product.

My thanks are due to Mr. J. Bush of these Laboratories for the preparation of L-canaline.

H. RINDERKNECHT

California Corporation for Biochemical Research,
3625 Medford Street, Los Angeles, 63.

---

[1] Kitagawa, M., and Tomiyama, T., *J. Biochem.* (Tokyo), 11, 265 (1929).

[2] Gulland, J. M., and Morris, C. J. O. R., *J. Chem. Soc.*, 763 (1935).

[3] Kitagawa, M., *J. Biochem.* (Tokyo), 25, 23 (1937).

[4] Rockland, L. B., and Underwood, J. C., *Anal. Chem.*, 26, 1553 (1954).

[5] Rinderknecht, H., Thomas, D., and Aslin, S., *Helv. Chim. Acta*, 41, 1 (1958).

Maintenance of α-Ketoglutarate and Succinate Oxidation in E-Deficient Liver Homogenates by α-Tocopherol, a Tocopherol Metabolite, Menadione and Diphenylphenylenediamine

RATS on a *Torula* yeast diet deficient in vitamin E and factor 3 show a metabolic disturbance in liver slices, termed respiratory decline, 1–2 weeks prior to succumbing to necrotic liver degeneration[1]. Dietary supplementation of vitamin E as well as intraportal injection of the vitamin prevents the disturbance, whereas dietary factor 3 (and also selenite) alleviates the decline without, however, preventing it fully. The effects following dietary, intraportal, and *in vitro* application of a number of antioxidants have been analysed. A tocopherol metabolite[2] as well as diphenylphenylenediamine[3] are effective, *in vitro*, in preventing the respiratory failure of liver slices. While mitochondria of the deficient livers show an accelerated diminution of succinate oxidation in the presence of dinitropyridine nucleotide[4], homogenates of such livers, in previous work, did not show decline with glucose as substrate and optimal supplements of adenosine triphosphate and dinitropyridine nucleotide[1]. In this communication, a different homogenate system is described which shows respiratory decline with α-ketoglutarate or succinate as substrates. The preventive effects, *in vitro*, of tocopherol, the tocopherol metabolite (kindly supplied by Dr. Eric J. Simon of New York University College), menadione and diphenylphenylenediamine are demonstrated.

Weanling rats of the Fischer 344 strain were fed a basal 30 per cent *Torula* yeast diet described elsewhere[5]. Vitamin E was supplemented as 50 mgm. of D,L-α-tocopheryl acetate per 100 gm. ration. Factor 3 was introduced by the addition of 15 μgm. per cent of selenium (as sodium selenite). Some controls were fed McCollum's wheat casein diet[6]. The 10 per cent liver homogenates were made up in 0·25 *M* sucrose. The equivalent of 50 mgm. of tissue was added to 2·5 ml. of a medium containing the following ingredients: 300 μmoles sodium chloride, 12 μmoles potassium chloride, 40 μmoles of a sodium phosphate buffer at *p*H 7·4, and 4 μmoles of magnesium sulphate. The final volume was 3 ml. Water-insoluble supplements were added to the medium in ethanol (⩽ 0·02 ml.). In a separate series increased potency of tocopherol was achieved by rehomogenization of the vitamin with the liver homogenate. The additions, including substrates, were added at the expense of the medium and amounted to no more than 0·2 ml.

Under the experimental conditions described, oxygen consumption declines by approximately 69 per cent with α-ketoglutarate and 61 per cent with succinate as substrates (Table 1). This is completely prevented by dietary vitamin E if α-ketoglutarate is used. In this instance a slight, significant increase of oxidation is seen over the 1½-hr. incubation. It is important that fresh homogenates be used, since ageing in ice for several hours will nullify the protective effect of dietary tocopherol, so that decline will ensue. In contrast to the effect of tocopherol, dietary selenium is without effect in these systems.

Supplementation, *in vitro*, of α-tocopherol, the tocopherol metabolite of Simon *et al.*[7], menadione and diphenylphenylenediamine prevented the decline of α-ketoglutarate oxidation (Table 2). As little as 0·1 μgm. diphenylphenylenediamine afforded complete protection. When added directly to the medium, tocopherol was required at levels of about 50 μgm.

Table 1. EFFECT OF DIETARY α-TOCOPHEROL AND SELENITE ON DECLINE OF OXIDATION

Diet	No. of animals	α-Ketoglutarate				Succinate			
		0–30 min.	30–60 min.	60–90 min.	Decline (per cent)*	0–30 min.	30–60 min.	60–90 min.	Decline (per cent)
Torula	10	10·5 ± 0·5	8·4 ± 0·9	3·2 ± 0·4	69 ± 3	12·7 ± 0·7	7·3 ± 0·4	4·9 ± 0·4	61 ± 4
Torula + E	6	7·6 ± 0·7	8·1 ± 0·5	8·4 ± 0·4	† 11 ± 3	11·0 ± 0·7	9·9 ± 0·6	9·2 ± 0·7	16 ± 2
Torula + Na_2SeO_3	5	9·6 ± 0·8	7·0 ± 1·6	3·0 ± 0·7	69 ± 7	13·1 ± 0·5	8·4 ± 0·5	5·3 ± 0·1	57 ± 2
Wheat-casein	4	10·2 ± 0·3	10·2 ± 0·7	10·3 ± 0·7	† 1 ± 5	12·3 ± 0·5	9·7 ± 0·4	8·5 ± 0·2	29 ± 4

Results given as μatoms oxygen uptake per 30-min. interval. Medium contains 40 μmoles sodium phosphate (*p*H 7·4), 300 μmoles sodium chloride, 12 μmoles potassium chloride, 4 μmoles magnesium sulphate, 60 μmoles substrate, 3 μmoles diphosphopyridine nucleotide (when α-ketoglutarate is substrate). Final volume 3 ml.

* Decline = $(\mu\text{atoms } O_{(0-30)} - \mu\text{atoms } O_{(60-90)}/\mu\text{atoms } O_{(0-30)}) \times 100$.

† Indicates increase rather than decline.

Table 2. EFFECT OF *in vitro* SUPPLEMENTATION OF VARIOUS COMPOUNDS ON DECLINE OF OXIDATION

Substrate	Addition	No. of animals	Time-interval (min.) 0–30	30–60	60–90	Decline (per cent)
α-Ketoglutarate + diphosphopyridine nucleotide		10	10·5 ± 0·5	8·4 ± 0·9	3·2 ± 0·4	69 ± 3
,, ,,	20γ α-tocopherol, directly	3	10·2 ± 0·8	10·8 ± 1·4	5·8 ± 0·8	48 ± 3
,, ,,	50γ ,, ,,	3	10·1 ± 1·2	10·7 ± 1·2	11·1 ± 1·1	†10 ± 3
,, ,,	5γ ,, rehomogenized	7	9·1 ± 0·5	9·8 ± 0·5	9·3 ± 1·0	† 1 ± 9
,, ,,	10γ tocopherol metabolite	6	10·5 ± 0·6	11·6 ± 0·8	10·5 ± 1·1	1 ± 6
,, ,,	10γ menadione	6	12·0 ± 0·6	12·7 ± 0·8	11·6 ± 1·4	4 ± 5
,, ,,	0·5γ diphenylphenylenediamine	5	9·5 ± 0·6	10·0 ± 0·8	9·7 ± 1·3	† 2 ± 6
,, ,,	50γ coenzyme *Q*	3	10·2 ± 1·0	7·5 ± 1·7	3·2 ± 0·6	69 ± 3
Succinate	—	10	12·7 ± 0·7	7·3 ± 0·4	4·9 ± 0·4	61 ± 4
,,	20γ α-tocopherol	6	11·5 ± 0·4	9·9 ± 0·4	7·0 ± 0·4	38 ± 5
,,	20γ tocopherol metabolite	6	11·9 ± 0·6	11·1 ± 0·5	8·5 ± 0·4	29 ± 5
,,	20γ menadione	5	14·6 ± 0·7	10·1 ± 0·9	7·0 ± 0·7	52 ± 2
,,	2γ diphenylphenylenediamine	4	13·0 ± 0·2	12·9 ± 0·6	9·4 ± 0·2	28 ± 2

Conditions and definitions are the same as in Table 1.

to prevent the phenomenon, and about 20 μgm. for a 50 per cent protective effect. Rehomogenizing of tocopherol with the liver homogenate produced a markedly higher activity. In this case, tocopherol prevented the respiratory lesion completely at about 5 μgm., and approximately 2–3 μgm. gave a 50 per cent effect. Whether this improvement is due only to a better distribution of the vitamin, to a subsequent activation, or to a metabolic alteration (formation of an active metabolite) remains to be clarified. The amount of tocopherol necessary to prevent this respiratory lesion is much less than that required for other *in vitro* systems[8,9] and more nearly approaches physiological quantities. The other supplements used did not require rehomogenization for maximal activity. When added directly to the medium, the tocopherol metabolite of Simon, 2-(3-hydroxy-3-methyl-5-carboxy)-pentyl-3,5,6-trimethylbenzoquinone, was approximately as active as tocopherol after it had been rehomogenized. Menadione, added directly, was approximately as active as tocopherol or its metabolite, in spite of the fact that the animals did not seem to suffer from a vitamin K deficiency (their prothrombin times, kindly assayed by Dr. A. Leitner, were normal). Coenzyme *Q* was without effect on this system.

With succinate as substrate, the same general picture is found. However, even in homogenates from normal controls (McCollum's wheat-casein diet) oxygen consumption shows a slow decline (< 30 per cent), probably related to accumulation of oxalacetic acid[10]. By dietary application of tocopherol as well as by addition of tocopherol, the tocopherol–metabolite of Simon, menadione or diphenylphenylenediamine to vitamin E-deficient homogenates, the decline of succinate oxidation is brought back from about 61 per cent to this level of less than 30 per cent. However, for these *in vitro* effects on succinate oxidation, much higher quantities of the supplements were required than with α-ketoglutarate. This may be related to the particulate nature of the succinate system.

LAURENCE M. CORWIN
KLAUS SCHWARZ

Laboratory of Nutrition and Endocrinology,
National Institute of Arthritis and
Metabolic Diseases,
National Institutes of Health,
Bethesda, Maryland.

[1] Chernick, S. S., Moe, J. G., Rodnan, G. P., and Schwarz, K., *J. Biol. Chem.*, **217**, 829 (1955).
[2] Mertz, W., and Schwarz, K., *Proc. Soc. Exp. Biol. Med.*, **102**, 561 (1959).
[3] Schwarz, K., Mertz, W., and Simon, E. J., *Biochim. Biophys. Acta*, **32**, 484 (1959).
[4] Corwin, L. M., and Schwarz, K., *J. Biol. Chem.*, **234**, 191 (1959).
[5] Schwarz, K., *Proc. Soc. Exp. Biol. Med.*, **78**, 852 (1951).
[6] Mertz, W., and Schwarz, K., *Amer. J. Physiol.*, **196**, 614 (1959).
[7] Simon, E. J., Eisengart, A., Sundheim, L., and Milhorat, A. T., *J. Biol. Chem.*, **221**, 807 (1956).
[8] Carpenter, M. P., Kitabchi, A. E., McCay, P. B., and Caputto, R., *J. Biol. Chem.*, **234**, 2814 (1959).
[9] Donaldson, K. O., Nason, A., and Garrett, R. H., *J. Biol. Chem.*, **233**, 572 (1958).
[10] Pardee, A. B., and Potter, V. R., *J. Biol. Chem.*, **176**, 1085 (1948).

Iodination of Specific Sites on Bovine Serum Albumin

SERUM albumins have been widely studied with respect to their ability to bind a wide range of substances[1–3]. Of particular interest are the nature of the binding sites and the question of whether the same sites are involved in binding different substances. Attempts have been made to elucidate the nature of the binding sites by determining the effect of chemical alteration of the serum albumin molecule on its binding properties[3,4]. Unfortunately direct chemical alteration does not permit evaluation of whether loss of binding is due to an alteration of the site itself or some non-specific alteration of the molecule elsewhere, resulting in either a subsequent disruption of the site or to a non-specific effect on the site.

In the case of antibodies against certain haptens, we have been able to show conclusively that the antibody site itself is affected by iodination. This was done by comparing antibody activity after iodination in the presence and absence of specific hapten[5]. Koshland *et al.*[6] have recently presented supporting evidence.

We have now been able to prove that iodination affects the actual sites on bovine serum albumin which are capable of binding *p*-iodobenzoate ion. This was done by iodinating bovine serum albumin in the presence and also in the absence of *p*-iodobenzoate ion. The latter has been shown to be bound by bovine serum albumin[7]. The bovine serum albumin used was the 'Pentex' crystallized product. The iodination was carried out in the presence or absence of iodobenzoate ion in glycine buffer of *p*H 9 by adding a solution of hypoiodite labelled with iodine-131 in the same buffer[8]. After iodination the protein solutions were dialysed against four changes of 10 l. of buffer at 5° over a period of 4 days to remove unbound iodide and *p*-iodobenzoate ion. Binding of *p*-iodobenzoate or methyl orange to bovine serum albumin preparations were carried out at *p*H 8·0 in the same manner as described previously for binding to anti-azobenzoate antibody[9]. Protein concentration was determined by Nessler reaction. Binding of iodobenzoate and methyl orange was determined by radiolabile[9] and spectrophotometric[10] methods respectively. Radioactive *p*-iodobenzoate was described previously[11]. The results are shown in Table 1.

When iodination was carried out in the absence of *p*-iodobenzoate so that an average of 43·8 iodine atoms were fixed per bovine serum albumin molecule, there was a marked decrease in the ability of the protein to bind *p*-iodobenzoate ion. However, when iodination was carried out in the presence of 0·02 *M* *p*-iodobenzoate to essentially the same extent, that is, 44·8 groups per bovine serum albumin molecule, the ability of the protein to bind *p*-iodobenzoate remained essentially unchanged. These results show that the part of the bovine serum albumin molecule which binds *p*-iodobenzoate ion is affected by the iodination process and contains an amino-acid remnant capable of being iodinated or oxidized by iodine since the site can be protected against alteration by carrying out the iodination in the presence of *p*-iodobenzoate ion. The facts that iodination was carried to the same extent for both preparations, and that essentially no effect on the binding of *p*-iodobenzoate was found when iodination is carried out in the presence of iodobenzoate, prove that the loss of binding power cannot be due to a non-specific effect of iodination on the protein molecule as a whole.

Table 1. BINDING ACTIVITY OF IODINATED BOVINE SERUM ALBUMIN – SPECIFIC PROTECTION OF SITES CAPABLE OF BINDING *p*-IODOBENZOATE*

Treatment of bovine serum albumin	Iodine atoms per bovine serum albumin molecule	Iodobenzoate bound†,‡		Methyl orange bound†,§	
		Concentration ($M \times 10^5$)	Moles per mole protein	Concentration ($M \times 10^4$)	Moles per mole protein
Untreated	0	3·8	1 1	1·53	4·7
Iodinated in presence of 0 02 *M* iodobenzoate	44·8	3 2	1·0	0 96	2 9
Iodinated without protection	43·8	1·5	0 5	0 96	2·9

* Bovine serum albumin or iodinated bovine serum albumin concentration, 2 mgm./ml.

† All samples were dialysed against common outer reservoir.

‡ Free iodobenzoate concentration, 1·2 × 10^{-5} *M*.

§ Free methyl orange concentration, 1 17 × 10^{-4} *M*.

It is of interest that the ability to bind methyl orange dropped appreciably and to the same extent (with these experimental conditions) during iodination regardless of whether the iodination was carried out in the presence or absence of *p*-iodobenzoate ion. Iodination experiments were not carried out in the presence of methyl orange.

The fact that the binding activity of both preparations for methyl orange was decreased equally indicates that methyl orange is bound at sites other than those at which the *p*-iodobenzoate is bound, and is a further indication that the binding of various substances to bovine serum albumin does not always involve the same sites.

This work was supported by a grant from the National Institute of Allergy and Infectious Disease, U.S. Public Health Service.

DAVID PRESSMAN
GERALD RADZIMSKI

Roswell Park Memorial Institute,
Buffalo 3, New York.

[1] Klotz, I. M., in "The Proteins", edit. by Neurath, H., and Bailey, K., 1, *B*, 727 (Academic Press, Inc., New York, 1953).
[2] Markus, G., and Karush, F., *J. Amer. Chem. Soc.*, 79, 3264 (1957).
[3] McMenamy, R. H., and Oncley, J. L., *J. Biol. Chem.*, 233, 1436 (1958).
[4] Rabinovitch, B., *J. Amer. Chem. Soc.*, 81, 1883 (1959).
[5] Pressman, D., and Sternberger, L. A., *J. Immunol.*, 66, 609 (1951).
[6] Koshland, M. E., Englberger, F., and Koshland, jun., D. E., *Proc. U.S. Nat. Acad. Sci.*, 45, 1470 (1959).
[7] Pressman, D., and Siegel, M., *Arch. Biochem. Biophys.*, 45, 41 (1953).
[8] McFarlane, A. S., *Nature*, 182, 53 (1958).
[9] Nisonoff, A., and Pressman, D., *J. Immunol.*, 80, 417 (1958).
[10] Klotz, I. M., and Walker, F. M., *J. Amer. Chem. Soc.*, 69, 1609 (1947).
[11] Blau, M., Johnson, A. C., and Pressman, D., *Int. J. App. Radiation and Isotopes*, 3, 217 (1958).

5-Hydroxyindoles in Human Cerebrospinal Fluids

A MODIFICATION of the method described by Weissbach, Waalkes and Udenfriend[1] has been used for estimating the concentration of 5-hydroxyindoles in human cerebrospinal fluid. This is an estimation by fluorescence after protein precipitation using zinc hydroxide.

The first series of observations was made on two groups of patients on ventricular drainage in a neurosurgical ward. Group 1 of these patients (Table 1) were all hydrocephalic and had been previously showing high concentrations of protein in the cerebrospinal fluid for long periods of time. The 5-hydroxyindole concentrations were extremely high. Group 2, consisting of patients with a history of brain injuries or brain operations, had not been showing prolonged high protein concentrations in the cerebrospinal fluid and the 5-hydroxyindole figures were significantly lower than in group 1.

In one of the samples of cerebrospinal fluid from group 1 it was possible to identify 5-hydroxyindolyl-3-acetic acid by paper chromatography, colour reactions and fluorescence characteristics. Attempts at detecting 5-hydroxytryptamine were made in three

Table 1

Type of patient	No. of patients	Mean concentration 5-OH indoles ngm./ml.	Significance of difference
Group 1	4	313 ± 51*	$P < 0{\cdot}001$
Group 2	4	83 ± 15	

* ± *S.E.* of the mean.

instances with negative results (concentration < 1 ngm./ml.).

A second series of investigations is in progress on the 5-hydroxyindole concentration in lumbar cerebrospinal fluids. A comparison has been made between neurological patients requiring diagnostic air encephalography and psychiatric patients suffering from depressive psychoses. Table 2 shows a significantly lower concentration of 5-hydroxyindoles in the latter group.

Table 2

Type of patient	No. of patients	Mean concentration 5-OH indoles ngm./ml.	
Neurological patients	10	32·2 ± 2·8*	Significance of difference
Depressive psychoses	9	13·2 ± 2·5	$P < 0{\cdot}001$

* ± *S.E.* of the mean.

We wish to express our thanks to Dr. Elizabeth Robertson, Craig House, Royal Edinburgh Hospital; Dr. Hermann, Ward 20, Royal Infirmary, Edinburgh; Dr. Simpson and Dr. Stanton, Neurological Unit, Northern General Hospital, Edinburgh; and Dr. M. Vogt, Department of Pharmacology, University of Edinburgh, for their help and co-operation during this work.

G. W. Ashcroft
D. F. Sharman

Department of Pharmacology,
University New Buildings,
Teviot Place,
Edinburgh 8.

---

[1] Weissbach, H., Waalkes, T. P., and Udenfriend, S., *J. Biol. Chem.*, **230**, 865 (1958).

Detection of N-Oxides of the Pyrrolizidine Alkaloids

Reagents for the detection of alkaloidal N-oxides on paper chromatograms are few and are usually rather insensitive or of low selectivity. Reaction with acetic anhydride, which is known to produce highly coloured by-products with the N-oxides of many alkaloids[1], provides sensitive and characteristic tests for those of the pyrrolizidine series.

Paper chromatograms are dipped in acetic anhydride/benzene/petrol ether (1 : 4 : 5 v/v), hung at room temperature for not longer than 2 min., and then placed in an air oven at 90–100° C. N-oxide spots become fluorescent in ultra-violet light and also develop visible colour.

The fluorescence is excited by ultra-violet lamps having maximum emission either at 3650 or at 2536 Å.; but background fluorescence is less with the former and so sensitivity is greater. Maximum fluorescence results after heating usually for 10–15 min., and thereafter lessens either in the oven or at room temperature. N-oxides of alkaloids derived from heliotridine or retronecine produce a golden-yellow fluorescence detectable with 2–3 μgm./cm.^{2}; those of supinine a medium brown, of sarracine a bluish-white and of anagyroidine (after 30 min.) a light yellow fluorescence, all detectable at 5 μgm./cm.^{2}.

The visible colour becomes maximal after the same period of heating but is permanent. With N-oxides of alkaloids derived from heliotridine or retronecine, it is dark brown, detectable at 5–10 μgm./cm.^{2}. Supinine N-oxide yields a warm brown with greater sensitivity and sarracine and anagyroidine N-oxides, light browns with less sensitivity.

Epilupinine N-oxide, not of the pyrrolizidine series, gives a bluish-white fluorescence and a weak orange-brown colour, and it is likely that N-oxides of some other alkaloidal groups would also be detectable.

A. T. Dann

Animal Health Research Laboratory,
Division of Animal Health,
Commonwealth Scientific and Industrial
Research Organization,
Parkville, Victoria.

---

[1] Culvenor, C. C. J., *Rev. Pure and App. Chem.*, **3**, 104 (1953).

(+) S-Methyl-L-Cysteine Sulphoxide: an Inhibitor of Aspartic Acid Utilization in *Leuconostoc mesenteroides*

The dextro (+) form of S-methyl-L-cysteine sulphoxide has been isolated from turnips[1] and from cabbages[2], and its widespread occurrence in crucifers has been inferred from chromatographic evidence[1,2]. The next higher homologue, methionine sulphoxide, acts as an inhibitor of glutamic acid utilization by *Lactobacillus arabinosus*[3,4]. This structural relationship suggested that S-methyl-L-cysteine sulphoxide might act as an inhibitor of aspartic acid in an analogous manner. The two diastereoisomeric sulphoxides of S-methyl-L-cysteine ((+) and (–) S-methyl-L-cysteine sulphoxide) were tested as aspartic acid antimetabolites in *Leuconostoc mesenteroides*. The natural isomer (+) S-methyl-L-cysteine sulphoxide inhibits the utilization of aspartic acid, but (–) S-methyl-L-cysteine sulphoxide has no measurable activity. On several counts this system can be contrasted with the methionine sulphoxide–glutamic acid system.

L. mesenteroides (*ATCC* 8042) was maintained on liver tryptone agar between trials and on liver tryptone broth prior to use. The complete medium of Steele *et al.*[5] with the exclusion of aspartic acid and asparagine was used in inhibition studies. In general, the final volume per tube was 9 ml. and growth was measured by titrating the acid produced after 72 hr. incubation at 37° C. Over a range of 0–25 μgm. aspartic acid per tube-growth is linear.

With (+) S-methyl-L-cysteine sulphoxide, consistent growth inhibition was apparent from turbidity observations and acid measurements, whereas (–) S-methyl-L-cysteine sulphoxide had no detectable effect. An equimolar mixture of the (+) and (–) forms had an activity equivalent to the (+) form

Table 1. Effect of S-Methyl-L-Cysteine Sulphoxide (MCSO) on the Utilization of L-Aspartic Acid by *Leuconostoc mesenteroides*. Each figure represents the mean of three determinations

L-aspartic acid μmoles	Molar ratio sulphoxide : aspartic	Ml. of 0·02 *N* acid produced			Inhibition by (+) MCSO (per cent)
		Control	(+) MCSO	(–) MCSO	
0·11	100 . 1	5·98	5·50	6·25	8
0·15	133 : 1	8·87	7·49	8·71	15
0·11	1,000 : 1	5·98	2·75	6·05	54

Table 2. EFFECT OF L-ASPARAGINE AND METHYL CYSTEINE SULPHONE ON THE UTILIZATION OF L-ASPARTIC ACID BY *Leuconostoc mesenteroides*

Additions	Amount	Growth*
Aspartic acid	0·1 μmole	6·38
Aspartic acid + MOSO	0 1 μmole 100 μmole	2 06
Aspartic acid + asparagine	0·1 μmole 0·1 μmole	7 52
Aspartic acid + asparagine + MOSO	0·1 μmole 0·1 μmole 100 μmole	2 33
Aspartic acid + MOSO$_2$	0·1 μmole 100 μmole	7 58

* Ml. of 0 02 *N* acid produced in 72 hr. incubation at 37° C.; final volume. 10 ml. per tube.

alone. The inhibition of growth by (+) S-methyl-L-cysteine sulphoxide was overcome by the addition of more L-aspartic acid. Some typical results which show the magnitude of inhibition are summarized in Table 1. A molar ratio of 1,000 : 1 is required for 54 per cent inhibition.

In the Borek and Waelsch system[6], methionine sulphoxide, in 35 : 1 ratio, inhibits glutamic acid utilization to the extent of 88 per cent. In direct contrast to the system described in the present communication, the (−) form of methionine sulphoxide possesses the greater activity; however, it is only 2½ times as active as the (+) isomer[7].

Another difference between these two systems is encountered in comparing the relative activities of the sulphone derivatives. In the aspartic system, methyl cysteine sulphone has shown no inhibition at a ratio of 1,000 : 1 (Table 2); whereas Borek and Waelsch[6] observed that methionine sulphone, in 84 : 1 ratio, gave a 72 per cent inhibition of glutamic acid utilization.

With *L. arabinosus* the growth inhibition by methionine sulphoxide is completely eliminated by replacing the glutamic acid with an equivalent amount of glutamine[4]. It has been concluded that methionine sulphoxide affects the amidation of glutamic acid. In the *L. mesenteroides* system asparagine has no growth-promoting effects in the absence of aspartic acid; however, the different manner in which aspartic acid and glutamic acid are utilized may be due to differences in the organisms. If an equivalent amount of asparagine is added in the presence of aspartic acid there is no sparing effect on the aspartic acid inhibition by (+) S-methyl-L-cysteine sulphoxide (Table 2). In the *L. mesenteroides* system (+) S-methyl-L-cysteine sulphoxide is evidently affecting some reaction other than the amidation of aspartic acid.

WILFRED N. ARNOLD
CLAYTON J. MORRIS
JOHN F. THOMPSON

U.S. Plant, Soil and Nutrition Laboratory,
Agricultural Research Service,
U.S. Department of Agriculture,
and Department of Botany,
Cornell University,
Ithaca, New York.

[1] Morris, C. J., and Thompson, J. F., *J. Amer. Chem. Soc.*, **78**, 1605 (1956).

[2] Synge, R. L. M., and Wood, J. C., *Biochem. J.*, **64**, 252 (1956).

[3] Waelsch, H., Owades, P., Miller, H. K., and Borek, E., *J. Biol. Chem.*, **166**, 273 (1946).

[4] Borek, E., Miller, H. K., Sheiness, P., and Waelsch, H., *J. Biol. Chem*, **163**, 347 (1946).

[5] Steele, B., Sauberlich, H. E., Reynolds, M. S., and Baumann, C. A., *J. Biol. Chem.*, **177**, 533 (1949).

[6] Borek, E., and Waelsch, H., *J. Biol. Chem.*, **177**, 135 (1949).

[7] Borek, E, and Waelsch, H, *Arch. Biochem.*, **14**, 143 (1947).

PHYSIOLOGY

Non-Identity of Triosephosphate Dehydrogenase of Adult Male and Nymph Development Stages of *Triatoma infestans*

WHILE studying the mode of action of 2,2-*bis*-(*p*-chlorophenyl)-1,1,1-trichloroethane (DDT) on *Triatoma infestans* it was found that an *in vivo* dose of both DDT and 2,2-*bis*-(*p*-chlorophenyl)-1,1-dichloroethylene (DDE) which inhibited triosephosphate dehydrogenase derived from male adult specimens of *T. infestans* was without effect on the enzyme derived from nymph specimens (our unpublished observations). This different behaviour of triosephosphate dehydrogenase derived from two different stages in development of the same insect has been also observed *in vitro*. Extracts for enzymatic assay were prepared as follows. The thoraces and legs of male or nymph specimens were ground in a mortar with 0·15 *M* potassium chloride and extracted during 60 min. at 2°; the resulting brei was filtered through cheese-cloth to remove pieces of cuticle and the filtrate centrifuged at 20,000*g* for 60 min. at 2°; the supernatant fluid was finally filtered through Whatman No. 1 paper and used as such as a source of enzyme. Triosephosphate dehydrogenase was assayed as described elsewhere[1].

Table 1 shows that DDT or DDE added in acetone, at a final concentration of $2 \cdot 8 \times 10^{-5} M$, produced 26 and 28 per cent inhibition respectively of adult male triosephosphate dehydrogenase, while no effect was observed on the nymph enzyme. These observations suggested that although adult male and nymph triosephosphate dehydrogenase catalyse similar reactions, they may not be identical with each other. Evidence supporting this view was obtained by the use of specific antibodies. Specific antisera were prepared according to Freund *et al.*[2]. The antiserum against male adult triosephosphate dehydrogenase markedly inhibited the activity of male triosephosphate dehydrogenase; by contrast, the antiserum against nymph triosephosphate dehydrogenase did not affect the activity of the male enzyme, but strongly inhibited the activity of the nymph enzyme (Fig. 1).

Table 1. EFFECT OF DDT AND DDE ON TRIOSEPHOSPHATE DEHYDROGENASE ACTIVITY OF ADULT MALE AND NYMPH EXTRACTS OF *Triatoma infestans*

Additions	Male extracts	Nymph extracts
	Change in optical density/min./mgm. protein	
None	0·300	0 119
DDT	0·223	0·123
DDE	0·216	0·130

System: 100 μmoles pyrophosphate buffer, *p*H 8·5; 2 4 μmoles diphosphopyridine nucleotide; 10 μmoles magnesium chloride; 10 μmoles arsenate; 10 μmoles 1-cysteine; 0·5 μmole 3-phosphoglyceraldehyde to start the reaction; DDT and DDE added in 10 μl. acetone, final molarity, $2\ 8 \times 10^{-5} M$; 0 05 ml. male extract and 0·1 ml. nymph extract: the cuvettes without DDT or DDE had 10 μl. acetone as control; the blank cuvettes contained the same components as the experimental cuvettes with the exception of 3-phosphoglyceraldehyde. Final volume, 3 0 ml.

While studies on the effect of DDT on various enzymatic systems have so far failed to clarify the mode of action of DDT, the above observations may have some bearing on the problem of the resistance towards DDT, since adult male specimens of *T. infestans* are quite susceptible to DDT, whereas nymphs are relatively resistant.

This work was supported by grant *E*-2300 of the Division of Research Grants and Fellowships of the

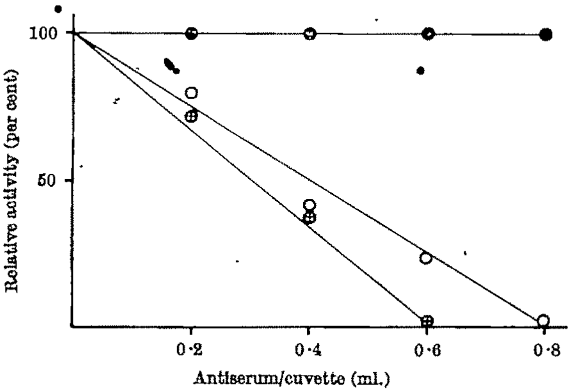


Fig. 1. The effect of specific antisera on the triosephosphate dehydrogenase of male and nymph specimens of *T. infestans*. System: 100 μmoles pyrophosphate buffer, *p*H 8 5; 2·4 μmoles diphosphopyridine nucleotide; 10 μmoles magnesium chloride, 10 μmoles arsenate; 10 μmoles 1-cysteine; male or nymph extracts to give a change in optical density of about 0 040 per min. All components were incubated in the presence of variable amounts of antiserum, as shown, during 20 min. at room temperature (25°) and then the reaction started by the addition of 0·5 μmole 3-phosphoglyceraldehyde. Adequate controls with normal serum were carried out. Final volume, 3·0 ml.

National Institutes of Health, U.S. Public Health Service.

M. Agosin
A. Neghme
N. Scaramelli

Department of Parasitology,
University of Chile,
Santiago, Chile.

---

[1] Agosin, M., and Aravena, L., *Exp. Parasitol.*, 8, 10 (1959).

[2] Freund, J., Thomson, K. J., Bough, H. B., Sommer, H. E., and Pisani, T. M., *J. Immunol.*, 60, 383 (1948).

Xanthine Dehydrogenase in the Silkworm, *Bombyx mori* L.

Although considerable amounts of uric acid have been demonstrated in the silkworm larva, *Bombyx mori*[1,2], very little is known about the intermediary purine metabolism in insects[3-5]. In the formation of uric acid it is the xanthine enzyme system which catalyses the oxidation of purine derivatives xanthine and hypoxanthine to the acid.

Recent studies on purine metabolism[5] have disclosed that the xanthine enzyme system in the silkworm moth behaves as dehydrogenase just like that of chicken liver[6]. It is highly probable that in the silkworm xanthine dehydrogenase plays an active part in uric acid formation.

The experiments described here were performed to establish the principal sites of xanthine dehydrogenase activity of the various organs and tissues in silkworm larvæ, demonstrating the existence of purine metabolic system.

Samples of the insect tissues were dissected out and washed to free them from adhering particles, and after removing the water with filter paper the tissues were weighed, then homogenized in 0·1 *M* pyrophosphate buffer (*p*H 8·3) to obtain 10 per cent homogenate.

As the xanthine enzyme catalyses the oxidation of xanthine by molecular oxygen and by other hydrogen acceptors such as methylene blue, both the aerobic manometric method and the anaerobic Thunberg method are suitable for the measurement of the enzyme activity.

Table 1. OXYGEN CONSUMPTION AND URIC ACID FORMATION FROM XANTHINE IN THE TISSUES (5TH INSTAR)

Materials	Oxygen uptake (μl./ml./hr.)		Uric acid formation (optical density/ml./hr.)	
	With methylene blue	Without methylene blue	With methylene blue	Without methylene blue
Digestive organ	10·90	1·60	0·232	0·016
Malpighian tube	15·70	0·20	0·258	0·001
Fat body	39·10	3·40	0 308	0·016
Integument	3 00	0·90	—	—
Blood	4·00	0 70	0 011	0 003

For the aerobic measurement[6-8], 1 ml. of the tissue homogenate was added to the main compartment of a Warburg flask containing 0·2 ml. of either distilled water or methylene blue (0·0113 *M*), the side arm and centre well of which carried 0·3 ml. of 0·025 *M* xanthine solution in 0·005 *M* sodium hydroxide and 0·2 ml. of 20 per cent solution of potassium hydroxide respectively, making the total fluid volume 1·7 ml. Oxygen uptake was measured manometrically at 37° C. with air as gas phase. Xanthine solution in the side arm was tipped in after 10 min. temperature equilibrium. Readings were taken every 10 min. for 60 min., and thereafter the reaction mixture was adopted to estimate the uric acid formation by Brown's methods[9].

For the anaerobic measurement[10-12], the enzyme activity in the tissues was measured using the anaerobic reduction of the colourless dye 2,3,5-triphenyl tetrazolium chloride in a Thunberg tube. The reaction was carried out by mixing the following solution (maintained at 37° C. for 40 min.): 1 ml. of 0·1 *M* pyrophosphate buffer (*p*H 8·3) and 1 ml. of tissue homogenate in the body of Thunberg tube, and 1 ml. of 10^{-3} *M* 2,3,5-triphenyl tetrazolium chloride solution and 1 ml. of xanthine (0·025 *M*) in the side arm. The reaction was stopped by 0·2 ml. of 20 per cent trichloroacetic acid, and the enzyme activity was expressed in optical density of the red formazan extracted with ethyl acetate.

Table 1 shows the xanthine dehydrogenase activity of the various tissues. The result clearly was demonstrated that the enzyme activity occurred in the digestive organ, Malpighian tube and fat-body preparations with methylene blue, but not without methylene blue.

However, little or no activity could be detected in the integument and blood with or without methylene blue. The enzyme activity of fat body was high in comparison with that of the digestive organ and Malpighian tube. Further, the tissue preparations described above could transform xanthine into uric acid only when methylene blue was used as hydrogen carrier. It is suggested that the enzyme in larvæ, like that of the silkworm moth, is essentially of dehydrogenase nature rather than oxidase.

The rate of reduction of 2,3,5-triphenyl tetrazolium chloride using xanthine as substrate is presented in Table 2. The result indicates that the homogenate from the digestive organ, Malpighian tube and fat-body reduced the 2,3,5-triphenyl tetrazolium chloride, except that from blood and integument. Xanthine dehydrogenase activity in these tissues is in general agreement with the experiment shown in Table 1 with methylene blue, using an aerobic procedure.

The 2,3,5-triphenyl tetrazolium chloride used in a Thunberg tube was demonstrated to be a satisfactory receptor of the xanthine dehydrogenase system in the

Table 2. REDUCTION OF 2,3,5-TRIPHENYL TETRAZOLIUM CHLORIDE BY THE XANTHINE DEHYDROGENASE IN THE TISSUES (5TH INSTAR)

Materials	Endogenous (*E*)	With substrate (*E*)
Digestive organ	0 030	0 086
Malpighian tube	0 097	0 301
Fat body	0·025	0·467
Integument	0·090	0 096
Blood	0 167	0·119

silkworm. The name of xanthine oxidase in chicken liver has been proposed as xanthine dehydrogenase by Remy, Richert and Westerfeld[6], only because the catalysis from xanthine to uric acid reacts more slowly with molecular oxygen than with methylene blue. Thus, in addition to the previous result it is further substantiated that the xanthine enzyme system in the silkworm is of a dehydrogenase character.

I wish to express my thanks to Prof. K. Hasegawa (Sericultural Laboratory) and Mr. A. Yoshida (Food and Nutrition Laboratory) for valuable advice and help throughout this work.

YOSHIYUKI HAYASHI

Sericultural Laboratory,
Faculty of Agriculture,
Nagoya University,
Anzyo, Aitiken.

[1] Hatamura, M., *J. Seric. Exp. Stat.*, 11, 347 (1942).
[2] Shimizu, S., *J. Seric. Exp. Stat.*, 11, 379 (1942).
[3] Anderson, A. O., and Patton, R. L., *Science*, **120**, 956 (1954).
[4] Sigematsu, H., *J. Seric. Sci.*, **25**, 115 (1956).
[5] Hayashi, Y., *Kagaku*, **27**, 467 (1957) (in Japanese).
[6] Remy, C. N., Richert, D. A., and Westerfeld, W. W., *J. Biol. Chem.*, **193**, 649 (1951).
[7] Axelrod, A. F., and Elvehjem, C. A., *J. Biol. Chem.*, **140**, 725 (1941).
[8] Dhungat, S. B., and Sreenivasan, A., *J. Biol. Chem.*, **208**, 845 (1954).
[9] Brown, H., *J. Biol. Chem.*, **156**, 601 (1945).
[10] Shellon, E., and Schneider, W. C., *Anat. Rec.*, **112**, 61 (1952).
[11] Brodie, A. F., and Gots, J. S., *Science*, **116**, 588 (1952).
[12] Villela, G. G., Mitidieri, E., and Affonso, O. R., *Nature*, **175**, 208 (1955).

Body-Weight and Age in Relation to the Metabolic-Rate of the Young Pig

AN animal's maturity at birth is manifested in part by its degree of dependence on its environment, and by its changes in metabolic-rate with age as distinct from changes caused by its increasing size and varying body temperature. Some animals tend towards poikilothermy in the period immediately after birth, while others are only weakly homoeothermic[1]. Mount[2,3] has shown that new-born pigs, on the other hand, of ages from 1 hr. onwards, react to exposure to a temperature of 4° C. with a marked rise in metabolic-rate, thus showing characteristics of the adult homœotherm. Mount's findings, however, were not in agreement with those of Holub, Forman and Ježková[4], who concluded that thermogenesis in response to cold does not begin to appear in the young pig until the ninth day after birth.

The question to be considered here is whether oxygen consumption varies with age independently of concomitant changes in body-weight. Holub, Ježková and Forman[5] have found oxygen consumption per unit body-weight to be closely correlated both with age and with body-weight. Because of the high correlation between body-weight and age, however, it is necessary to consider these variables simultaneously to determine whether oxygen consumption varies with age independently of body-weight. In interpreting the results of the experiment described below, therefore, multivariate regression analyses[6] were used so that the relation with age could be studied when body-weight was held constant; variations in rectal temperature were also taken into account.

Table 1. PARTIAL REGRESSION COEFFICIENTS AND THEIR STANDARD ERRORS FOR LOG (TOTAL OXYGEN CONSUMPTION ML. PER MIN.) ON LOG (BODY-WEIGHT), RECTAL TEMPERATURE, AND AGE

	log (body-weight, kgm.)	Rectal temperature (° C.)	Age (hr.)
30° C. first week	0·610 ± 0 064	0·157 ± 0 035	0·000748 ± 0 000403
4° C. first week	0 562 ± 0 186	0 105 ± 0·029	0·001106 ± 0·000763
30° C. 1–5 weeks	0 684 ± 0 083	0 150 ± 0 038	−0 000372 ± 0 000126

The experiment involved 98 pigs in the first five weeks after birth. Oxygen consumption was used as the index of metabolic-rate and the investigation was carried out on three groups of pigs, differing in respect of the ambient temperature for the measurement, and age; these groups will be referred to as 30° C. first week, 4° C. first week and 30° C. 1–5 weeks. Log (total oxygen consumption per min.) was examined in relation to age, rectal temperature and log (body-weight). The partial regression coefficients and their standard errors for each of the three variables are given in Table 1, and the expressions for oxygen consumption-rates for single animals are given below for the three groups (1) 30° C. first week, (2) 4° C. first week and (3) 30° C. 1–5 weeks:

$$(1)\ 0{\cdot}0442\ B.W.^{0\,610}\ e^{0\,157\,R.T.}\ e^{0\,000748\,\mathrm{age}}$$

$$(2)\ 0{\cdot}7134\ B.W.^{0\,562}\ e^{0\,105\,R\,T}\ e^{0\,001106\,\mathrm{age}}$$

$$(3)\ 0{\cdot}0598\ B.W.^{0{\cdot}684}\ e^{0\,150\,R.T.}\ e^{-0\,000372\,\mathrm{age}}$$

where *B.W.* = body-weight (kgm.) and *R.T.* = rectal temperature (°C.); oxygen consumption-rate was measured in ml./min. and age in hours.

The relative effects of body-weight and age on oxygen consumption have been examined by calculating from the above expressions the effects of differences in body-weight for pigs of a given age, and the effects of differences in age for pigs of a given body-weight (rectal temperature was held constant at 39° C. in all cases). The age–weight regression shows

Table 2 (*a*). EFFECTS OF DIFFERENCES IN BODY-WEIGHT ON OXYGEN CONSUMPTION OF PIGS AT A GIVEN AGE

	Age (constant)	Body-weight (kgm.)	Oxygen consumption (ml./min.)	Difference
30° C. first week	3 days	1·50	27·6	
		1·86	31·5	3·9
4° C. first week	3 days	1 50	58·5	
		1·86	65 9	7 4
30° C. 1–5 weeks	3 weeks	3·83	43·6	
		5 68	57·0	13·4

Table 2 (*b*). EFFECTS OF DIFFERENCES IN AGE ON OXYGEN CONSUMPTION OF PIGS OF A GIVEN BODY-WEIGHT; THE AGE DIFFERENCES USED CORRESPOND TO THE WEIGHT DIFFERENCES IN TABLE 2 (*a*)

	Body-weight (constant)	Age	Oxygen consumption (ml./min.)	Differences
30° C. first week	1 68 kgm.	2 days	29·0	
		4 days	30·1	1·1
4° C. first week	1·68 kgm.	2 days	60·7	
		4 days	64 0	3·3
30° C. 1–5 weeks	4·75 kgm.	2 weeks	53 8	
		4 weeks	47·4	−6·4

that during the period between 2 and 4 days after birth, body-weight increased from 1·50 to 1·86 kgm. (mean = 1·68 kgm.). Thus the difference in oxygen consumption between 3-day-old pigs of weights 1·50 and 1·86 kgm. was compared with the difference in oxygen consumption between pigs aged 2 and 4 days but the same weight, 1·68 kgm. A similar procedure was adopted for the older pigs (1–5 weeks). The results of these calculations are given in Tables 2*a* and 2*b* and show that differences in body-weight had at least double the effect on oxygen consumption of corresponding differences in age. Indeed, during the first week, it is not certain whether age affected oxygen consumption at all; the individual partial regression coefficients for the first two groups shown in Table 1 were not significant but, taken together, there is a suggestion that oxygen consumption increases slightly with age (body-weight and rectal temperature fixed). From 1 to 5 weeks, the reduction in oxygen consumption with age (body-weight and rectal temperature fixed) was significant; possible reasons for this comparatively small effect will be discussed in a later paper.

As a result of this experiment, it appears that the changes in the oxygen consumption-rate of the young pig with age are of only minor importance when body-size and body-temperature changes have been taken into account. This conclusion considered in conjunction with the vigorous metabolic response of the newly born pig to cooling of its environment reported by Mount[3] suggests that thermogenesis is well developed at birth.

We are indebted to Dr. J. H. Gaddum for discussion of the statistical analysis of this investigation.

L. E. MOUNT

Agricultural Research Council
Institute of Animal Physiology,
Babraham,
Cambridge,

J. G. ROWELL

Agricultural Research Council
Statistics Group,
School of Agriculture,
University of Cambridge.

---

[1] Gellneo, S., *Usp. sovrem. biol.*, **47**, 108 (1959).

[2] Mount, L. E., *Nature*, **182**, 536 (1958).

[3] Mount, L. E., *J. Physiol.*, **147**, 333 (1959).

[4] Holub, A., Forman, Z., and Jeřková, D., *Nature*, **180**, 858 (1957).

[5] Holub, A., Jeřková, D., and Forman, Z., *Physiol. Bohem.*, **7**, 521 (1958)

[6] Fisher, R. A., "Statistical Methods for Research Workers", thirteenth ed. (Oliver and Boyd, Edinburgh, 1958).

Determination of Small Rapid Volume Changes in a Muscle during Activity

A METHOD has been developed for measuring small rapid volume changes occurring in a muscle during a single twitch. In order to achieve the necessary sensitivity and speed of response, a capacitance transducer has been developed which uses a commercially available detector-amplifier circuit (the 'Dynagage', from Photocon Products). The changes are displayed on a cathode-ray oscilloscope. Single gastrocnemius and sartorius muscles from *Rana pipiens* are used.

Following a stimulus applied through a multi-electrode assembly, volume changes occur after a short latent period. An initial apparently small increase in volume precedes the main decrease of volume (Fig. 1), which is about 1·6 × 10^{-5} c.c./gm. in gastrocnemius and 5 × 10^{-6} c.c./gm. in sartorius muscle.

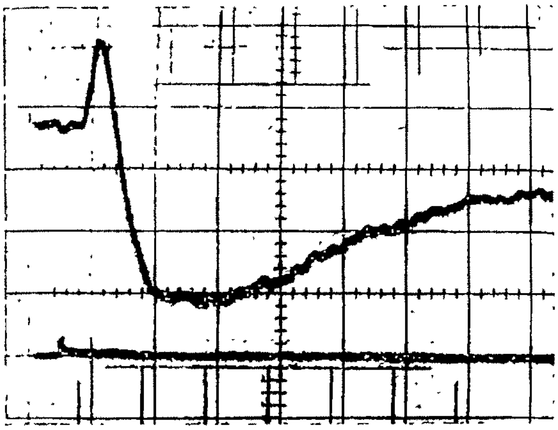


Fig. 1. Record of volume changes at 18° C., in single frog sartorius muscle. The muscle is held isometrically at reference length and is stimulated with a single shock. The stimulus point is indicated below the volume record. Each large division represents 20 msec. on the abscissa and 0 3 × 10^{-6} c.c. on the ordinate. Uncorrected for delay

Analysis to correct for delays in the chamber using a step-function volume-change from a loudspeaker coil movement showed that the early increase is actually almost as large as the later decrease in volume, and has almost the same time course as latency relaxation (Sandow, 1944) and as early transparency changes in a twitch (D. K. Hill, 1953).

The increase in volume is rapidly reversed and the maximum decrement in volume is reached appreciably before the peak of isometric tension. At the end of relaxation a decrease in volume persists (Fig. 1), and at 0° C. almost no volume recovery occurs in sartorius muscle. It therefore seems unlikely that these volume changes result from internal pressure changes due to muscle tension (A. V. Hill, 1948), and perhaps the time course of decrease in volume reflects that of the developing active state.

In view of the continuing inability to demonstrate chemical changes during a single contraction, it may be well to re-estimate the information, which measurements such as volume and opacity changes can provide, on the events both of the excitation coupling and on protein organization in contraction.

B. C. ABBOTT
R. J. BASKIN

Department of Zoology,
University of California at Los Angeles.

HÆMATOLOGY

A Hæmoglobin-binding β-Globulin in Human Serum

A NUMBER of human serum proteins have the property of forming definite compounds with hæmoglobin. The term haptoglobin has been applied to them by Jayle[1,2], who was able to isolate them by salt fractionation and characterize them as α_2-globulins by electrophoresis. In several studies using paper electrophoresis, hæmoglobin-binding proteins have been detected in the α_2 region. Hæmoglobin has also been found in the β-globulin region, especially when large amounts are present, but since free hæmoglobin itself migrates as a β-globulin, it has been assumed that this represents uncombined hæmoglobin. Neale, Aber and Northam[3] found that a discrete band in the β-globulin region reacted with benzidine reagents, but did not appear to be free hæmoglobin. They suggested that a β-globulin binds hæmoglobin as well as an α_2-globulin.

The technique of immuno-electrophoresis[4] has certain advantages in investigating the problem since the effect of free hæmoglobin may be largely ruled out. After the anti-serum diffusion stage, excess protein was removed by washing the agar extensively with water and the preparations stained for hæmoglobin with benzidine, using sodium nitroprusside as a stabilizing agent[5]. Two lines stained blue with benzidine, one in the α_2 region and one in the β region (Fig. 1). The α_2 line can just be seen to be doubled in some individuals. Combination with hæmoglobin does not noticeably affect the electrophoretic mobility of these components, since the same lines can be seen in the same place in hæmoglobin-free serum. The α_2 line or lines appear to correspond with the now well-known haptoglobins 1 and 2 of Smithies[6], while the fact that only two lines can be detected lends some support to the hypothesis of Allison[7] that the numerous haptoglobins found in some individuals by starch-gel electrophoresis are polymers, either of the type 2 haptoglobin with itself or with type 1.

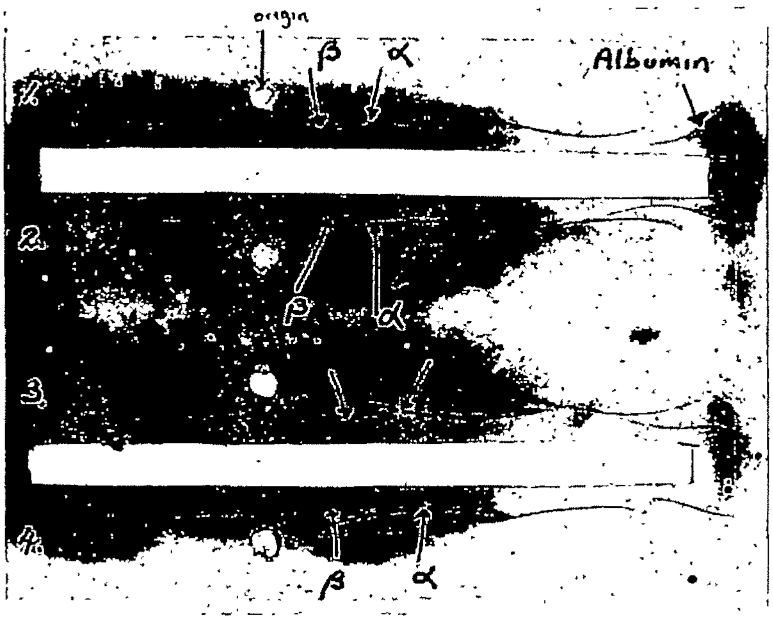


Fig. 1. Immunoelectrophoresis patterns of four different sera after benzidine staining. Each serum contained 200 mgm. hæmoglobin per 100 ml. The two lines which stained blue with benzidine are marked α and β

The line in the β region cannot be due to free hæmoglobin, both because it is readily seen in serum which contains no hæmoglobin and because hæmoglobin itself gives no precipitin line with the anti-serum used (horse anti-human serum, Institut Pasteur, Paris). Burtin *et al.*[8] have reported that on storage the α_2-haptoglobins become transformed into a component with β mobility. The hæmoglobin-binding β-globulin detected in immuno-electrophoresis does not represent this converted form of the α_2-haptoglobin since it is present in fresh serum. Furthermore in very old sera the α_2-haptoglobin has a much lower electrophoretic mobility than in fresh sera, but gives a precipitin arc quite different from that shown by the hæmoglobin-binding β-globulin. It is possible that the β-globulin-antibody complex, when formed in the presence of free hæmoglobin, is capable of binding it, while the β-globulin alone does not. Other arcs formed in the presence of free hæmoglobin do not show binding, however, and it is most unlikely that this was the source of the benzidine staining found.

These results suggest strongly that there is a β-globulin in human serum capable of binding hæmoglobin, in addition to the well-known α_2-globulins. Studies in which increasing amounts of hæmoglobin have been added to serum indicate that the β-haptoglobin has a lower affinity for hæmoglobin than the α_2-haptoglobins, and it does not start to bind hæmoglobin until the α_2-haptoglobin is substantially saturated. It has been detected in each of thirty sera and two cord sera so far examined, and unlike the α_2-haptoglobins it does not show marked individual variation, at least by this technique. It is not transferrin, since it forms an arc just inside that of transferrin in immunoelectrophoresis. However, its electrophoretic mobility on paper and in starch gels, solubility in ammonium sulphate (just soluble in half saturated) and its behaviour on ion-exchange cellulose columns are all closely similar to those of transferrin.

Although the β-globulin described appears to have a much smaller capacity for hæmoglobin than the α_2-haptoglobins, which are undoubtedly the major haptoglobins quantitatively, its existence should be taken into account in determining the hæmoglobin-binding capacity of serum; some existing methods appear to exclude it. It may also take a significant physiological role in those individuals who normally have a very low level of α_2-haptoglobin. In one such case the β-haptoglobin was present but did not appear to be elevated.

I am much indebted to the British Empire Cancer Campaign for financial support and to the Photographic Department for Fig. 1.

M. P. Tombs

Department of Chemical Pathology,
Westminster Medical School,
London, S.W.1.

[1] Jayle, M. F., *Bull. Soc. Chim. Biol.*, **21**, 14 (1939).

[2] Jayle, M. F., Boussier, G., and Tonnelat, J., *Bull. Soc. Chim. Biol.*, **38**, 343 (1956).

[3] Neale, F. C., Aber, G. M., and Northam, B. E., *J. Clin. Path.*, **11**, 206 (1958).

[4] Scheidegger, J. J., *Intern. Arch. Allergy App. Immunol.*, **7**, 103 (1955).

[5] Swarup, S., Ghosh, S. K., and Chatterjea, J. B., *Bull. Calcutta School Trop. Med.*, **7**, 150 (1959).

[6] Smithies, O., *Biochem. J.*, **61**, 629 (1955).

[7] Allison, A. C., *Nature*, **183**, 1312 (1959).

[8] Burtin, P., Grabar, P., Boussier, G., and Jayle, M. F., *Bull. Soc. Chim. Biol.*, **36**, 1029 (1954).

Fibrinogenolysis in Joints

THE following observations were made in the course of an investigation into the reasons for the apparent failure of blood to clot when shed into synovial joints.

Growing rabbits, 3–4 months old, were used. Plasma was prepared from citrated blood (two volumes 3·8 per cent sodium citrate to eight of blood). Veterinary nembutal was used as anæsthetic. The rabbit's knee joint was injected with plasma until full (2·0–2·5 ml.). A control specimen was placed in a siliconed tube in a water-bath at 37° C. At pre-set intervals 0·25-ml. samples of fluid were aspirated for fibrinogen estimations. At the end of the experiment the animal was killed by excess nembutal or bleeding. The knee joint was then opened, free fluid collected and clots thoroughly searched for. Any clot found was retained for estimation of fibrin content.

Fibrinogen estimations were carried out in duplicate using King's Nesslerization method[1] modified only by the use of thrombin (Maw's, 10–20 units) to precipitate the fibrin instead of simple recalcification. The duplicate results were averaged. Plasma clots recovered from the joints were washed in saline once, and in distilled water three times, with firm expression of the contained fluid between glass slides at each stage. The fibrin content was estimated by Nesslerization.

The findings in fifteen experiments are exemplified in Fig. 1. The fibrinogen-level falls to zero in 1–1¼ hr. Plasma incubated *in vitro* shows no fall or only a relatively slight drop in fibrinogen-level over the same period.

Recovery of the full volume of plasma injected was not achieved, about half leaking out of the joint during the experiment. In three experiments no clot was found in exploring the joint. Analysis of the residual clot when present in no instance revealed enough fibrin to account for the observed fall of fibrinogen-levels in the volume of fluid recovered, let alone in that injected. In the experiment illustrated 0·33 mgm. fibrin was recovered from the joint as clot. The loss of fibrinogen observed in the volume of fluid recovered was equivalent to 1·29 mgm. fibrin. As fibrinogen was lost almost certainly from a greater volume of plasma than that recovered by aspiration, the total fibrinogen to be accounted for is greater than this figure.

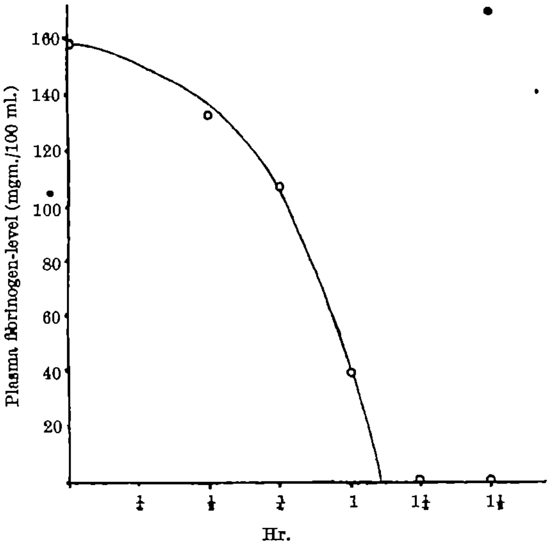


Fig. 1. Fibrinogen-levels of citrated plasma in the knee joint of the rabbit

Although it was difficult to avoid the entry of thrombin and the formation of small clots, it seemed that the greater part of the fibrinogen in the joint was destroyed by lysis.

In further experiments it was found that fibrinogenolysis does not occur in the dead animal; it is much slower in fully grown animals than in the young; it is completely inhibited by heparin (5 units/ml.) and is inhibited by crystalline soya bean trypsin inhibitor at a concentration of 1 mgm./ml., but not at 0·13 mgm./ml.

These experiments suggest that, in contrast to most *in vitro* experiments, *in vivo* conditions may exist in which fibrinogenolysis occurs quite rapidly while, at the same time, fibrinolysis occurs but slowly, if at all. The possibility that fibrinogenolysis is caused by the activation of plasmin is supported by the observed inhibitory effects of heparin and soya bean inhibitor. The presence of plasmin activators in joint tissues has already been reported[2,3].

Intra-articular fibrinogenolysis could be one factor responsible for the partial failure of blood to clot when shed into synovial joints.

A. J. HARROLD

Institute of Orthopaedics,
Royal National Orthopaedic Hospital,
Brockley Hill, Stanmore,
Middlesex.

---

[1] King, E. J., "Microanalysis in Medical Biochemistry" (Churchill, 1946).

[2] Astrup, T., and Sjolin, K. E., *Proc. Soc. Exp. Biol., N.Y.*, **97**, 852 (1958).

[3] Lack, C. H., *J. Bone Jt. Surg.*, **41** B, 384 (1959).

HISTOLOGY

Localization of Amino-acids for Histochemical Estimation

SERRA[1] attempted to determine total amino-acids in frozen tissue sections with alloxan and ninhydrin. However, the coloured products diffused rapidly from their original sites so that localization was not possible. Other methods have also been found to be unsatisfactory for the same reason[2,3]. Certain amino-acids have been successfully fixed *in situ*[1,4,5], but these probably cannot be used as a reliable indication of total amino-acids in the tissues.

To circumvent the above difficulties, the following method was developed which prevents diffusion of the acids and their ninhydrin products from their original sites. Kill, dehydrate and fix the tissue with anhydrous, peroxide-free dioxane (1,4-diethylene dioxide). Be sure that the dioxane is entirely peroxide-free because even traces of peroxides depress colour development. Fix the tissue in three changes of dioxane under partial vacuum over a period of 24 hr. or longer, depending upon the size of the piece of tissue. Clear in steps with mixtures of dioxane and chloroform to pure chloroform. Infiltrate with 'Tissuemat'. Section to desired thickness and mount adjacent sections on duplicate slides covered with a thin film of Haupt's adhesive[6,7]. Duplicate slides containing adjacent sections are necessary to distinguish between the relative contribution of protein and free amino-acids to the overall colour density after the ninhydrin reaction. Deparaffinize the sections in two changes of xylol. For determining protein only, dissolve out the amino-acids on one slide by taking the slide through absolute ethanol to 70 per cent ethanol and then to dioxane. For total amino-acids plus protein, take the second slide directly from xylol into dioxane. Change the dioxane once, and after 5 min. allow the slide to stand for 2 min. in a 1 per cent solution of ninhydrin in dioxane. Drain off the excess solution and place the slide in a covered Coplin jar preheated to 100° C. and containing a little ethanol at the bottom to keep the atmosphere in the jar saturated with ethanol. Develop the colour for 45 min. in an oven at 100° C. Take care that the sections are not immersed in the ethanol since this results in diffusion of the ninhydrin products. Clear the sections in two changes of xylol and mount in Fisher 'Permount'.

The colour density of one cell or a group of cells is determined microphotometrically with a simplified apparatus of the type used by Pollister and Moses[8], using a 570-mμ filter. Measurements may be made at any time up to 24 hr. After 24 hr. the colour produced by amino-acids begins to fade; but that produced by protein is stable for 7 days or longer (Fig. 1).

The relationship between colour density and concentration was determined with glycine to test the feasibility of the procedure. Glycine solutions at 200, 400, 600 and 1,000 p.p.m. were prepared. Sections were deparaffinized and the endogenous amino-acids were removed with 70 per cent ethanol. The slides were drained thoroughly, air dried and then the sections were infiltrated with glycine at each of the above concentrations. The glycine was then fixed in the tissue with dioxane and taken through the whole procedure. The amino-acid concentration was determined in cortical and procambial cells, along with comparable control sections containing only protein background. The values after correction for protein background are plotted in Fig. 2. The results show that the optical density after correction for protein background is directly proportional to the amount of amino-acid in the infiltrating solution.

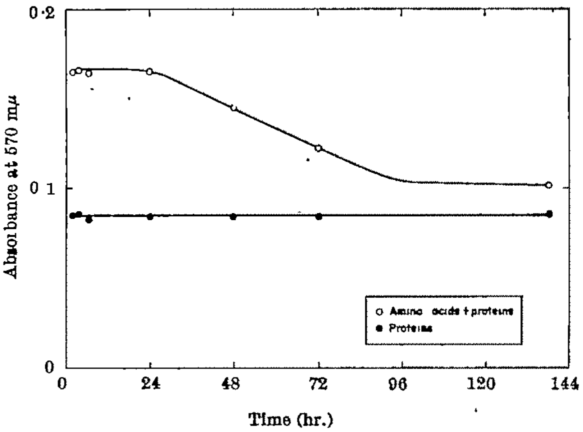


Fig. 1. Relationship between time and colour density of ninhydrin reaction products of amino-acids and proteins in tomato root sections

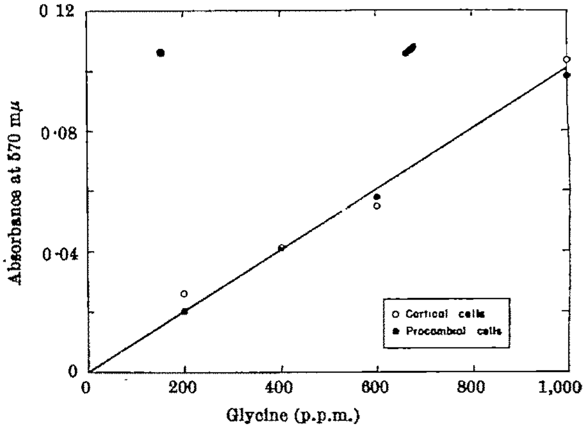


Fig. 2. Relationship between colour density of the ninhydrin reaction product and the concentration of glycine in the solution added to tomato root sections. Infiltrating, fixing and reaction procedures are described in the text

Since tissue sections contain a mixture of amino-acids in different proportions, and ninhydrin products with different extinction coefficients at 570 mμ, standards cannot be calculated directly to determine actual amounts in the cells. However, protein and amino-acid concentrations in different cells and tissues within the same section can be compared.

HELEN M. NOTOVNY
ROBERT G. OWENS

Boyce Thompson Institute for Plant Research, Inc.,
Yonkers, New York.
May 3.

---

[1] Serra, J. A., *Stain Technol.*, 21, 5 (1946).

[2] Millon, M. E., *C.R. Acad. Sci., Paris*, 28, 40 (1849).

[3] Rasch, E., and Swift, H., *J. Histochem. Cytochem.*, 8, 4 (1960).

[4] Gomori, George, "Microscopic Histochemistry" (University of Chicago Press, Chicago, 1952).

[5] Lillie, R. D., "Histopathologic Technic and Practical Histochemistry" (Blakiston Co., New York, 1954).

[6] Haupt, A. W., *Stain Technol.*, 5, 97 (1930).

[7] Johansen, D. A., "Plant Microtechnique" (McGraw-Hill, New York, 1940).

[8] Pollister, A. W., and Moses, M. J., *J. Gen. Physiol.*, 32, 567 (1949).

PATHOLOGY

Precipitating Antibody in Trypanosomiasis of Cattle and Other Animals

PRECIPITATING antibody has been demonstrated in sera from animals which have been infected with trypanosomes, or given a course of injections of material of trypanosome origin, by means of a modified technique of double diffusion in agar gel[1].

Plates were prepared to a depth of 3–4 mm. from 1 per cent New Zealand agar in 0·85 per cent saline containing 0·02 per cent sodium azide, and wells 6 mm. in diameter were cut and lined with a thin film of agar. The distance between centres of adjacent wells was varied from 9 to 11 mm. to suit the system being investigated. Plates were left on the bench at room temperature (20–28° C.) and the wells were refilled at 24 hr. if necessary. Precipitation was usually present at 24 hr. and maximum in 4 days.

Antigens have been prepared from *Trypanosoma vivax*, *T. brucei* and *T. gambiense*. Trypanosomes were separated by centrifugation from citrated blood

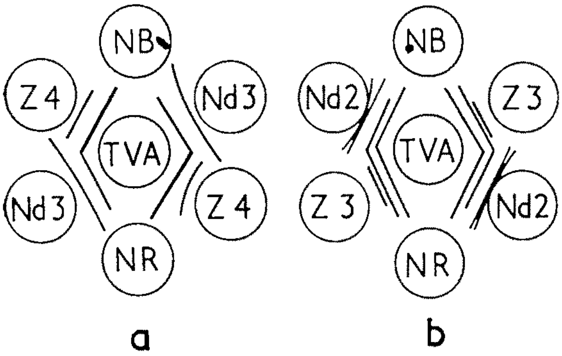


Fig. 1. Examples of precipitation patterns obtained at 24 hr. with *T. vivax* antigen reacting with sera from infected animals and normal (uninfected) controls. *a*, *T. vivax* antigen (*TVA*) against sera from an infected N'dama (*Nd.* 3), an infected Zebu (*Z*.4), a normal bovine (*NB*) and a normal rat (*NR*). *b*, The same antigen reacting with sera from two other infected animals, an old re-challenged N'dama (*Nd*.2) and a Zebu with a chronic *T. vivax* infection (*Z*.3); the same controls as above are also included

of rats showing massive infections. All traces of rat serum were removed by repeated washing with 0·85 per cent saline. Two volumes of saline were added to one volume of packed, serum-free trypanosomes and the suspension was shaken for 30 min. with glass ballotini (No. 12) in a Mickle disintegrator. The cellular debris in the homogenate thus obtained was deposited by centrifugation and the concentrated, opalescent supernatant used as antigen. A satisfactory antigen from trypanosomes of the *congolense* group has not yet been successfully prepared.

Serum samples from infected Zebu and N'dama cattle have given positive reactions; sera from uninfected cattle have been consistently negative.

The period between the beginning of a parasitæmia and the appearance of precipitating antibody to *T. vivax* antigen has been determined in four instances. Two calves, a Zebu (*Z*.1) and an N'dama (*Nd*.1) when first infected by *Glossina morsitans* carrying a mixed infection of *T. vivax* and *T. congolense*, showed precipitating antibody 25 and 39 days respectively after trypanosomes appeared in the blood. Serum from a Zebu bull (*Z*.2) which was exposed to the same challenge contained antibody after 21 days of parasitæmia. An old N'dama bull (*Nd*.2) which had not been exposed to infection for a period of 2 years and showed no chronic infection was rechallenged; antibody appeared after 11 days of parasitæmia.

After treatment of the infections with ethidium bromide, antibody disappeared from the serum of the calves *Z*.1 and *Nd*.1 in 28 days. Precipitating antibody may persist in the serum of an infected, untreated animal even when no trypanosomes can be found in the peripheral blood. The serum of a Zebu bull (*Z*.3) which showed clinical signs of trypanosomiasis in the form of emaciation, enlarged superficial lymph nodes and anæmia, consistently gave a strong reaction with *T. vivax* antigen over a period of 8 months. *T. vivax* has been detected in the blood of this animal in only seven of the wet films examined daily throughout this period. The sporadic parasitæmia, persistence of antibody and the observed clinical signs correspond closely with the findings of Fiennes[2] in cryptic trypanosome infections.

Great variation in the pattern of precipitation occurs in the reactions of sera from individual cattle with antigen obtained from a single source. Fig. 1*a* illustrates the reaction between sera from a Zebu (*Z*.4) and an N'dama (*Nd*.3) and *T. vivax* antigen. Both animals have been repeatedly exposed to tsetse flies carrying a mixed trypanosome infection at intervals during a period of 2 years and are still suffering from trypanosomiasis. They have been treated several times with ethidium bromide when dangerously ill. Fig. 1*b* illustrates the reaction between the same antigen and the serum of the re-challenged N'dama (*Nd*.2) which now has a *T. congolense* infection and the serum of the Zebu (*Z*.3) which has a pure chronic *T. vivax* infection. The differences shown may be due either to the species of infecting organism or to the previous history of the animals or to breed peculiarities.

Antibodies in the serum of an animal with a pure infection have been shown to react with antigenic material from several species of trypanosome. In these cross-reactions the lines of precipitation are characteristically reduced in number, less distinctly defined, and may take longer to reach maximum development.

Serum samples from experimental rabbits, a horse and a duiker have also given positive results after pre-infection samples were negative. Precipitating antibody has been detected by this method in three out of five cases of human sleeping sickness caused by *T. gambiense*. This work is being continued and extended.

I am grateful to several of the senior staff of this Institute for their help: to Dr. K. C. Willett for his constructive criticism, to Drs. J. Williamson and R. S. Desowitz for technical advice and encouragement and to Dr. L. E. Stephen for sera from several of his experimental animals.

A. R. Gray

Veterinary Section,
West African Institute for
Trypanosomiasis Research,
Vom,
Northern Nigeria.

[1] Mansi, W., *J. Comp. Path.*, 67, 297 (1957)
[2] Fiennes, R. N. T.-W., *Ann. Trop. Med. Parasit.*, 44, 222 (1950).

Non-Protein Sulphydryl Group in the Original Strain and Sub-line of the Ascites Tumour resistant to Alkylating Reagents

I HAVE succeeded in establishing resistant variants of the Yoshida ascites sarcoma and ascites hepatoma (*AH* 13 and *AH* 7974) to methyl-*bis*-(β-chlorethyl)-amine N-oxide, one of the alkylating agents, by passing tumour cells through animals treated with the reagents[1]. These resistant variants were proved to be cross-resistant to the other alkylating reagents, but not cross-resistant to the unrelated reagents[2]. Furthermore, no difference could be detected in cytological features of tumour cells between the original and resistant sub-lines. Details concerning the biological properties of these resistant sub-lines are to be found in previous papers[1–3]. The mechanism of development of resistance to this reagent is not yet clear. However, it is well known that nitrogen mustard inactivates sulphydryl groups. Also a preferential affinity of methyl-*bis*-(β-chlorethyl)-amine N-oxide to sulphydryl groups has already been reported by Torigoe[4] and Ishidate[5]. From this point of view, I attempted to study the non-protein

Table 1. CONTENT OF NON-PROTEIN SULPHYDRYL GROUP IN THE ORIGINAL STRAIN AND RESISTANT SUB-LINE OF THE YOSHIDA ASCITES SARCOMA AND ASCITES HEPATOMA

	μM per gm. based on wet weight*		
	Yoshida ascites sarcoma Mean ± *S.E.*	Ascites hepatoma *AH* 13 Mean ± *S.E.*	Ascites hepatoma *AH* 7974 Mean ± *S.E.*
Original strain	2·54 ± 0·27	3·11 ± 0·31	3·96 ± 0·48
Resistant sub-line	5·71 ± 0·48	5·31 ± 0·30	5·53 ± 0·32
Probability	$P < 0{\cdot}001$	$P < 0{\cdot}001$	$P < 0{\cdot}01$

* Each value indicates average of nine rats.

sulphydryl content of tumour cells in the original strain and resistant sub-line.

In this work, the Yoshida ascites sarcoma, *AH* 13, *AH* 7974, and their resistant sub-lines were used. All these resistant sub-lines were successfully transmitted in the absence of the reagent. A total of 54 rats of mixed breed and weighing about 130 gm. were used, each receiving an intraperitoneal inoculation of 0·5 c.c. of undiluted tumour ascites in the state of nearly pure culture, that is, the tumour cells of each original strain or resistant sub-line were inoculated into nine rats respectively. They were highly susceptible to these tumours. The tumour ascites were withdrawn from the peritoneal cavity when the state of nearly pure culture after inoculation with the tumour was reached, washed immediately with saline, and centrifuged for 3 min. at 3,500 rev./min. Tumour cells thus obtained were weighed, and with the use of about 500 mgm. of tumour cells in wet weight, non-protein sulphydryl group was determined according to the amperometric method described by Weissman *et al.*[6] and Goldzieher *et al.*[7].

Results are shown in Table 1. A difference of mean value between each original strain and its resistant sub-line was tested statistically. The average content of non-protein sulphydryl in the original strain of the Yoshida ascites sarcoma was 2·54 μmoles/gm. and that in the resistant sub-line was 5·71 μmoles/gm.; that is, the average content in the resistant sub-line was more than twice that in the original strain. Furthermore, also in the ascites hepatoma, *AH* 13 and *AH* 7974, the average content of non-protein sulphydryl in the resistant sub-line was found to be increased as compared with that in the corresponding original strain. The difference between the original strain and its resistant sub-line in both *AH* 13 and *AH* 7974 was statistically significant (Table 1). From these results it is evident that the sub-line resistant to methyl-*bis*-(β-chlorethyl)-amine N-oxide, which was established by passing tumour cells through animals treated with the reagents, showed a significant increase in non-protein sulphydryl content as compared with the original strain, whether the Yoshida ascites sarcoma or ascites hepatoma.

Since alkylating reagents show an affinity for sulphydryl groups, it seems to be most probable that tumour cells containing a large amount of non-protein sulphydryl group are more endurable, owing to counteracting the action of the reagents, than those containing a smaller amount. As a matter of course, many factors might be related to the mechanism of resistance to alkylating reagents. However, it is considered that the non-protein sulphydryl group of tumour cells plays an important part in the mechanism of resistance to alkylating reagents, at least in that of induced resistance as revealed in this work.

I wish to express my thanks to Prof. T. Yoshida for supplying the tumour strains and for his encouragement in many ways, and to Dr. Y. Sakurai and Dr. K. Kaziwara for supplying methyl-*bis*-(β-chlorethyl)-amine N-oxide. I am also indebted to the Department of Bacteriology, Nagoya University, for providing laboratory facilities.

The work was aided by a grant from the Japanese Cancer Society.

IWAO HIRONO

Department of Pathology,
Nagoya University School of Medicine,
Nagoya, Japan.
Jan. 14.

[1] Hirono, I., *Nagoya J. Med. Sci.*, 17, 102 (1954); *Gann* (in the press).
[2] Hirono, I., *Proc. Soc. Exp. Biol. and Med.*, 88, 147 (1955); *Nature*, 176, 1168 (1955).
[3] Hirono, I., and Yokoyama, O., *Cytologia*, 20, 84 (1955).
[4] Torigoe, M., *Pharm. Bull.*, 1, 349 (1953).
[5] Ishidate, M., *Gann*, 47, 431 (1956).
[6] Weissman, N., Schoenbach, E. B., and Armistead, E. B., *J. Biol. Chem.*, 187, 153 (1950).
[7] Goldzieher, J. W., Rawls, W. B., and Goldzieher, M. A., *J. Biol. Chem.*, 203, 519 (1953).

Enhanced Resistance of Mice to Infection with *Pasteurella pestis* following Vaccination with Fractions of Phenol-killed Tubercle Bacilli

THE growing recognition that the immunological responses initiated by certain micro-organisms are not necessarily limited in their scope, but may be manifested towards taxonomically and antigenically heterologous organisms[1], raises the question of whether many states of specifically acquired immunity rest entirely on specific mechanisms. The increased resistance which accrues to survivors of a first infection, or which follows a specific immunization procedure, may not always be based on specific immunological reactions, that is, those involving antibody or tissue hypersensitivity, but may result from the same non-specific effects which underlie the development of heterologously orientated changes in immunity.

This may be true not only of diseases immunity to which has never been proved to be associated with a classical immune response, but also of those where heightened resistance is accompanied predictably by the formation of antibody: the antibody response may be incidental to, not causative of, the acquisition of the immunity. An analysis of the area and mechanisms of the non-specific immunological abilities of a micro-organism may therefore contribute as well to an understanding of its homologously directed activity.

Such a comparative approach to the problem of the mode of action of specifically acquired immunities requires a determination of whether the microbial moieties responsible for the homologous effects are the same as, or distinct from, those exerting an immunological influence of wider implication. In the course of a study of the mechanisms of acquired resistance to tuberculosis, an investigation was accordingly undertaken to ascertain whether fractions of the tubercle bacillus which show homologous immunogenicity are related to those reported to affect resistance to other diseases[2,3].

Table 1

Vaccine	No. of animals per group	Deaths* on following days after *Pasteurella* infection: 4	5	6	7	8	9	12	13	14	15	No of survivors†
Methanol extract, in saline	10	0	0	0	2	0	0	4	0	0	0	4 of 10
Methanol extract, in adjuvant	13	0	0	0	1	0	1	0	0	0	1	10 of 13
Saline (control)	18	0	3	4	6	2	1	1	0	0	0	1 of 18

* All animals dying after infection were found to have extensive lesions of the spleen, liver and mesenteric nodes.

† All animals surviving past the fifteenth day appeared normal; experiment terminated on twentieth day.

Initial experiments were designed to establish the range of experimental infections of laboratory animals which could be influenced by previous vaccination with components of chemically killed tubercle bacilli. Early in the course of this investigation it was found that certain crude fractions which have been shown capable of enhancing the resistance of mice and guinea pigs to tuberculous infection[4,5] bestow a marked degree of heightened resistance on mice against infection with a strain of *P. pestis*, *EV* 76[6,7]. Also of interest was the observation that, unlike many of the hitherto reported instances of non-specific resistance to infections, this immunity was still discernible even when the experimental *Pasteurella* infection occurred some weeks or months after vaccination with tubercle bacillus substances. This communication reports on two experiments illustrating these findings.

Experiment 1. Groups of Swiss albino mice (Rockefeller strain) were injected intraperitoneally with 1·0 mgm. quantities of a crude methanol-soluble extract of phenolized bacilli of the *B.C.G.* strain[5], suspended in saline or in incomplete Freund's adjuvant. Two months later, these animals, and a saline-injected control group, were given an intraperitoneal injection of 1 × 10⁷ living organisms of the *EV* 76 strain of *P. pestis*. The post-infection survival time of the animals is shown in Table 1.

Experiment 2. Groups of mice received intraperitoneal injections of one of the following, in 0·5 c.c. quantities: distilled water; a young 'Tween'-albumin culture of the *B.C.G.*-Phipps strain; 1·0 mgm. of the bacterial residue of a methanol extraction of phenolized *B.C.G.* organisms. Three weeks later, the animals were challenged by the intraperitoneal route with 3 × 10⁷ organisms of the *Pasteurella* strain. The post-infection survival-time of the animals is shown in Table 2.

The lower degree of survival protection bestowed by living *B.C.G.* and extraction residue does not necessarily indicate their inferiority *vis-à-vis* methanol extract in initiating this non-specific immunity, but might be accounted for by the larger challenge dose, or by the shorter vaccination-challenge interval, in the second experiment.

Table 2

Vaccine	No. of animals per group	Deaths* on following days after *Pasteurella* infection: 3	4	5	6	7	8	11	12	13	14	15	No. of survivors†
Extraction residue	23	0	4	3	3	2	0	1	1	2	0	0	7 of 23
Living *B.C.G.*	21	0	8	2	3	1	0	1	2	0	0	0	4 of 21
Distilled water (control)	22	0	19	0	1	0	0	0	0	0	0	0	2 of 22

* All animals dying after infection were found to have extensive lesions of the spleen, liver and mesenteric nodes.

† All animals surviving beyond the fifteenth day appeared normal; experiment terminated on twentieth day.

More extensive experiments on the extent and conditions of the effects of substances derived from tubercle bacilli on the resistance of laboratory animals to other infections, and to tumour transplants, are now in progress, and will be reported in detail elsewhere.

I wish to acknowledge the help of Mr. Salvatore Margherita in certain phases of this work.

DAVID W. WEISS

Department of Bacteriology,
University of California,
Berkeley 4,
California.

[1] Shilo, M., "Ann. Rev. Microbiol.", 13, 255 (1959).

[2] Dubos, R. J., and Schaedler, R. W., *J. Exp. Med.*, 106, 703 (1957).

[3] Schaedler, R. W., and Dubos, R. J., *J. Exp. Med.*, 106, 719 (1957).

[4] Weiss, D. W., and Wells, A. Q., *Amer. Rev. Tuberc* (in the press).

[5] Weiss, D. W., and Wells, A. Q., *Amer. Rev. Tuberc.* (in the press).

[6] It has been reported previously that tuberculous and leprous diseases confer resistance on man and on laboratory animals against plague infection (Girard, G., and Grumbach, F., *C.R. Soc. Biol., Paris*, 152, 280 (1958); Rep. Internat. Plague Conf., Mukden, 1911).

[7] The *EV* 76 strain of *P. pestis* is relatively avirulent (Walker, D. L., *et al.*, *J. Immunol.*, 70, 245 (1953)), but kills mice when given in large numbers.

Zinc Sulphate Treatment of Parakeratosis in Cattle

UNDERWOOD[1], discussing the nutritional significance of trace elements, states "zinc deficiency has never been observed in man or in farm stock, under either naturally occurring or experimental conditions. It seems very unlikely that such a deficiency could ever arise in grazing or stall fed sheep or cattle, because of the normal high content of zinc in plant materials". Symptoms indicating zinc deficiency conditioned by high dietary calcium have, however, been reported in pigs.

During the period 1957–59 we have observed, in cattle on the Berbice savannahs, lesions closely resembling those described in rats fed on diets deficient in zinc. In the more acute cases, parakeratosis spreads rapidly over about 40 per cent of the body surface. The following areas are affected, usually in the order given: muzzle (except when this is black in colour), vulva, anus, top of tail, ears, back of hind limbs, 'knee fold', flanks and neck. On this Station, these symptoms have occurred seasonally, namely, March–June; during this period in 1958 there were about six cases, and in 1959 upwards of twenty among 1,000 cattle. The over-all body condition of cows affected has been generally below average; yearlings have shown little or no live-weight gains for some months whereas very young calves have been otherwise normal. The stock affected, other than the young calves, have been born and reared under range conditions; the soils are poor and sandy. Some of the yearlings had been transferred to planted, fertilized pastures of pangola grass (*Digitaria decumbens*), 2–4 weeks before symptoms were observed.

During April and May 1959 some affected animals have been given zinc sulphate either orally (2 gm./

week) or by injection (1 gm./week); similar animals kept as controls have been treated later. The skin of two cows and four yearlings treated early showed new hair growth one week after treatment commenced, and were normal after three weeks, while three cows and one yearling untreated for periods ranging from 2 to 8 weeks deteriorated during this period, but again, after treatment, recovery was rapid. In one yearling which finally became weak and had to be destroyed, the skin condition responded to zinc administration. On June 23, one cow with a newly born calf and seven in-calf cows were removed from Range 2, where most cases had occurred, to pangola grass pastures. This calf and four others born to the cows during June all shed the bulk of the hair from large areas of the body; this was accompanied by hyperkeratinization along the mid line of the back. The hair and skin rapidly returned to normal after oral administration of zinc sulphate. The dams of these calves showed no lesions nor were there any cases among other calves born on these pastures during the same period. Two of the cows moved from the Range on June 23 calved during July and August; one had quite normal hair and skin and the other only very slight parakeratosis.

In pot trials on these soils in which the plant grown had been the tomato, growth responses have been obtained from the application of zinc (Spector, J., private communication). The zinc content of various grass species is given in Table 1. The plant material, collected after the first cases of parakeratosis were observed, consisted of leaf cut about 1 in. above ground-level.

Table 1. Zinc Content of Grass Samples collected at Ebini, 1959

Date collected	Description of pasture	Species	Zinc content (p.p.m. of D.M.)
May 14	Fertilized pasture No. 15	Pangola (*Digitaria decumbens*)	34
June 11	,,	,,	42
June 27	,,	,,	42
June 13	Fertilized pasture No. 16	,,	30
June 27	,,	,,	38
May 16	Range 2	*Trachypogon polymorphus*	22
June 26	,,	,,	18
June 28	Range 12	,,	20
May 15	Range 2	*Axonopus strogalus*	26
June 26	,,	,,	28
June 28	Range 12	,,	36

Radiochemical balance studies indicate that the absorption of zinc from the alimentary tract in steers is not greater than 50 per cent[3]. These absorption studies and the low zinc content of the fibrous *Trachypogon* indicate that cattle in these conditions may not always receive adequate zinc in the diet. Our observations add support to this view.

We are indebted to the Director of Agriculture, Georgetown, for the facilities for making these observations and to Dr. H. Evans of Bookers Sugar Estates, Ltd., for carrying out the zinc assays.

S. P. Legg
L. Sears

Ebini Livestock Station,
Berbice River,
British Guiana.

---

[1] Underwood, E. J., "Trace Elements in Human and Animal Nutrition" (Academic Press, Inc., 1956).

[2] Tucker, H. F., and Salmon, W. B., *Proc. Soc. Exp. Biol. N.Y.*, 88, 163 (1955).

[3] Feaster, J. P., Hansard, S. L., McCall, J. T., Skipper, F. H., and Davis, G. K., *J. Anim. Sci.*, 13, 781 (1954).

RADIOBIOLOGY

The Sigmoid Survival Curve in Radiobiology

A strictly exponential form of survival curve is much more rarely encountered in radiobiology than might be supposed from statements sometimes made. The form of survival curve illustrated by Fig. 1 (which would be sigmoid on a linear plot) has been established, with varying degrees of accuracy, for many single-cell populations, ranging from bacteria to mammalian cells.

It has become common practice to describe such curves as 'multihit' or 'multiple-target' curves; and to regard the existence of the initial shoulder as inevitably implying the existence of a 'multiplicity' or 'target-number' or 'hit-number' of discrete morphological sites or entities, the number of which may be determined by extrapolating the exponential portion of the curve back to zero dose and measuring the intercept on the ordinate plotted on a logarithmic scale. While it is useful to have a name for the number so derived, we consider that those commonly used carry an unjustifiable implication as to the mechanism of radiation damage to cells. This has become particularly undesirable in view of recent work which has shown that this number may in some cases depend, over a wide range, on conditions imposed after irradiation[1-3]. Conditions before irradiation have long been known to produce such changes in survival curves[4], and it may be that in such cases the change in 'multiplicity' of the survival curve corresponds to a real morphological change in the cell. But when cells irradiated as one population demonstrate survival curves with different 'multiplicities', depending on how they are treated after irradiation, the concept that such curves imply a multiple number of discrete morphological sites becomes very strained.

We propose, therefore, in our future publications to use the term 'extrapolation number' to refer to the intercept e, or the ratio e', shown in Fig. 1. We do

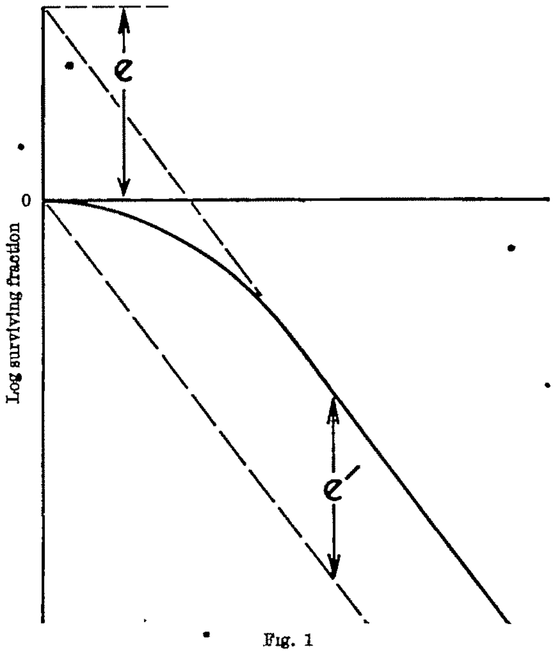


Fig. 1

not abandon the postulate that this number may refer to a multiplicity of some sort, and we concede that in some instances it may be identifiable with a number of specific morphological entities[5]; but we would suggest that the number in question should be referred to as a 'target' or 'hit' number only when such identification can be made.

TIKVAH ALPER
N. E. GILLIES

Medical Research Council
Experimental Radiopathology Research Unit,
Hammersmith Hospital,
London, W.12.

M. M. ELKIND

National Cancer Institute,
U.S. Public Health Service,
Bethesda 14,
Maryland.

[1] Elkind, M. M., and Sutton, H., *Nature*, **184**, 1298 (1959).

[2] Alper, T., and Gillies, N. E., *J. Gen. Microbiol.*, **22**, 113 (1960).

[3] Alper, T., in "Mechanisms in Radiobiology", edit. by Forssberg, A., and Errera, M. (Academic Press, New York) (in the press).

[4] Hollaender, A., Stapleton, G. E., and Martin, F. L., *Nature*, **167**, 103 (1951).

[5] Munson, R. J., and Maclean, F. I. (in preparation).

An Assessment of the Quantities of Fission Products likely to be found in Milk in the Event of Aerial Contamination of Agricultural Land

THERE is considerable evidence that the most widespread hazard which could result from the deposition of fission products on agricultural land would be the contamination of milk with the isotopes of iodine and strontium[1]: other fission products which might in certain circumstances contribute to this hazard are barium-140 and cæsium-137.

In the initial period after the release of fission products the first information on the extent of deposition which is likely to be available will be the results of gamma monitoring, from which the deposition per unit area of land can be estimated on the basis of an assumed composition of the released material. It is therefore of considerable practical importance to consider the relationships which may occur between the quantity of radioactivity deposited per unit area after a single incident and the level in the milk.

The transfer of certain fission products from the diet of cows to their milk has been studied experimentally in this laboratory: results are now available from 28 experiments with iodine-131 on 20 animals, 16 experiments with strontium-89 on 12 animals, 5 experiments with barium-140 on 5 animals, and 4 experiments with tellurium-132 on 3 animals. Preliminary accounts of part of this work have been given[2,3] and detailed reports will be published elsewhere. Studies with cæsium-137 have not been made, but results from experiments on 5 animals are available in the literature[4].

Under field conditions the extent to which fission products deposited upon grazing land will enter milk may vary greatly depending upon many factors including: (1) the extent to which the deposited material is initially retained on edible herbage; (2) the extent to which the initially contaminated herbage is 'diluted' with new growth; (3) the extent to which the fission products are removed by rain from the edible tissues; (4) the method of animal management.

In order to make some estimate from the experimental data of the maximum level of contamination in milk likely to be encountered in the field, the following conditions have been assumed: (*a*) that 25 per cent of the deposited material is initially retained on edible herbage; (*b*) that the activity on herbage decreases only as a result of the decay of radioactivity; (*c*) that animals have unrestricted access to grazing and receive no supplementary food; (*d*) that animals consume 20 lb. dry matter a day and that the yield of edible herbage is 500 lb. dry matter per acre. Estimated values for levels in milk following continuous grazing for 21 days when the initial total deposition of individual fission products from a single incident is 1 $\mu c./m.^2$ are given in Table 1.

The assumptions made are considered to represent the worst case likely to occur under conditions of British agriculture. There are many factors which, in normal circumstances, would probably reduce the quantity of fission products transferred to milk. Thus the combined effect of the growth of new grass and the removal of activity from edible herbage by rain should normally cause the extent of contamination of herbage, and hence the contamination of milk, to fall considerably more rapidly than is suggested in Table 1. Further, should an accident occur at a time when grazing is poor, derivation of most of the food from uncontaminated supplementary feeding-stuffs would considerably reduce the animals' intake of fission products. However, mitigating factors of this kind cannot be predicted, and hence no allowances can be made for them in the early stages after an accident. The figures given are therefore put forward as being of value in the preliminary planning of control measures following the release of radioactivity: any steps to be taken thereafter must be based upon measurements made upon the milk itself.

Table 1. ESTIMATED ACTIVITY IN MILK ($\mu c./l.$) FOLLOWING AN INITIAL TOTAL DEPOSITION OF 1 $\mu c./m.^2$

Days after deposition	Iodine-131	Iodine-133	Tellurium-132	Strontium-89	Strontium-90	Barium-140	Cæsium-137
1	0·12	0·060	0·0029	0·006	0·006	0·0028	0·01
2	0·16	0·038	0·0072	0·014	0·015	0·0058	0·06
3	0·16	0·019	0·0090	0·020	0·021	0·0075	0·14
4	0·15	0·009	0·0090	0·023	0·025	0·0085	0·21
5	0·15	0·004	0·0082	0·025	0·027	0·0090	0·26
6	0·14	0·002	0·0071	0·026	0·028	0·0092	0·29
7	0·13	0·001	0·0059	0·027	0·029	0·0092	0·32
8	0·12	—	0·0049	0·027	0·030	0·0091	0·35
9	0·11	—	0·0040	0·027	0·030	0·0089	0·36
10	0·10	—	0·0033	0·027	0·030	0·0086	0·39
21	0·04	—	—	0·023	0·031	0·0049	0·48

I wish to thank the staff of the Agricultural Research Council Radiobiological Laboratory, Letcombe Regis, for allowing the use of the results of early experiments.

R. J. GARNER

Radiobiological Laboratory,
Agricultural Research Council Field Station,
Compton,
Berkshire.

[1] Medical Research Council, Committee on Protection against Ionizing Radiations, *Brit. Med. J.*, 1, 967 (1959).

[2] Squire, H. M., Middleton, L. J., Sansom, B. F., and Coid, C. R., "Radioisotopes in Scientific Research", **4**, 207 (Pergamon Press, London, 1958).

[3] Garner, R. J., and Sansom, B. F., *Vet. Rec.*, **71**, 670 (1959).

[4] Ilin, D. I., and Moskalev, Y. I., *Atomnaya Energiya*, **2**, No. 2, 163 (1957).

Inability of Methionine to affect Lethality in Mice and Rats exposed to X-Rays

NERURKAR *et al.*[1] have shown that administration of methionine either before or after X-irradiation decreases the damage caused to nucleic acid synthesis in irradiated rats. Post-irradiation administration of methionine appears to be more effective. Other assays have shown a lower increase in nitrogen, uric acid and in creatinine excretion in irradiated rats injected with methionine after irradiation[2]. The increase in uric acid excretion suggests excessive breakdown of nucleic acids as a result of cellular destruction. Treatment with methionine also results in a beneficial influence on the rate of growth after irradiation.

The present communication shows that the administration of methionine, apparently effective in slowing down the fall in nucleic acid levels caused by a single exposure to ionizing radiations, affords no decrease in the mortality of mice (*C*57 black) and rats (Wistar albino) irradiated with 700 or 800 r. of X-rays.

220 male black *C*57 mice, weighing 20–25 gm., were divided into eight groups. Each irradiated group consisted of fifteen controls injected intraperitoneally with 0·9 per cent sodium chloride and fifteen animals injected intraperitoneally with an aqueous solution of L-methionine (Sigma) (5 mgm., 25 mgm., and 250 mgm./kgm.) 5 min. before or 30 min. after irradiation respectively. One irradiated group received one injection 30 min. after irradiation and two daily injections of methionine (5 mgm./kgm.) during the five days following irradiation. A control group, injected with methionine (250 mgm./kgm.), was not irradiated.

Table 1. EFFECT OF INTRAPERITONEAL INJECTION OF L-METHIONINE BEFORE AND AFTER TOTAL-BODY X-IRRADIATION OF 700 R. ON MORTALITY MOUSE BLACK *C*57 STRAIN.
kV., 200; m.amp., 20; d.f., 42 cm., 0·5 copper; dosage-rate, 84 r./min. in air

Dose of L-methionine	No. of animals	Total mortality at 15 days (per cent)	Average time of survival (in days) ± *S.D.*
Methionine 5 min before 700 r.			
Controls	15	100	8 00(±2 17)
5 mgm./kgm.	15	100	8 33(±2 16)
Controls	15	100	8 93(±1·39)
25 mgm./kgm.	15	100	10 06(±1 58)
Controls	15	100	9·33(±2·41)
250 mgm /kgm.	15	100	8 60(±2 29)
Methionine 30 min. after 700 r			
Controls	15	100	7 60(±3 34)
5 mgm./kgm.	15	100	6·80(±1·22)
Controls	15	100	8 06(±1 87)
25 mgm./kgm.	15	100	7 20(±2 78)
Controls	15	100	7·69(±2 23)
250 mgm./kgm.	15	100	8 06(±2 52)
Chronic treatment			
Controls	15	100	8 40(±1 88)
5 mgm./kgm. × 11	15	100	7·13(±1 60)

Methionine does not significantly affect the mortality after irradiation ($P < 0\ 01$).

Table 2. EFFECT OF INTRAPERITONEAL INJECTION OF METHIONINE (5 MGM./KGM.) AFTER A SINGLE TOTAL-BODY X-IRRADIATION OF 800 R. ON MORTALITY MALE WISTAR ALBINO RATS.
(kV., 200; m.amp., 20, d.f., 55 cm., 0 5 copper; dose-rate, 50 r./min. in air

Dose of methionine	No. of animals	Total mortality at 30 days (per cent)	Average time of survival (in days) ± *S.D.*
Controls	30	96·6	8·16(±4·70)
5 mgm./kgm.	30	100	8 96(±4·55)

Methionine does not affect significantly the mortality after irradiation ($P < 0\ 01$).

Sixty male Wistar rats, weighing 175–225 gm., were divided into two groups of thirty animals each. The first group served as control and received an intraperitoneal injection of 0·9 per cent sodium chloride; the second group, an injection of L-methionine 30 min. after a total-body X-irradiation of 800 r.

Physical factors of irradiation are given in Tables 1 and 2. All the mice irradiated with 700 r. and 96 per cent of rats irradiated with 800 r. died between the fourth and fifteenth days after irradiation. The same mortality was observed in the groups treated with methionine before or after irradiation (Tables 1 and 2). L-Methionine is not toxic, at the above-mentioned doses, to our mice or rats. In previous investigations, Bacq *et al.*[3] have observed that methionine does not protect mice against X-irradiation. The present results confirm these findings.

According to Nerurkar *et al.*[1,4] there is after irradiation a lack of available methionine, and the injection of methionine should help the restoration of the nucleic acid-synthesizing mechanism. But, in our opinion, this effect of methionine is not sufficiently important to affect the mortality.

ZENON M. BACQ
MARIE L. BEAUMARIAGE

Département de Pathologie générale,
Institut Interuniversitaire des Sciences
Nucléaires, Belgique.

[1] Nerurkar, M. K., Baxi, A. J., Ranadive, N. S., Nerurkar, M. V., and Sahasrabudhe, M. B., *Nature*, **180**, 193 (1957).

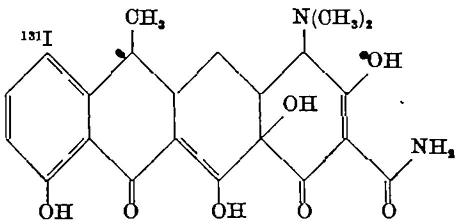
[2] Nerurkar, M. K., Baxi, A. J., and Sahasrabudhe, M. B., *J. Sci. Indust. Res.*, **16**, C, 175 (1957).

[3] Bacq, Z. M., and Alexander, P., "Fundamentals of Radiobiology" (Butterworth, London, 1960) (in the press).

[4] Sahasrabudhe, M. B., Proc. Second U.N. Internat. Conf. Peaceful Uses Atomic Energy, Geneva, **23**, 94 (1958).

Radioactive 7-Iodo-6-Deoxytetracycline in Tumour Tissue

THE observation[1,2] that several of the tetracyclines are localized in various tumour tissues for prolonged periods of time suggested the possible utility of a tetracycline labelled with iodine-131 in the detection of neoplastic disease by the use of external body-scanning techniques. In a recent communication[3] from this Laboratory, the preparation of 7-iodo-6-deoxytetracycline was described; this was the first report of an iodotetracycline of unequivocal chemical structure. A labelled iodo (131) derivative was prepared by essentially the same method, by the reaction of N-iodosuccinimide[4] (^{131}I) and 6-deoxytetracycline in concentrated sulphuric acid:



The radioactive preparation was administered intravenously at a dose of 15 mgm./kgm. to dogs that had well-developed, spontaneous mammary tumours. The level of radioactivity at marked areas on selected portions of the dog was then determined at various intervals of time.

Some of these results are shown in Fig. 1. It can be seen that in the first three hours there is a pronounced difference in the degree of radioactivity in the areas of the various organs and tissues. The area over the liver gave the highest reading, followed by the tumour and kidney. The muscle and skeletal readings were considerably lower than that of the tumour tissue.

The differences in the radioactivity after 24 hr. were much less pronounced, and some considerable changes appeared in the relative ranking of the various areas measured.

There appeared to be no preferential retention of radioactivity in the tumour during a period of 24 hr.–6 days, but some small preferential retention was noted in the thyroid region. Although it has been shown that some of the other tetracyclines are not metabolized by animals[5], it is possible that de-iodination *in vivo* may have occurred to some small extent, and any iodide liberated would be taken up by the thyroid.

Other areas surveyed, but not shown in Fig. 1, include the occipital bone, last sacral, mid-shoulder back, knees and thyroid. During the first three hours, the level of radioactivity for these locations was generally less than that of the thigh muscle.

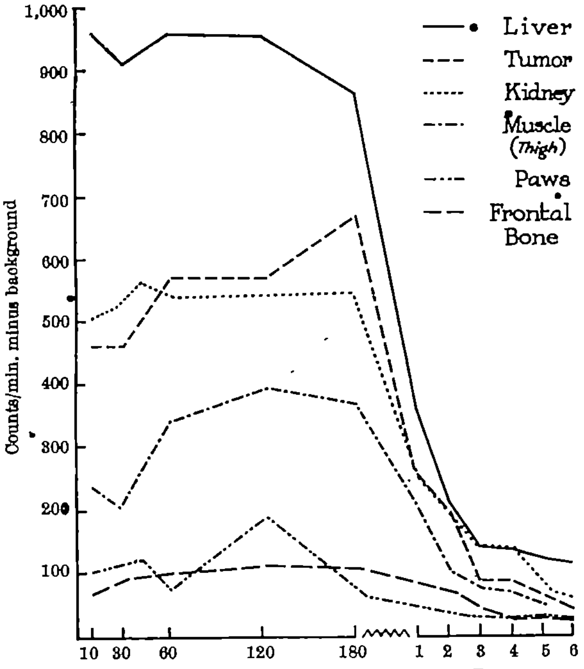


Fig. 1

Direct radiometric readings were made on various tissues removed from a dog (with a mammary tumour) 10 min. after an intravenous administration of the radiolabelled compound. As was expected in this short period, the liver, kidney, spleen and blood contained the highest levels of radioactivity. However, the tumour contained three or four times the counts per minute per milligram of muscle or bone. Healthy tissue, adjacent to and more highly vascularized than that of the tumour, contained only one-half of the radioactivity, on a counts per mm./mgm. basis, of the tumour. The iodotetracycline has also been studied in mice containing spontaneous mammary tumours, but no pronounced selective localization or retention was found with this type of tumour.

Although the biological work with this compound is in an early development stage, it appears that the differential localization of 7-iodo-6-deoxytetracycline in tumour tissue, relative to that of other tissue, may be sufficient to allow the use of this compound as a diagnostic aid in the location of cancerous growths.

A therapeutic application by the internal irradiation of selected tissues, either with a tetracycline derivative containing a pre-formed radioisotope, or by the induction of irradiation by a procedure such as neutron activation, is a possibility but will require much additional work.

We thank Dr. J. H. Boothe, Dr. A. W. Vogel and Dr. S. Kushner for their helpful suggestions, and Mr. D. Colucci for technical assistance.

JOSEPH J. HLAVKA
DONALD A. BUYSKE

Organic Chemical Research Section,
Experimental Therapeutics Research Section,
Lederle Laboratories Division,
American Cyanamid Company,
Pearl River, New York.

[1] Rall, D. P., Loo, T. L., Lane, M., and Kelley, M. G., *J. Nat. Cancer Inst.*, 19, 79 (1957).

[2] Loo, T. L., Titus, E. D., and Rall, D. P., *Science*, 126, 258 (1957).

[3] Boothe, J., Hlavka, J., Petisi, J., and Spencer, J., *J. Amer. Chem. Soc.*, 82, 1253 (1960).

[4] The N-iodosuccinimide (^{131}I) was prepared by a modification of the method of Djerassi, C., *J. Amer. Chem. Soc.*, 75, 3494 (1953), using radioiodine and N-silversuccinimide.

[5] Kelly, R., and Buyske, D. A., *J. Pharm. and Exp. Therap.* (in the press).

BIOLOGY

Dependence of the Sex Ratio at Birth on the Age of the Father

SZILARD's conjecture about the effect of paternal age on the sex ratio, which his figures for man support[1], might perhaps be capable of further confirmation in horses. Unlike the ages of man and wife, those of mare and stallion are uncorrelated, and both are commonly bred into old age. I investigated the effects of paternal age on foal longevity[2], which is also germane to Szilard's theory, and found no appreciable decline in the vigour of the fillies of old stallions, judged by life-spans in the "General Stud Book"—no records of colt longevity are available. My material gives some figures for the sex ratio, though the numbers are too small to do more than suggest the absence of any gross age effect. The ratio of males to females was exactly 100·00 for the

446 live progeny born during 1885–96 of a group of stallions known to be more than twenty years old at covering, against 100·47 for all foals in the same period. Masculinity in thoroughbred horses is less than in man, and the ratio has been reasonably stable for a century or more (1853–68 $R = 100 \cdot 32$; 1869–80 $R = 99 \cdot 18$; 1885–96 $R = 100 \cdot 47$; 1925–40 $R = 99 \cdot 31$).

We may attempt to predict the expected change in R for thoroughbreds if Szilard's assumptions hold good. Their last decile survival is reached at about 30 years against 90 in man, but the proportionate 'weight' of the Y chromosome will be less, since for horses $2n = 66$, say 1·4 per cent. Other things being equal the change in the value of R would therefore be about 2·8 per decade, approaching $R = 106$ per cent for stallions more than twenty years of age. A difference of this order could probably be detected from siring records, and this appears worth attempting in spite of the number and variety of the other numerical assumptions which Szilard's theory requires.

A. COMFORT

Department of Zoology,
University College,
London, W.C.1.

---

[1] Szilard, L., *Nature*, **186**, 649 (1960).

[2] Comfort, A., *J. Geront.*, **13**, 342 (1958).

[3] Szilard, L., *Proc. U.S. Nat. Acad. Sci.*, **45**, 30 (1959).

Purification of a Specific Inducer of the Male Sex Organ in Certain Fern Species

A NATURALLY occurring, highly specific substance has been found which induces vegetative cells of gametophytes of certain fern species to differentiate and organize the male sex organ or antheridium. Döpp[1] showed that a water extract of mature prothalli of the common bracken fern *Pteridium aquilinum* hastened the formation of antheridia in young prothalli of this and of another fern species. He was inclined to interpret his findings to indicate that antheridia were initiated by way of non-specific growth inhibition. Naf[2] reported that the promotion of antheridium formation by the extract was due to a specific antheridium-inducing factor rather than to non-specific growth inhibition. The biologically active factor was found to induce antheridium formation in representatives of 7 of the 9 sub-groups of the family Polypodiaceae listed by Eames[3] as well as in *Dennstaedtia punctilobula*, a member of the family Dicksoniaceae[4]. It appeared likely, therefore, that a relatively simple chemical substance is capable of directing morphogenesis in a highly specific way. In view of its unique properties, an attempt was made to isolate and characterize chemically the biologically active material. The present report describes a procedure for the purification of this substance.

Quantities of antheridium-inducing factor for chemical isolation were obtained batchwise by seeding 1,000 125-ml. Erlenmeyer flasks containing 33 ml. of Moore's synthetic medium with sterile spores of *Pteridium aquilinum*. The cultures were grown under continuous illumination for a period of 7 weeks. Using this procedure, about 30 l. of culture filtrate with a dilution end-point of about 1 : 10,000 were obtained from most batches.

The progress of the isolation of the biologically active substance was followed using young gametophytes of the sensitive fern *Onoclea sensibilis* as the test object according to the assay method described by Näf[2]. Prothalli of this species failed to form antheridia spontaneously under the conditions of culture employed, but produced numerous antheridia after exposure to the biologically active factor. This made it possible to test with certainty the antheridium-inducing activity of any preparation.

The 30 l. of culture filtrate used as starting material for each isolation contained about 1 mgm. of solids per ml. This solution was concentrated *in vacuo* in a circulating evaporator, below 45° C., to a volume of 1 litre and stirred at room temperature for 1 hr. under nitrogen with 10 gm. of 'Norite *A*' which had been boiled with dilute acetic acid and washed with boiling water. This treatment removed more than 99 per cent of the activity from the concentrated culture filtrate. The charcoal was removed by filtration, washed twice with 500 ml. of water, and the washings discarded. The active material was eluted from the charcoal by stirring for 15 min. with 100 ml. of methanol. No more activity was removed after three such treatments. 10 µgm. of material obtained in this way induced antheridium formation at a maximum dilution of 1 : 4,000, representing a fortyfold increase in activity over the original culture filtrate.

The combined methanol eluates were concentrated *in vacuo* to remove methanol and made up to a volume of 50 ml. with ice-cold 0·01 M phosphate–citrate buffer adjusted to pH 7·2. This solution was extracted three times with cold ethyl acetate, removing inert material amounting to about 40 per cent of the dry weight of the methanol eluate. The pH of the cold buffer solution was lowered to 5·1 with hydrochloric acid, and the active material was removed by extracting three times with ethyl acetate. This fraction contained about 20 per cent of the dry weight of the methanol eluate and all the antheridium-inducing activity. 10 µgm. induced antheridium formation at a maximum dilution of 1 : 20,000, representing two-hundredfold increase in activity over the original culture filtrate. An average yield of 3 mgm. was obtained from 30 l. of culture filtrate.

Final purification was made by concentrating the ethyl acetate extracts to a small volume and subjecting the material to a 50-tube counter-current distribution between normal butanol and 5 per cent ammonium acetate buffer pH 6·65. Almost all the activity was distributed as a single peak with a maximum in tube 23. An exact quantitative determination of activity was difficult since more than one-half of the starting weight remained in the first three tubes or migrated completely into the last four or five tubes of the series. A very small amount of activity was also found in the last few tubes. When tubes 19 and 32 of this series were redistributed in the same solvent system, only a single peak of activity was found with a maximum in tube 23, in each case. Thus, the active material purified in this way appeared to be homogeneous. Because of the difficulty of weighing the tiny quantities obtained, it was not possible to determine the specific activity on a dry-weight basis. However, it was apparent that this purified material would induce antheridium formation in *Onoclea sensibilis* at a concentration of less than 1 part in 10,000,000,000 (10^{-4} µgm. per ml.).

As indicated by the manipulations used in the isolation procedure, the antheridium-inducing factor behaves as a weak acid. It is relatively stable in acid solution, but is readily inactivated at pH above 7. It is also readily inactivated by oxidizing agents, and dry preparations quickly darken and lose activity on exposure to air. The factor is readily soluble in a number of alcohols and esters, slightly soluble in ethers, and relatively insoluble in aliphatic and aromatic hydrocarbons or chlorinated aliphatic hydrocarbons. Activity is strongly adsorbed on activated alumina from alcohol solutions, from which it can be partially eluted by glacial acetic acid. The factor can be chromatographed on filter paper in a variety of alcohol/water solvent systems. Good resolution was obtained in descending chromatography on Whatman filter paper No. 1, using (1 : 4) *iso*propanol/water, where the factor has an $R_F = 0 \cdot 8$.

It is not possible at the present point in this investigation to state that antheridium-inducing factors other than that described here are not present in the culture filtrate or gametophytes of *Pteridium aquilinum*. However, it is clear that a single, homogeneous, relatively simple chemical substance is capable, at extremely low concentration, of directing cellular differentiation and organization. Studies on the chemical constitution of the antheridium-inducing factor described here will be continued.

This work was supported in part by a research grant (NSF Grant No. *G*-6144) from the National Science Foundation.

ROSS B. PRINGLE
ULRICH NÄF
ARMIN C. BRAUN

The Rockefeller Institute,
New York 21, New York.

Feb. 1.

---

[1] Dopp, W., *Ber. deut. bot. Gesell.*, 63, 139 (1950).

[2] Näf, U., *Growth*, 20, 91 (1956).

[3] Eames, A. J., "Morphology of Vascular Plants. Lower Groups" (McGraw-Hill, New York and London, 1936).

[4] Näf, U., *Nature*, 184, 798 (1959).

Manganese Toxicity in *Grevillea robusta*

Grevillea robusta A. Cunn. is commonly grown as a shade tree in East African tea plantations. Seedlings are usually raised in nurseries and transplanted to the field when about 4 in. high. Failure of the plants has been reported when they are transplanted into the red, highly acid soils characteristic of some tea areas, of which the *p*H may be as low as 4·2.

Some such seedlings, which had died within three weeks of transplanting, were sent for examination from a Kericho estate. Two specimens (on the dry-weight of leaf plus stem) contained 1,940 and > 4,000 p.p.m. of manganese respectively, and those of a healthy seedling had 880 p.p.m.

On another estate, *Grevillea* seeds had been nursery planted, some in a red soil (*p*H 4·6) and others in a less-acid soil (*p*H 5·4). Seedlings from the former soon died (dry weight of the aerial portion of the plants about 0·05 gm.), and one specimen had a manganese content of 3,650 p.p.m., while a healthy plant from the less-acid soil had 262 p.p.m. of dry weight.

Local applications of basic slag were recommended when transplanting into acid soil. F. Haworth[1] notes that in Ceylon basket plants of *G. robusta* and *Albizia moluccana* are potted in a soil limed to a *p*H value of between 6·0 and 7·0.

R. CHILD
A. N. SMITH

Tea Research Institute of East Africa,
Kericho, Kenya.

---

[1] Haworth, F., *Tea Quarterly*, 23, 114 (1952).

Monoxenic Cultivation of an Enchytræid Annelid

A CULTURE of *Enchytræus fragmentosus* Bell, 1959 [1], was kindly sent us by Prof. A. W. Bell of Los Angeles City College in May 1959. We have been able to grow it without difficulty since that date, on rolled oats kept on moistened filter paper, and can now report success in putting it into monoxenic culture (that is, growing in the presence of a single species of associated organism—in this instance *Escherichia coli*).

A single specimen of *E. fragmentosus* from a xenic culture (that is, growing in the presence of a mixed microbial flora) was transferred to a Petri dish of 'Difco Nutrient Agar' previously seeded with enough *E. coli* to yield a thin continuous bacterial layer. It was allowed to migrate there and, on an average of every other day over a period of a month, was transferred to a fresh Petri dish of agar and *E. coli*. The track of the worm during each stay could be readily seen; it is thus possible to say that, because of its relatively sluggish movement under the conditions described, it seldom looped back over its path. Only after the thirteenth transfer (one month) was it found to have fragmented into several pieces. This long period without fragmentation suggested a nutritionally unfavourable state. Three short pieces were then put on to a single agar slant streaked with *E. coli*, where they grew into long worms within two weeks. A subculture was next made with one worm, followed by additional fragmentation into two.

Repeated bacteriological checks of both slants revealed only *E. coli*. We can therefore conclude that the original worm was effectively monoxenized merely by migrating for an extended period in successive thin layers of *E. coli* growing on nutrient agar.

Subsequent work has shown that nutrient agar with *E. coli* is not satisfactory by itself for indefinite subculture of *E. fragmentosus*. But grains of autoclaved rolled oats dropped on the surface of the slant provide for continued vigorous growth, and the combination so established appears satisfactory for indefinite monoxenic cultivation of the annelid.

More recently we have sometimes found it possible to axenize *E. fragmentosus* directly from xenic culture by a method based on that applied to the planarian *Dugesia dorotocephala* by Miller and Johnson[2]. In one instance, after three days of washing about 40 worms in initially sterile (sintered-glass-filtered) pond water, starting with four brief washes and continuing with two longer washes (24 hr. and 48 hr. respectively), we selected 25 worms and transferred them to a solution of antibiotics similar to that used by Miller and Johnson (exceptions: penicillin *G*, 1,000 U./ml.; streptomycin sulphate, 100 γ/ml.; filipin, omitted). Worms left for 2 days thus and then washed six times in sterile pond water were found not to have been axenized. But one out of three worms put through another wash of 2 days (totalling 5 days of washing) and then 7 days in the foregoing antibiotic mixture was afterwards found to be free of bacteria.

With a number of animal organisms, both protistan and metazoan, monoxenic culture has been a preliminary to successful axenic culture (that is, to growing in the absence of living organisms of any other species)[3]. Our aim with *E. fragmentosus*, as it was with rhabditid nematodes[4] and is at present with rotifers and gastrotrichs[5], is to put it into axenic culture and thus make it available for nutritional and metabolic studies. The organism is of particular interest because of its extensive regenerative powers (in sharp contrast to the inability to regenerate exhibited by the aschelminths—nematodes, rotifers, gastrotrichs).

To the best of our knowledge this is the first time an annelid has been put into monoxenic culture. The axenic cultivation of an annelid has yet to be achieved. It is our next goal with *E. fragmentosus*.

We wish to thank the National Science Foundation for partial support of this work (through Grant *G*-6018).

ELLSWORTH C. DOUGHERTY
BJØRN SOLBERG

Laboratory of Comparative Biology,
Kaiser Foundation Research Institute,
S. 14th St. and Cutting Blvd.,
Richmond,
California.
Feb. 9.

[1] Bell, A. W., *Science*, **129**, 1278 (1959).

[2] Miller, C. A., and Johnson, W. H., *Ann. N.Y. Acad. Sci.*, **77**, 87 (1959).

[3] Dougherty, E. C., *Ann. N.Y. Acad. Sci.*, **77**, 27 (1959).

[4] Dougherty, E. C., Hansen, E. L., Nicholas, W. L., Mollett, J. A., and Yarwood, E. A., *Ann. N.Y. Acad. Sci.*, **77**, 176 (1959). Nicholas, W. L., Dougherty, E. C., and Hansen, E. L., *ibid.*, **77**, 218 (1959).

[5] Dougherty, E. C., and Solberg, B., *Anat. Rec.*, **134**, 555 (1959). Dougherty, E. C., Solberg, B., and Harris, L. G., *ibid.* (in the press).

Life-like Preservation of Cytoplasmic Detail in Plant Cells

BIOCHEMICAL and physiological data from plant material are reported frequently as the amount or activity of matter per cell, yet remarkably few such studies are made directly on the cells. Thus, for example, in a large number of publications on the chemistry and physiology of cell differentiation, very few have included any cytochemical investigations. That this is a general phenomenon is due, very largely, to the fact that no method exists by which plant cells may be investigated both for structure and for chemical activity, without the introduction of gross artefacts[1]. Animal cytology has advanced more rapidly because of the technique which involves freezing and drying the tissues, which are then embedded directly in paraffin wax and sectioned[2]. The wax is removed with xylol and the cells are fixed in absolute alcohol. This procedure has failed when applied to plant cells; moreover, the use of fat solvents is to be avoided at any stage.

The present communication describes a new procedure for producing sections of plant tissues in which the cytological detail is retained, apparently as in life. Thus, for example, sections of meristematic cells from roots have been obtained which resemble the living cells isolated from similar roots, as described previously[3]. Moreover, this method can be used in as routine a manner as is the usual technique which involves embedding the tissue in paraffin wax.

The tissues are treated first for about 2 hr. with a 5 per cent (w/v) aqueous solution of polyvinyl alcohol (Bush, Beach and Guest, *PVA*, type *MO*5/140). They are then frozen at between − 40° and − 70° C. in small glass specimen tubes (2 in. × 1 in.); freezing should be complete, as judged by eye, within 5–10 sec. This can be effected most simply by cooling the tubes first, for some hours or overnight, in solid carbon dioxide. The frozen material can be stored at − 40° C. or at lower temperatures, or it can be sectioned directly at between − 20° to − 25° C. by means of a refrigerated freezing microtome[4]. The sections are dried under vacuum in a desiccator containing phosphorus pentoxide and maintained at below − 20° C.

The function of the polyvinyl alcohol is to stabilize delicate cellular structures, for which purpose it has been used in other work[5]; it may be dispensed with where such labile organelles do not occur. Very low temperatures are to be avoided as they seem to damage plant cells, while gross ice crystal artefacts are apparent if the temperature of freezing is nearer 0° C., or if freezing is slow for any other reason, for example, if the tissue does not make immediate contact with the chilled wall of the tube.

It will be noted that this procedure differs markedly from the conventional freezing and drying method for animal tissues in that it depends on relatively slow freezing, as compared with the rapid quenching at the temperature of liquid nitrogen used in the latter. The reasons for this difference are twofold; first, because the results indicate that plant cells require such treatment, and secondly, because whenever tissue is to be maintained alive in a frozen condition it is cooled slowly[6]. This latter reason has been strengthened further by work such as that of Asahina[7], who observed, and photographed, living plant cells at temperatures below 0° C. He, and many other workers[8], suggest that when the cells are cooled at an optimal rate, the extracellular water freezes first and desiccates the intracellular protoplasm; for this to happen, the cell membrane must remain intact as it acts as a barrier to the extracellular ice-crystals. The complete lack of intracellular ice-crystal artefacts makes it reasonable to suppose that at these temperatures the protoplasm either never freezes, remaining in a supercooled condition, or that, possibly at very low temperatures, it may freeze but has too low a concentration of water to cause much damage. It is probable, however, that under the conditions used in the present technique, the former condition occurs; this seems likely in view of the gross distortion which can be produced by having the knife too blunt or set at the wrong angle.

The method has been used satisfactorily on root tips of *Allium cepa*, on roots and stems of *Vicia faba*, on leaves of *Ranunculus repens*, *Narcissus poeticus*, *Sorghum* and on leaves of the ferns *Ceterach officinarum* and *Dryopteris filix mas*. In the roots there was no sign of deformation so that cell lineages could be decided easily, the cytogenerative centre being very obvious (Fig. 1). Most striking, however, was the excellent preservation of the very delicate cytoplasmic granules in the active meristematic cells, which are almost never retained by other procedures[1] (Fig. 2). Normal Feulgen-stained preparations can be produced from such sections although the granules are acid-labile. In the leaves, too, no deformation was seen, as demonstrated by the good preservation of guard cells and of the cells lining the air space below. Weak birefringence has been observed in the chloroplasts and strong birefringence in all cell walls, not only in those of secondarily thickened elements. In the cells of leaves, too, more cytoplasmic detail was preserved by this procedure than by any other used previously by us[8]. Some leaves were grown in the presence of carbon dioxide labelled with carbon-14, and water-soluble substances were demonstrated in autoradiographs prepared by the apposition technique (Gahan, P. B., unpublished work) used on such frozen, sectioned and dried sections. This technique has also made possible a study of the effect of drought on plant tissues since the dried cells were chilled, sectioned and examined dry, without water or other fluids having been used at any stage of the preparation.

It seems likely, therefore, that this may be the method of choice for future studies in plant cytology and cytochemistry. It appears to give plant cytologists the equivalent of the freezing and drying technique, which has assisted so greatly the study of animal cells, yet it is simple to perform and considerably quicker than are the usual methods.

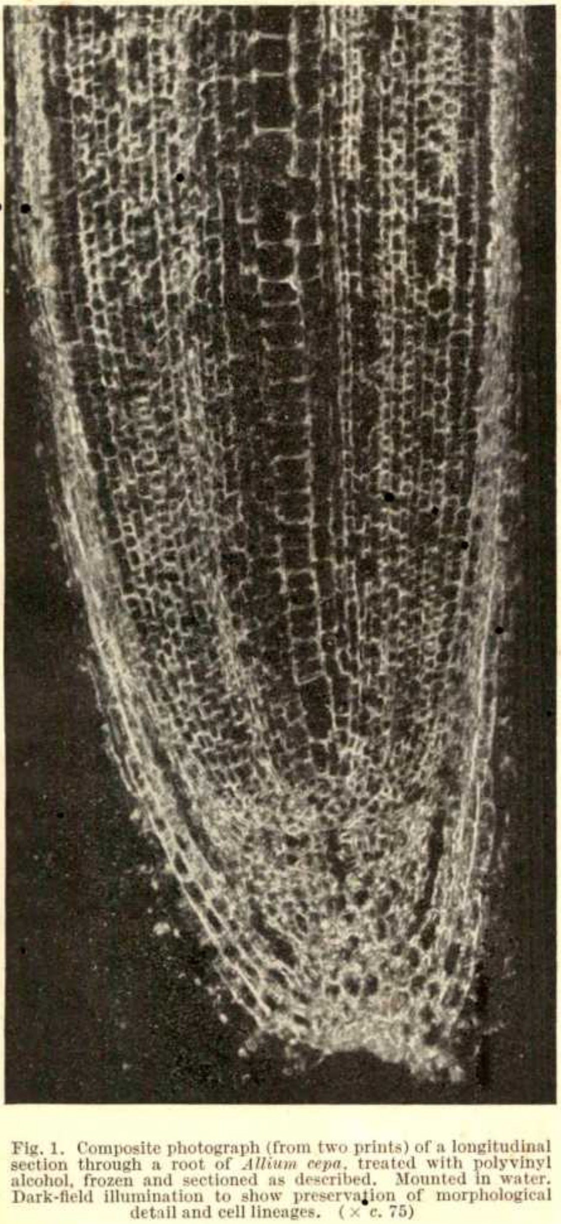


Fig. 1. Composite photograph (from two prints) of a longitudinal section through a root of *Allium cepa*, treated with polyvinyl alcohol, frozen and sectioned as described. Mounted in water. Dark-field illumination to show preservation of morphological detail and cell lineages. (× c. 75)

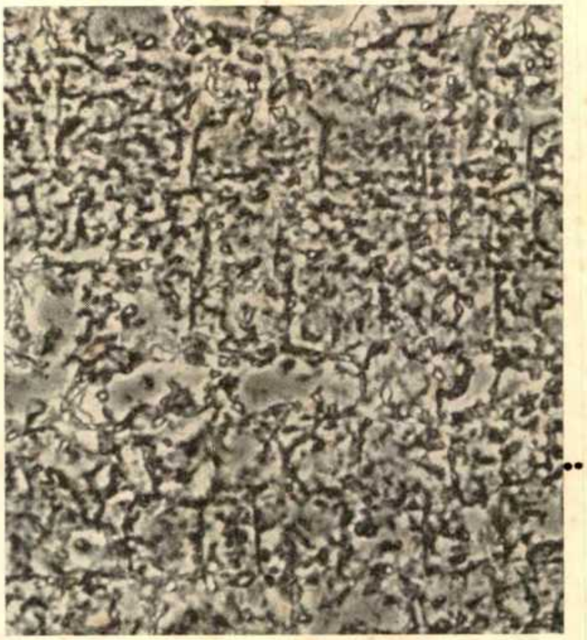


Fig. 2. As Fig. 1. Photographed with phase contrast illumination to show cytoplasmic granular and mitochondrial structures. (× 600)

A fuller account of the technique, and of results obtained by its use, will be published elsewhere[9].

J. Chayen*
G. J. Cunningham
P. B. Gahan
A. A. Silcox

Department of Pathology,
Royal College of Surgeons,
Lincoln's Inn Fields,
London, W.C.2.

* Also Imperial Cancer Research Fund.

[1] Chayen, J., and Jackson, S. F., *Symp. Soc. Exp. Biol.*, **10**, 134 (1957).
[2] Bell, L. G. E., *Int. Rev. Cytol.*, **1**, 35 (1952).
[3] Chayen, J., *Nature*, **164**, 930 (1949); **170**, 1070 (1952).
[4] Coons, A. H., Leduc, E. H., and Kaplan, M. H., *J. Exp. Med.*, **93**, 173 (1951).
[5] Chayen, J., and Miles, U. J., *Quart. J. Micro. Sci.*, **94**, 29 (1953); *Stain Technol.*, **29**, 33 (1954).
[6] Smith, A. U., in "Biological Applications of Freezing and Drying", edit. by Harris, R. J. C., 1 (Academic Press, New York, 1954). Billingham, R. E., *ibid.*, 253.
[7] Asahina, E., Contributions from the Inst. Low Temp. Sci. Japan, No. 10, 83 (1956).
[8] Chayen, J., and Gahan, P. B., *Quart. J. Micro. Sci.*, **100**, 275 (1959).
[9] Chayen, J., Cunningham, G. J., Gahan, P. B., and Silcox, A. A., Bull. Res. Counc. Israel D. (in the press).

Sulphydryl Content of the Embryos of the Australian Cattle Tick

Thompson and Johnston[1] reported that the total sulphydryl content of embryos of an arsenic-resistant strain of the South African blue tick (*Boophilus decoloratus*) was approximately twice that of an arsenic-susceptible strain. Harington[2] afterwards examined larvæ of these strains and reported that the cystine–cysteine, glutathione and total free sulphydryl values were significantly higher in the arsenic-resistant strain. To establish whether the same relation as reported by Thompson and Johnston

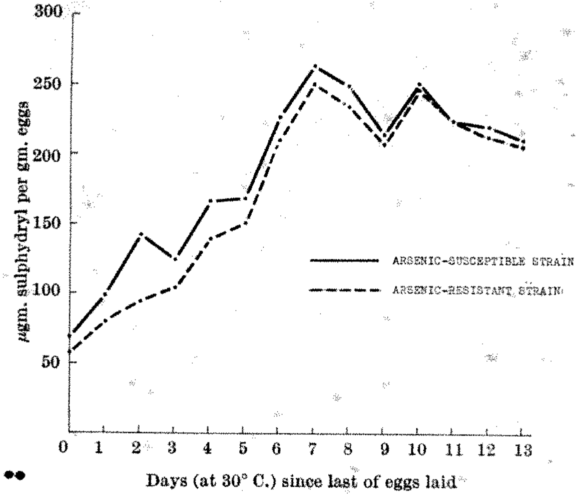


Fig. 1. Sulphydryl content of eggs of arsenic-susceptible and arsenic-resistant strains of *Boophilus microplus* throughout development

held in *Boophilus microplus*, investigations were carried out with a strain from northern New South Wales, larvæ of which exhibited a 10·7 fold (9·3–14·0; $P < 0{\cdot}001$) degree of resistance to arsenic in comparison with those of the susceptible Yeerongpilly reference strain. Adults of both strains were maintained at 30° C. and the ticks removed from the containers four days after oviposition had commenced. Daily thereafter throughout incubation four samples of eggs were taken and their total sulphydryl content determined by a nitroprusside method[3], using as a standard a solution of glutathione freshly prepared each day.

The sulphydryl content of samples of both strains up to the day before hatching commenced are shown in Fig. 1. During the first nine days of sampling the sulphydryl content of the arsenic-resistant strain was significantly lower than that of the susceptible strain (day 0, $P < 0{\cdot}05$; days 1–8, $P < 0{\cdot}001$), and at no time was the sulphydryl content of the arsenic-resistant strain significantly higher than that of the susceptible strain.

It is clear that the stage of development must be taken into account in comparing the sulphydryl content of embryos of different strains of *Boophilus microplus*, and therefore it is desirable to use eggs laid over the shortest possible period for such analyses. In this case the four-day period of oviposition which was allowed, to obtain sufficient eggs for analyses, was effectively three days, as very few eggs are laid on the first day of oviposition[4]. Owing to the nature of the curve, it is now realized that a more precise result would be obtained if eggs laid on one day only were used. However, the technique employed does not invalidate the results, because both strains were treated similarly.

Thompson and Johnston do not give details of the age-range or conditions of incubation of the embryos of *B. decoloratus* which they analysed, so that it is not possible to determine the extent to which differences in mean age could have influenced the relative amounts of sulphydryl compounds in their two strains. *B. decoloratus* may differ genuinely from *B. microplus* in this regard, but even making some allowance for errors which may arise from the age-spread of our cultures, it does not seem possible to correlate arsenic-resistance in *Boophilus microplus* with greater relative abundance in the resistant strain of compounds containing sulphydryl groups.

Thanks are due to Mr. B. F. Stone for determining the degree of arsenic-resistance of the strains of ticks and to Mr. K. P. Haydock for statistical treatments.

W. J. ROULSTON
C. A. SCHUNTNER

Commonwealth Scientific and
Industrial Research Organization,
Fairfield Road,
Yeerongpilly,
Queensland.

---

[1] Thompson, M. E., and Johnston, A. M., *Nature*, **181**, 647 (1958).

[2] Harington, J. S., *Nature*, **184**, 1739 (1959).

[3] Thompson, R. H. S., and Watson, D., *J. Clin. Path.*, **5**, 25 (195

[4] Hitchcock, L. F., *Aust. J. Zool.*, **3**, 295 (1955).

GENETICS

Genetic Instability and Outcrossing in the Groundnut Variety Mani Pintar

IN the course of groundnut variety selection work carried on in Northern Rhodesia since 1954, a number of unusual groundnut varieties have been obtained from various sources. The most unusual and interesting of these has been the variety Mani Pintar, obtained from the Queensland Department of Agriculture and Stock, Australia, in the early part of 1955. This variety has yielded consistently well in trials and appears to be well adapted to local conditions. It suffers, however, from the serious disadvantage of having a variegated red and white testa; in all other respects the variety is eminently satisfactory. Mani Pintar is an alternately branched spreading bunch variety which matures locally in 140–150 days, it has dark green foliage and is fairly resistant to the *Cercospora* leafspots, the seeds remain dormant for some time after maturity, the kernel oil content is fairly high (about 50 per cent) and is higher than most locally grown varieties; in addition, the yields of kernels and hay are consistently good. The combination of bunch habit and variegated red and white testa found in this variety is rather unusual. In *Arachis nambiquarae* Hoehne, a form with a similarly variegated testa, the habit is prostrate.

In their review of relevant literature, Gregory, Smith and Yarbrough[1] note the apparent instability of pure lines of groundnuts in the absence of selection pressures and summarize present genetical knowledge of the inheritance of colour and other kernel characters. Instability of pure lines may arise from two causes—chromosomal instability and natural outcrossing. A study of Mani Pintar showed that this variety exhibits a degree of instability; it was therefore decided to exploit this so far as possible in an attempt to produce from it a type which retained its many good qualities, but which was more acceptable commercially. In 1956 single plant selections were made some of which differed from Mani Pintar in having a self-coloured red testa. One strain which showed promise was selected for trial against the parental strain and not only was it little if any inferior to it in yielding capacity but also it bred substantially true. Occasionally reversions to the parental type were noted; but these formed only an infinitesimal fraction of the bulk of this new strain. It is possible that the change from variegated to non-variegated is reversible and results from rearrangement of chromosomal material and not from allelic differences, that it is in fact a position effect. From the practical point of view, by maintaining the selection pressure in favour of self-coloured testas, it should be possible to maintain this strain indefinitely. Varieties with red testas are well known in commerce, for example, Valencia, and this strain should not therefore be under any disadvantage in this respect.

It was noted in the course of seed selection in Mani Pintar stocks that a number of brown kernels were being discarded. On closer inspection some of these russet-brown kernels were found to be variegated. Variegation of brown kernels has not been reported by Gregory, Smith and Yarbrough[1] or by Bunting[2]; this character has re-appeared in subsequent generations. The remaining russet-brown non-variegated kernels were planted, and at harvest proved to be a mixture of material which showed definite affinities to Mani Pintar and other material which appeared to be present as a result of contamination.

It is now apparent that the brown-seeded material of Mani Pintar origin, both variegated and non-variegated, is of a hybrid nature. Segregation is occurring within single plant progenies for a great number of morphological characters. Variegated red and white kernels have appeared in pods of some progeny which are quite unlike those of the original Mani Pintar strain.

This work is continuing, and it is hoped to present elsewhere a more detailed account at a later date.

J. Smartt

Central Agricultural Research Station,
Mount Makulu,
P.O. Box 7,
Chilanga,
Northern Rhodesia.

[1] Gregory, W. C., Smith, B. W., and Yarbrough, J. A., "The Peanut the Unpredictable Legume" (National Fertilizer Association, Washington, D.C., 1951).

[2] Bunting, A. H., *Empire J. Exp. Agric.*, **23**, 158 (1955); **26**, 254 (1958).

Interspecific Hybrids of *Lycopersicum*

In a recent issue of *Nature*, H. Nirk[1] described the achievement of fertile interspecific tomato hybrids by the reciprocal grafting of parent plants prior to hybridization. The technique has an older history than is suggested by Nirk's communication. It was used on a large scale more than thirty-five years ago by the Russian plant breeder I. V. Michurin, who termed it "vegetative approximation".

In a report[2] published in 1925 Michurin commended his own innovation in the following terms:

"My original method has been elaborated on the basis of the considerable changes that the properties of a small part of a young plant (a cutting) undergo when grafted on to the crown of a different variety. These changes take place under the action that the entire root and leaf system of the latter exerts upon a very small part of a young plant that is as yet rather unstable in respect to various changes . . .

"I use this vegetative change as an auxiliary means of approximating two different plant species so as to obtain a sexual hybrid by crossing them in the future.

"This is the secret of my success in obtaining interspecific plant hybrids, such as crosses between the apricot and the plum, sweet and sour cherry, *Pyrus salicifolia* and the local cultivated pear varieties; between the various species of walnut, the various species of grapes, the various species of quince; between the pear and the mountain ash; between distant species of apple; between species of currant and other small-fruit shrubs; between pumpkins and muskmelon, musk and watermelon; between the various species of lilies; between Physalis and tomatoes, etc."

Michurin's published descriptions do not in general lend themselves to exact scientific evaluation, so that it is not easy to say how many of his successful crosses were in reality facilitated by the 'approximation' procedure. On the other hand, at least one claim for the method made by members of his school[3] has been independently confirmed. Hall[4], working in Sweden, was able to increase the yield of wheat-rye hybrids from 2–3 per cent to 14 per cent, by grafting the embryo of the future maternal parent (wheat) on to rye endosperm.

It is to be hoped that the new results reported by Nirk will once more direct the attention of geneticists and embryologists to a challenging, and still unexplained, phenomenon.

Donald Michie

Department of Surgical Science,
University of Edinburgh.

[1] Nirk, H., *Nature*, **184**, 1819 (1959).

[2] English translation on pp. 161–172 of "I. V. Michurin: Selected Works" (Foreign Languages Publishing House, Moscow, 1950).

[3] Pissarev, W. E., and Vinogradova, N. M., *C.R. Acad. Sci. U.R.S.S.*, **45**, 129 (1944).

[4] Hall, O. L., *Hereditas*, **40**, 453 (1954).

Dr. Michie is of course correct in his statement regarding the claims of Michurin *et al.* in respect of this approach to interspecific hybridization. However, irrespective of whether the results of the present investigation furnish corroborative evidence of Michurin's claims, their immediate significance lies in their application in the field of practical plant breeding, particularly in relation to the hybridization of *Lycopersicum* species.

Helgi Nirk

Victoria Department of Agriculture,
Melbourne, C.2.

PSYCHOLOGY and PSYCHIATRY

Cross-Modal Transfer of Training in Monkeys

In a previous communication[1] the question was raised whether monkeys that have been trained to discriminate at a high level of confidence between two dissimilar solid forms by vision (in the light) will maintain their accuracy of discrimination when objectively the same cues are later made available for discrimination only by palpation (in the dark). The absence of cross-modal transfer between visual and tactile shape discriminations was reported for four unoperated monkeys. Support of this finding was forthcoming from the study of seven additional animals with brain lesions[2].

It was decided to extend this investigation to another sensory modality, and to look for cross-modal transfer between pairs of visual and auditory rhythms.

Table 1. SEQUENCE OF TRAINING FOR ANIMALS *C*1–*C*4, *F*1–*F*4 AND *T*1, *T*3, *T*4

<table>
<tr><th colspan="2">Group I animals</th><th>Group II animals</th></tr>
<tr><th>C1, F1, T1</th><th>C2, F2</th><th>C3, C4, F3, F4, T3, T4</th></tr>
<tr><td colspan="3">Visual shape discrimination
Interrupted tone versus click</td></tr>
<tr><td colspan="2">Low versus high visual frequency</td><td rowspan="3">Visual rhythm discrimin. (failed)
Visual rhythm versus dark</td></tr>
<tr><td>Auditory rhythm discrimin. (failed)</td><td>14 days rest</td></tr>
<tr><td colspan="2">Low versus high visual frequency (retention)</td></tr>
<tr><td colspan="3">Low versus high auditory frequency (1,000 trials)</td></tr>
</table>

However, not one of nine animals was able (under our conditions) to discriminate accurately between two simple visual or auditory rhythms within 3,000 trials of training. It was therefore asked: Will monkeys that have been trained to discriminate between two rates of interruption of a light maintain their accuracy of discrimination when a sound is interrupted at the same two rates ?

Eleven naïve rhesus monkeys (weight-range 3·5–4·7 lb.) were divided at random into two groups of five and six animals. No animal received a brain lesion. Their training histories (equated in the sense of one auditory and two visual tests learnt by each group) are shown in Table 1.

Standard apparatus (Wisconsin General Testing Apparatus) and the pull-in technique were used. By pulling one of two strings the animal could draw towards itself along sloping rails the left or right box, which on release returned by gravity to its starting position. Each box contained a light source, a loudspeaker and a food container. The onset of the light or sound was switched by tension on a string, although the frequency and modality of the cue had been silently predetermined on a control panel. Forty trials were given each day (non-correction) with right/left positions of the positive cues determined by the Gellerman schedule.

The luminance of the light was 229 ft. lamberts against a ground of 0·04 ft. lamberts. The sound was a 370 c.p.s. tone with a small component at 1,850 c.p.s. Its intensity was judged to be about 60 decibels above the hearing threshold, against a constant background noise of about 20 decibels. For the positive cues, the light or sound was interrupted at a rate of 4 c.p.s., for the negative cues, at 16 c.p.s. The on/off ratio of the positive cues was 0·44 in both modalities. The energy content of the high-frequency light was greater than that of the low-frequency light in the ratio of 1·7 : 1, owing in part to the thermal delay of the filaments ; of the high-frequency sound relative to the low-frequency sound in the ratio of 1·3 : 1, owing to an increase in the on/off ratio with frequency.

The animals of Group I required an average of 1,178 trials to learn the visual frequency discrimination (range 500–2,030 trials). The mean of their scores during retention training in the visual modality was 122 trials (range 0–380 trials). On the auditory form of the same frequency discrimination the mean error score in 1,000 trials is 352 for the five animals of Group I (range 265–414 errors) as compared with a mean of 347 errors for the six animals of Group II (range 295–408). The difference between the error scores of Group I and Group II animals does not approach significance (*P* = 0·465, one-tailed Mann–Whitney test). There was one animal in Group I and there were three in Group II that made 20 or less errors in the last 100 trials of training on the auditory frequency discrimination. These results provide no evidence of transfer between visual and auditory frequency discriminations in the monkey.

In a review of the literature[1] unequivocal evidence of positive cross-modal transfer in animals was found only in respect of the avoidance situation, with use of a single warning cue. Moreover, certain findings in man[3] indicate that cross-modal matching of lengths or nonsense shapes can be considerably more difficult than intra-modal comparisons. The authors of a recent report[4] state, " . . . we feel no doubt that inter-sensory rate matching between the eye and the ear (in man) is much poorer than intra-sensory matching for either of these sensory processes". Nevertheless under different conditions, cross-modal matching can be accurately accomplished by man[5]. We suggest that language may serve as a cross-modal bridge under these latter conditions[5], but perhaps not when small differences in lengths or rates have to be observed[3,4], nor in the experiment described in this report.

This work was supported by the Research Fund of the Institute of Neurology, and by the Medical Research Council, in grants to one of us (G. E.). We are sincerely grateful to Dr. E. A. Carmichael, Dr. W. A. Cobb and Dr. E. T. O. Slater for facilities which enabled this work to be undertaken ; to H. B. Morton, who designed and constructed the apparatus ; and to Prof. O. L. Zangwill for encouragement.

D. Burton
G. Ettlinger

Psychological Laboratory,
Institute of Neurology,
Queen Square, London, W.C.1.

[1] Ettlinger, G., *Behaviour*, **16**, 56 (1960).

[2] Bates, J. A. V., and Ettlinger, G., *Arch. Neurol.* (Chicago) (in the press).

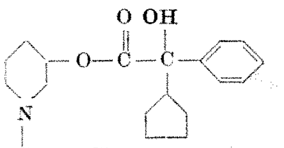
[3] Kelvin, R. P., and Mulik, A., *Quart. J. Exp. Psychol.*, **10**, 187 (1958). Krauthamer, G., Ph.D. thesis, New York University College of Medicine (1959).

[4] Gebhard, J. W., and Mowbray, G. H., *Amer. J. Psychol.*, **72**, 521 (1959).

[5] Cannon, R. C., Ph.D. thesis, Department of Psychology, University of Colorado (1955). Krauthamer, G., as ref. 3.

Blocking Effect of Tetrahydroaminacrin on a New Psychotomimetic Agent

TETRAHYDROAMINACRIN, a cholinesterase inhibitor, has been found to be an effective antidote to induced 'model psychosis' as well as the central and peripheral effects of an acetylcholine inhibitor, *JB* 329, in eight cases.



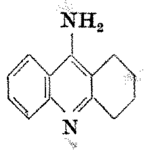
(I)

N-Ethyl-3-piperidyl cyclopentyl phenyl glycolate hydrochloride

The compound designated *JB* 329 (I) is a member of a series of 3,4-substituted piperidyl benzylates which have been recently demonstrated to possess psychotomimetic properties[1,2]. This compound has clinical effects that simulate some aspects of psychosis more closely than lysergic acid diethylamide or mescaline and is therefore of considerable interest.

The anticholinergic effect of *JB* 329 on guinea pig ileum is comparable to and may exceed atropine. It also is a weak antihistaminic but has no anti-serotonin activity (Research Division of Chemistry and Pharmacology, Lakeside Laboratories). Substitution of H for OH in the benzylic acid nearly abolishes psychotomimetic properties and consequently greatly reduces anticholinergic potency, whereas substitution of a quaternary nitrogen in the piperidyl ring also abolishes psychotomimetic properties, but has little effect on anticholinergic properties.

Tetrahydroaminacrin, 1,2,3,4-tetrahydro-5-amino-acridine (II) was synthesized by Albert *et al.* in 1945 [3].


(II)

1,2,3,4-Tetrahydro-5-aminoacridine

Rubbo and others[4,5] have shown that 1,2,3,4-tetrahydro-5-aminoacridine has no bacteriostatic properties in contradistinction to other related acridines. Later this compound was shown to possess a significant antagonistic effect to morphine depression in dogs[6], producing good arousal with the animal appearing normal and alert. This stimulant effect, the production of alertness with increased mental clarity, has also been observed clinically when 1,2,3,4-tetrahydro-5-aminoacridine has been added to the high morphine dosages frequently employed in patients with severe pain from terminal carcinoma (Shaw, F. H., personal communication).

1,2,3,4-Tetrahydro-5-aminoacridine has marked anticholinesterase activity, is an effective decurarizing agent[7], displays eserine-like activity on the intestine, and atropine-like properties on the heart.

Therefore it seemed that 1,2,3,4-tetrahydro-5-aminoacridine would warrant a trial as an antidote to the peripheral and central effects induced by *JB* 329. Preliminary screening was carried out in animals and 1,2,3,4-tetrahydro-5-aminoacridine was found to counteract the increased activity produced in mice by *JB* 329 as measured in an activity cage.

Clinical trials were then undertaken, and 1,2,3,4-tetrahydro-5-aminoacridine, given intravenously, was a complete and effective antidote for both the central and peripheral effects of *JB* 329 in eight subjects. To date we have studied the effects of *JB* 329, given both orally and intramuscularly, in a large number of cases. In the present work four chronic alcoholics, one sociopath and three schizophrenics were given 10–20 mgm. of *JB* 329 intramuscularly. All subjects were able to speak adequately. Autonomic symptoms such as mydriasis, tachycardia, dryness of the mouth and muscle weakness were seen in all the subjects. The central effects produced in these subjects and in many others studied were essentially the same as those already reported by others. These began about 20 min. after administration of the drug and consisted of confusion, difficulty in speech and concentration, disorientation and hallucinations. Hallucinations were visual, olfactory, tactile and auditory, lasted up to 24 hr. and reproduced earlier real or hallucinated experiences. They were accompanied by gross distortion of visual perception, and by hallucinating objects and people. A number of subjects exhibited paranoid ideation and ideas of grandeur. Some showed complete loss of contact with the environment and reacted to their hallucinations. In some cases stupor and mussitant delirium were produced.

One illustrative case will be presented. This patient, *M*, an alcoholic with good verbal level and little deterioration, was given 10 mgm. *JB* 329 intramuscularly. He became for a time confused and drank imaginary glasses of alcohol, refilling them from non-existent bottles. His speech also became progressively more incoherent until in about 1½ hr. he became stuporose, with eyes staring fixedly ahead, and unable to articulate any word or sound, and with his limbs markedly hypotonic. At this point 30 mgm. 1,2,3,4-tetrahydro-5-aminoacridine were administered intravenously over 5 min. Two min. after commencement of the injection he spoke and responded rationally, was alert and in complete contact. Muscle tone was restored to normal and he could walk without assistance. He did not relapse into stupor, and conversation was at all times clear and lucid and showed no evidence of a return to confusion, disorientation or the production of psychotic material of a delusional or hallucinatory type. This type of response is typical for alcoholics given *JB* 329.

Subjects belonging to different diagnostic categories respond to *JB* 329 with distinct and different pictures. These will be reported in detail elsewhere (Gershon, S., and Olariu, J., unpublished work).

In all eight cases, the intravenous injection of between 30 and 60 mgm. of 1,2,3,4-tetrahydro-5-aminoacridine was a complete antidote to the *JB* 329-induced state, whatever the predominant clinical picture. Furthermore, the 1,2,3,4-tetrahydro-5-aminoacridine reversed the blood pressure and heart-rate changes induced by *JB* 329, whether initially an elevation or a depression of these functions occurred.

These observations demonstrate that 1,2,3,4-tetrahydro-5-aminoacridine, a cholinesterase inhibitor, is a successful and complete antidote to the 'model psychosis' induced by *JB* 329, in both non-psychotic and psychotic subjects. Although these two compounds affect cholinesterase and acetylcholine *in vitro*, this may not necessarily be their mechanism of action in producing the changes reported here. However, it is felt that this is a promising area for further investigation.

This work was supported by a grant from the National Institute of Mental Health, No. 1972.

SAMUEL GERSHON

Joint Research Project in
Schizophrenia and Psychopharmacology,
University of Michigan and
Ypsilanti State Hospital,
Box A, Ypsilanti, Michigan.

---

[1] Abood, L. G., and Meduna, L. J., *J. Nerv. Ment. Dis.*, **127**, 546 (1958).

[2] Abood, L. G., Ostfield, A. M., and Biel, J., *Proc. Soc. Exp. Biol. Med.*, **97**, 483 (1958).

[3] Albert, A., and Gledhill, W., *J. Soc. Chem. Indust.*, **64**, 169 (1945).

[4] Albert, A., Rubbo, S. D., Goldacre, R. J., Davey, M. E., and Stone, J. D., *Brit. J. Exp. Path.*, **26**, 160 (1945).

[5] Rubbo, S. D., Albert, A., and Maxwell, M., *Brit. J. Exp. Path.*, **23**, 69 (1942).

[6] Shaw, F. H., Gershon, S., and Bentley, C. A., *J. Pharm. Pharmacol.*, **9**, 666 (1957).

[7] Gershon, S., and Shaw, F. H., *J. Pharm. Pharmacol.*, **10**, 638 (1958).

STATISTICS

The Meaning of Binomial Distribution

Two generalizations of the simple binomial distribution are common in statistical text-books, one due to W. Lexis and the other to S. D. Poisson. Lexis considered the case in which the probability of an event occurring, p, is constant in the N trials of one experiment, but varies among several such experiments. He showed that the mean and variance of the resulting binomial distribution are $N\bar{p}$ and $N\bar{p}\bar{q} + N(N-1)V(p)$, where $\bar{p} = 1-\bar{q}$ is the mean, and $V(p)$ the variance, of p between experiments. The variance thus exceeds that of the simple binomial distribution with the same mean. Poisson considered the case in which p takes the value p_i at the ith trial in each experiment, and showed that the mean and variance of the resulting distribution are $N\bar{p}$ and $N\bar{p}\bar{q} - NV'(p)$, where $V'(p)$ is the variance of p within experiments.

In order to specify the exact form of the modified binomial distribution, it is necessary to postulate a distribution for p, in the first case, and the values p_i in the second. A convenient distribution for p is the β-distribution, and the resulting Lexian binomial has been described and used by Edwards[1] in connexion with work on the human sex ratio. The Poisson binomial is not commonly used, although to do so would be a simple, if tedious, matter. Parkes[2] gives some data on the sex ratio in pigs which exhibit unexpectedly small variances, and if he had known of this distribution he need not have observed that his was "a finding very hard to interpret".

David[3] describes Lexian and Poissonian variation adequately, including the case in which both types occur simultaneously. But she perpetrates a common fallacy when she concludes that if the observed variance of a binomial distribution does not differ significantly from $N\bar{p}\bar{q}$ then "the probability may be assumed to be constant throughout the observations". For the two types of variation may be masking each other, and the only valid inference is that there is no evidence for variations in the probability.

I have recently found a third generalization of the simple binomial distribution useful. Suppose that the probability is p at each trial, but that the result of a trial is causally correlated to the result of the previous one, with correlation coefficient r. Then, formulating the problem like a Markov process, the matrix of transition probabilities from one trial to the next is:

$$\begin{pmatrix} p + rq & q - rq \\ p - rp & q + rp \end{pmatrix}$$

and the generating function of the 'Markov binomial' distribution is:

$$G(s) = (ps\ q) \begin{pmatrix} (p + rq)s & q - rq \\ (p - rp)s & q + rp \end{pmatrix}^{N-1} \begin{pmatrix} 1 \\ 1 \end{pmatrix}$$

where s is a dummy variable.

The matrix of transition probabilities has the interesting property:

$$\begin{pmatrix} p + rq & q - rq \\ p - rp & q + rp \end{pmatrix}^{N} = \begin{pmatrix} p + r^N q & q - r^N q \\ p - r^N p & q + r^N p \end{pmatrix}$$

Thus the correlation coefficient between trials separated by $N-1$ other trials is r^N. The coefficient is, in fact, the determinant of the matrix.

The mean of the distribution is clearly Np, and the variance can be found from the formula for the variance of the sum of N correlated variables:

$$\sigma^2 = Npq + 2(N-1)rpq + 2(N-2)r^2pq + 2(N-3)r^3pq \ldots + 2r^{N-1}pq$$

$$= Npq + 2pq \cdot \frac{r}{(1-r)^2} (N(1-r) - 1 + r^N)$$

This variance exceeds Npq if the correlation is positive, but is less than Npq if the correlation is negative.

In practice it is impossible to separate out the three effects here described when the data are solely in the form of binomial distributions; but if the data are available broken down into series, an analysis may be made:

It can be shown that the correlation coefficient between successive trials is equal to:

$$r + (1-r) \frac{V(p)}{pq}$$

where r is the correlation coefficient between successive trials within experiments and $V(p)$ is the variance of p between experiments. Small variations in p between trials are second-order effects in the expression and may be neglected. Thus the correlation coefficient between trials separated by $(N-1)$ other trials is:

$$r^N + (1-r^N) \frac{V(p)}{pq}$$

and this formula enables V and r to be estimated. Variation in p between trials may, of course, be estimated directly.

We are thus equipped to analyse binomial data on the fairly comprehensive hypothesis that the probability of an event occurring at the ith trial in the jth experiment is $p_i + p_j$, where the p_i's are small and $\sum_i p_i = 0$, there being an additional real correlation, with coefficient r, between the results of successive trials in an experiment. Further generalization may, of course, be made, at the risk of some complexity, but it is doubtful whether any data exist that warrant it.

In conclusion, it must again be emphasized that no useful inferences can be made from the fact that data fit the simple binomial distribution satisfactorily; for, on one hand, variability of p between experiments, and a positive correlation between successive trials, increase the variance, and on the other, variability of p between trials, and a negative correlation, reduce it.

A. W. F. EDWARDS

Department of Genetics,
University of Cambridge.

Feb. 12.

---

[1] Edwards, A. W. F., *Ann. Hum. Genet.*, **23**, 6 (1958).

[2] Parkes, A. S., *Biometrika*, **15**, 373 (1923).

[3] David, F. N., "Probability Theory for Statistical Methods" (Cambridge University Press, 1951).

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Research Assistant, for work on the structure of crystalline proteins using X-rays and electronic computers—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (June 29).

Assistant Lecturer (with a degree in botany with some zoology) in Biology—The Registrar, University College of North Staffordshire, Keele, Staffs (June 30).

Demonstrator in the Department of Geology—The Registrar, University College of North Staffordshire, Keele, Staffs (June 30).

Laboratory Technician (with experience of chemical or biochemical analysis) in the Department of Veterinary Hygiene and Preventive Medicine—The Secretary, University of Edinburgh, Old College, South Bridge, Edinburgh, quoting Ref. No. LT/VH/5/60 (June 30).

Lecturer in Applied Mathematics—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (July 3).

Assistant Lecturer in Pure Mathematics—The Registrar, The University, Sheffield (July 9).

British Coke Research Fellow in the Department of Chemistry, for research on the carbonization of high polymers—The Registrar, The University, Hull (July 9).

Lecturer (Grade I) in Pure Mathematics—The Registrar, The University, Leicester (July 9).

Shell Students (graduates in chemistry or engineering) in Chemical Engineering—The Registrar, King's College (University of London), Strand, London, W.C.2 (July 4).

Assistant Lecturer or Lecturer in the Department of Zoology—The Registrar, The University, Liverpool, quoting Ref. No. CV/T (July 9).

W. J. Rees Research Fellow (with some research experience) in the Department of Refractories Technology in the Faculty of Metallurgy, to advance knowledge in the field of refractory materials—The Registrar, The University, Sheffield (July 9).

Research Assistant (with a good honours degree in botany or agricultural botany and an interest in experimental ecology and/or genetics) in Agricultural Botany, for investigations on the mineral nutrition of natural populations of agriculturally important grass species—The Registrar, University College of North Wales, Bangor, North Wales (July 15).

Assistant (preferably with an interest in systematics of the fungi) in Botany—The Secretary of University Court, The University, Glasgow (July 16).

Fellow (chemist or biochemist, with the Ph.D. degree or about to obtain it) in the Chemistry Department of the Faculty of Science, for the study of nucleotides in relation to the bacterial cell wall—The Registrar, The University, Manchester 13 (July 16).

Lecturer in Electronic Computing—The Registrar, The University, Leeds 2 (July 16).

Student (with good honours in a first degree in physics) in the Department of Physics, for research on the thermionic and related aspects of the direct conversion of thermal to electrical energy—The Professor of Physics, The University, Southampton (July 16).

Fellow or Senior Fellow in the Department of Physical Biochemistry, John Curtin School of Medical Research, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 18).

Senior Lecturers and Lecturers in Chemistry, Mathematics, Physics, Zoology and Engineering at Monash University, Clayton, Victoria, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (July 18).

Temporary Assistant Lecturer or Temporary Lecturer (preferably with interests in applied mathematics) in the Department of Mathematics—The Secretary, University College, Gower Street, London, W.C.1 (July 20).

Assistant Forest Entomologist (with a degree or diploma in science or an applied science with training and aptitude for forest entomological research) with the Forests Commission of Victoria, Australia, to undertake field investigations into the incidence and control of forest insect pests, under the Forest Entomologist and Research Officer—The Agent-General for Victoria, Victoria House, Melbourne Place, Strand, London, W.C.2 (July 23).

Research Assistant in Theoretical Physics in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (July 23).

Lecturer (with a good honours degree and a special interest in mycology and plant pathology) in Botany at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 25).

Chair of Civil Engineering, and Chair of Electrical Engineering at the Royal Technical College of East Africa and proposed University College in Nairobi—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 30).

Chair of Geography in Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, July 30).

Assistant Professor in the Department of Chemical Engineering—Head of the Department of Chemical Engineering, University of British Columbia, Vancouver, B.C., Canada (July 31).

Lecturer (preferably with experience in comparative physiology or experimental zoology) in Zoology at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 31).

Lecturer (with a degree in chemical engineering and experience in the practice of chemical engineering in industry and/or in teaching and research) in Chemical Engineering at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, July 31).

Senior Lecturer in Statistics; and a Lecturer in Pharmacy at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, July 31).

Director of the South Australian Institute of Technology, North Terrace, Adelaide, South Australia—The Agent-General for South Australia, South Australia House, 50 Strand, London, W.C.2 (August 20).

Lecturer in Archæology—The Secretary of University Court, The University, Glasgow (August 31).

Reader in Electric Traction at the Imperial College of Science and Technology, London, S.W.7—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 12).

Assistant Experimental Officers (2) (graduates), one for a trapping and marking programme and population and distribution studies (an unmarried man), and the other for the study of parasite ecology—The Assistant Director (Research), The Wildfowl Trust, Slimbridge, Glos.

Assistant, Grade B, in Mathematics—The Registrar, Bradford Institute of Technology, Bradford 7.

Assistant Lecturer in Physical Chemistry—Prof. R. M. Barrer, F.R.S., Chemistry Department, Imperial College of Science and Technology, London, S.W.7.

Assistant or Associate Professor (with Ph.D. or equivalent, plus demonstrated ability in pharmacology or related fields of physiology or biochemistry) in the Department of Pharmacology and Therapeutics—Dr. Mark Nickerson, University of Manitoba, Winnipeg, Canada.

Biochemist (Senior or Basic grade) to the Rochdale Group of Hospitals, to work under the Consultant Pathologist and to carry out biochemical work for the hospitals and clinics of the Group—The Group Secretary, Rochdale and District Hospital Management Committee, Central Offices, Birch Hill Hospital, Rochdale, Lancs.

Biochemist (non-medical) in the Department of Medicine, Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Head of the School of Librarianship, Manchester College of Science and Technology—The Secretary, The Library Association, Chaucer House, Malet Place, London, W.C.1.

Junior Physicist—The Clerk to the Governors, St. Bartholomew's Hospital, London, E.C.1, marking envelope "Physicist".

Lecturer (with a good honours degree and preferably a higher degree) in Geology with emphasis on Petrology and Structural Geology—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

Postdoctoral Fellow in the Department of Chemical Engineering, for research into flame spectroscopy or a related subject—Dr. A. G. Gaydon, F.R.S., Imperial College of Science and Technology, London, S.W.7.

Research Assistant (Physicist) (preferably with a knowledge of electronics and a degree in physics), for work with the X-ray scanning micro-analyser (electron probe) in the field of ore microscopy—Dr. A. P. Millman, Mining Geology Department, Royal School of Mines, Prince Consort Road, London, S.W.7.

Research Assistant (preferably with experience in cytology), to take part in a programme designed to study human chromosome abnormalities and associated disorders—The Secretary, Genetics Department, The University, Sheffield 10.

Research Fellow (with a Ph.D. degree or equivalent research experience) in the Chemistry Department, for work on the kinetics of gaseous oxidation reactions, in collaboration with Dr. R. R. Baldwin—The Professor of Chemistry, The University, Hull.

Research Student in Chemistry, for work on the chemistry of urease under the direction of Prof. W. Cocker—The Registrar, Trinity College, Dublin.

Senior Grade Technician (A.I.M.L.T. or B.Sc.) in the Biochemistry Department, for general routine work—The Secretary, Group 9 Pathological Laboratory, 6 Rickmansworth Road, Watford, Herts.

Senior Lecturer in Physics, and a Lecturer in Physics—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

Senior Lecturer (well qualified, with industrial and/or research experience) in Organic Chemistry—The Registrar, Bradford Institute of Technology, Bradford 7.

Senior Technician II to take charge of the Biochemistry Department in the Group Laboratory—The Secretary, Forest Group H.M.C., Langthorne Road, London, E.11.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Co-ordinating Advisory Committee on Oil Pollution of the Sea. Report of Proceedings of the International Conference on Oil Pollution of the Sea, 3–4 July, 1959, Copenhagen. Pp. 93. (London: Miss P. Barclay-Smith, c/o British Museum (Natural History), 1960.) 3*s*. [303

Department of Scientific and Industrial Research. Radio Research 1958: The Report of the Radio Research Board and the Report of the Director of Radio Research. Pp. iv+43+4 plates. (London: H.M. Stationery Office, 1960.) 3*s*. 6*d*. net. [303

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 64: Warble Flies of Cattle. Pp. 5. (Belfast: Ministry of Agriculture, 1960.) [303

Research Defence Society. Conquest Pamphlet No. 10: The Use of Laboratory Animals in the Standardization of Drugs—Outstanding questions posed and answered by the Research Defence Society. Pp. 6. (London: Research Defence Society, 1960.) 6*d*. [44

The University College Farm in the Agriculture of Rhodesia and Nyasaland: an Inaugural Lecture given in the University College of Rhodesia and Nyasaland. By Prof. A. G. Davis. Pp. 43. (London: Oxford University Press, 1960.) 4*s*. net. [44

Henry Wiggin and Co., Ltd. Nimocast Heat-Resisting Alloys. Pp. 36. (Birmingham: Henry Wiggin and Co., Ltd., 1960.) [44

Forestry Commission. Leaflet No. 45: The Roe Deer. Pp. 16. (London: H.M. Stationery Office, 1960.) 1*s*. 6*d*. net. [44

South-West Essex Technical College and School of Art. Annual Report, Session 1958–1959. Pp. 26. (21st Anniversary.) (Walthamstow: South-West Essex Technical College and School of Art, 1960.) [44

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 1012, Vol. 252 (March 31 1960): Random Walk on a Sphere and on a Riemannian Manifold. By P. H. Roberts and H. D. Ursell. Pp. 317–356. 12*s*. 6*d*. No. 1013, Vol. 252 (31 March, 1960): The Thermodynamic Properties of Fluid Helium. By R. W. Hill and O. V. Lounasmaa. Pp. 357–395. 12*s*. No. 1014, Vol. 252 (31 March, 1959): Studies on Magneto-Hydrodynamic Waves and other Anisotropic Wave Motions. By M. K. Lighthill. Pp. 397–430. 10*s*. 6*d*. (London: The Royal Society, 1960.) [44

Agricultural Research Council: Radiobiological Laboratory. Report No. 2: Strontium 90 in Milk and Agricultural Materials in the United Kingdom, 1958–1959. Pp. xi+91. (London: H.M. Stationery Office, 1960.) 5*s*. net. [44

Association of Universities of the British Commonwealth. Conference of the Universities of the United Kingdom 1959—Report of Proceedings. (Conference convened by the Committee of Vice-Chancellors and Principals, and held in the William Beveridge Hall, University of London Senate House, 11th and 12th December, 1959.) Pp. 104. (London: Association of Universities of the British Commonwealth, 1960.) 5*s*. [44

Ministry of Education. Pamphlet No. 38: Science in Secondary Schools. Pp. vi+164+6 plates. (London: H.M. Stationery Office, 1960.) 6*s*. net. [44

Imperial College of Science and Technology (University of London). Postgraduate Course in Nuclear Technology (Chemical), 1960–61. Pp. 9. (London: Imperial College of Science and Technology, 1960.) [44

Federation of British Industries. The Technical Colleges and Their Government: an Industrial Appraisal. (F.B.I. Handbook.) Pp. vii+44. (London: Federation of British Industries, 1960.) 5*s*. [44

University of London. University College Annual Report 1958–1959. Pp. 95. (London: University College, 1960.) [44

Institution of Chemical Engineers. Regulations for the Admission of Student, Graduate, and Corporate Members, and for the Examination of the Institution. Pp. iii+27. (London: Institution of Chemical Engineers, 1960.) [44

Chelsea College of Science and Technology. Sixty-fourth Annual Report, 1958–59. Pp. 46. (London: Chelsea College of Science and Technology, 1960.) [44

Department of Scientific and Industrial Research. Forest Products Research. Bulletin No. 1: Dry Rot in Wood. By Dr. W. P. K. Findlay and J. G. Savory. Sixth edition. Pp. viii+36+10 figures. (London: H.M. Stationery Office, 1960.) 4*s*. net. [44

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 14[illegible]: Metabolic Disorders of Cattle and Sheep (Acetonaemia, Milk Fever, Hypomagnesaemic Tetany.) Pp. 7. (Belfast: Ministry of Agriculture, 1960.) [44

The Registrar General's Statistical Review of England and Wales for the year 1958. Part 1: Tables, Medical. Pp. xi+330. (London: H.M. Stationery Office, 1960.) 20*s*. net. [44

General Register Office. The Registrar-General's quarterly return for England and Wales—Births, Deaths and Marriages; Infectious Diseases; Weather; Population Estimates, quarter ended 31st December 1959. (No. 444, 4th Quarter 1959.) Pp. 27. (London: H.M. Stationery Office, 1960.) 2*s*. net. [44

Ministry of Labour. Central Youth Employment Executive. Choice of Careers Series. No. 1: Choosing Your Career. Pp. 32. 1*s*. 6*d*. net. No. 94: Laboratory Technicians and Assistants. Pp. 56. 2*s*. 6*d*. net. No. 100: The Scientist. Pp. 48. 1*s*. 3*d*. net. (London: H.M. Stationery Office, 1960.) [44

Ministry of Education. Circular 1/60 (28th March 1960): The Future Development of Management Education and of Business Studies—Revision of Joint Examination Schemes. Pp. 3. Appendix to Circular 1/60: Report of the Working Party appointed to examine the Scheme of Management Studies. Pp. i+57. (London: Ministry of Education, 1960.) [44

Wool Industries Research Association. Report of the Director of Research for 1959. Pp. 39. (Publication No. 214.) (Headingley, Leeds: Wool Industries Research Association, 1960.) [74

Hertfordshire County Council Technical Information Service. Microtexts as Media for Publication. (The papers and discussion of a Symposium held at Hatfield Technical College on the 10th November, 1959, under the Chairmanship of Mr. D. T. Richnell, B.A., F.L.A.) Pp. 87. (Roe Green, Hatfield: County Technical Librarian, Hatfield Technical College, 1960.) [74

Other Countries

Tokyo Astronomical Observatory. Tokyo Astronomical Bulletin, Second Series. No. 117: Meridian Observations of the Right Ascensions of the Moon and Planets during the year 1958. By S. Nakano, H. Yasuda and H. Hara. Pp. 1359–1366. No. 118: Approximate Positions of Artificial Satellites Obtained with the Baker-Nunn Schmidt Camera (1). By the Sky Patrol Section of the Tokyo Astronomical Observatory. Pp. 1367–1380. No. 119: Revision of the Tokyo UT2 on the Basis of the Improved Star Places for the PZT. By Masahisa Torao. Shigetaka Iijima and Seiichi Okazaki. Pp. 1381–1394. No. 120: Photographic Observations of Minor Planets and Comets (35). By Hidewo Hirose and Koichiro Tomita. Pp. 1395–1407. No. 122: Attempts to Observe the Solar Ultraviolet Radiation with a Rocket-borne Spectrograph. By Kuniji Saito and Keizo Nishi. Pp. 1497–1509. No. 123: Note on the Elements of the Eclipsing System AH Virginis. By Masatoshi Kitamura and Chie Takahashi. Pp. 1511–1514. No. 125: Frequency Change due to Doppler Shift in WWVH Signals as received at Tokyo. By Shigetaka Iijima, Yoshima Ohki and Iwai Oyuma. Pp. 1525–1536. (Tokyo: Tokyo Astronomical Observatory, 1959 and 1960.) [303

Organization for European Economic Co-operation: European Nuclear Energy Agency. The Industrial Challenge on Nuclear Energy 3: Stresa Conference. Part 3: The Market for Nuclear Materials—Fuels—Moderators—Special Metals. Pp. 297. (Paris: Organization for European Economic Co-operation; London: H.M. Stationery Office, 1960.) 12 NF.; 18*s*. 6*d*.; 3 dollars; 12 Swiss francs; 10.20 D.M. [44

Neunzehnter Jahresbericht der Schweizerischen Gesellschaft für Vererbungsforschung—Société Suisse Génétique (S.S.G.), 1959. Mit Unterstützung der Julius Klaus-Stiftung für Vererbungsforschung, Sozialanthropologie und Rassenhygiene in Zürich. Herausgegeben von Marthe Ernst-Schwarzenbach. (Separatabdruck aus Archiv der Julius-Stiftung für Vererbungsforschung, Sozialanthropologie und Rassenhygiene, Band XXXIV, 1959, Heft 1/4). Pp. 193–319. (Zürich: Art. Institut Orell Füssli AG., 1959.) [44

South African Council for Scientific and Industrial Research: National Nutrition Research Institute. C.S.I.R. Research Report 172: Food Enrichment in South Africa—a Study of Principles of Food Enrichment and Their Application to Food Policy in South Africa, with special reference to the Use of Fish Flour for the Protein Enrichment of Bread. Pp. xiii+157. (Pretoria: South African Council for Scientific and Industrial Research, 1959.) [44

Uganda Electricity Board. Twelfth Annual Report and Accounts for the year ended 31st December, 1959. Pp. 52. (Kampala: Uganda Electricity Board, 1960.) 5*s*. [74

Meddelelser fra Danmarks Fisheri- og Havundersøgelser. Ny Series, Bind 2, Nr. 23–26. Nr. 23: Investigations on the Quantitative and Qualitative Distribution of Zooplankton in the Southern Part of the Norwegian Sea. By V. K. Hansen. Nr. 24: A Quantitative Investigation of the Echinoderm Fauna of the Central North Sea. By Erik Urson. Nr. 25: Conditioning *Ostrea edulis* L. from the Limfjord for Reproduction out of Season. By I. A. Aboul-Ela. Nr. 26: The Oligochaete Fauna of Three Danish Brackish Water Areas. By I. Dahl. Pp. 292+5 plates. (København: C.A. Reitzels Forlag, 1960.) 47 Danske Kr. [74

Chicago Museum of Natural History. Fieldiana: Anthropology. Vol. 50: Leadership and Cultural Change in Palau. By Roland W. Force. Pp. 211. 5 dollars. Vol. 51, No. 1: Excavations in the Upper Little Colorado Drainage, Eastern Arizona. By Paul S. Martin and John B. Rinaldo. Pp. 127. 4 dollars. (Chicago: Chicago Natural History Museum, 1960.) [74

World Health Organization. Technical Report Series. No. 192: Epidemiology of Cancer of the Lung—Report of a Study Group. Pp. 13. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars. [74

Council of Scientific and Industrial Research: Regional Research Laboratory, Hyderabad, India. Annual Report, 1958–59. Pp. xiii+172. (Hyderabad: Regional Research Laboratory, 1960.) [74

Folia Medica, Tomus 1, Fasciculus 1. Pp. iv+68. (International Supplement of "Collection of Scientific Works" of Pavlov's Higher Medical Institute, Plovdiv, Bulgaria.) Yearly subscription (4 numbers), Leva 20. Single numbers, Leva 6. (Plovdiv: Academic Medica "I.P. Pavlov", 1959.) [74

Annual Report of the Indian Council of Agricultural Research for 1956–57. Pp. vi+209. (Delhi: Manager of Publications, 1959.) Rs. 5.25; 8*s*. 3*d*. [74

Indian Forest Records (New Series). Mycology. Vol. 2, No. 2: Heart-Rots in Relation to Management of Sal. By B. K. Bakshi. Pp. ii+13–23+3 plates. (Delhi: Manager of Publications, 1959.) Rs. 1.25; 2*s*. [74

Report on the Revision of the Patents Law. By Shri Justive N. Rajagopala Ayyangar. Pp. x+397. (Delhi: Manager of Publications, 1959.) [74

Bulletin of the Madras Government Museum. New Series—General Section. Vol. 7, No. 2: Select Sātavāhana Coins in the Government Museum, Madras. By Dr. M. Rama Rao. Pp. 27 (2 plates). Rs. 1.75. Vol. 7, No. 4: Beginnings of the Traditions of South Indian Temple Architecture. By P. R. Srinivasan. Pp. iii+34. Rs. 1.70. (Madras: Madras Government Museum, 1959.) [74

Australian National University: Mount Stromlo Observatory. Annual Report for the year 1959. Prepared by Bart J. Bok, Director. Pp. 14. (Canberra: Australian National University, 1960.) [84

Transactions of the American Philosophical Society. New Series, Vol. 50, Part 3: The Archaeology of the Lower Tapajós Valley, Brazil. By Helen Constance Palmatary. Pp. 243 (121 plates). (Philadelphia: American Philosophical Society, 1960.) 5 dollars. [144

Commonwealth Scientific and Industrial Research Organization, Australia. Bulletin No. 282: A Survey of Fruit Cool Store. By G. M. Rostos. Pp. 76. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1960.) [144

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

one gauge

gives independent readings

for chamber pressure

and temperature

COMPLETE RANGE OF

AUTOCLAVES

FOR THE MODERN LABORATORY

The single gauge on each of the new BTL 'Bara' autoclaves is angled for easy reading and shows chamber pressure and temperature independently. A B.T.L. regulator maintains set pressure to within ±½ lb. per sq. in., and a safety valve limits maximum pressure to 28 lbs. per sq. in. A perfect seal is obtained with easy hand-tightening of the heat-insulated lid handles. The autoclaves are convenient and safe in use and each autoclave is provided with a test certificate.

The range comprises vertical and horizontal models in various sizes. Heating of the standard models is normally by gas or electricity. Autoclaves conforming to B.S. 2646:1955 are also available. *Please write for full details.*

BTL

complete
laboratory
service

BAIRD & TATLOCK (LONDON) LTD., CHADWELL HEATH, ESSEX, ENGLAND
Branches in London, Manchester and Glasgow.
Agents throughout U.K. and all over the world
TAS/BT 54

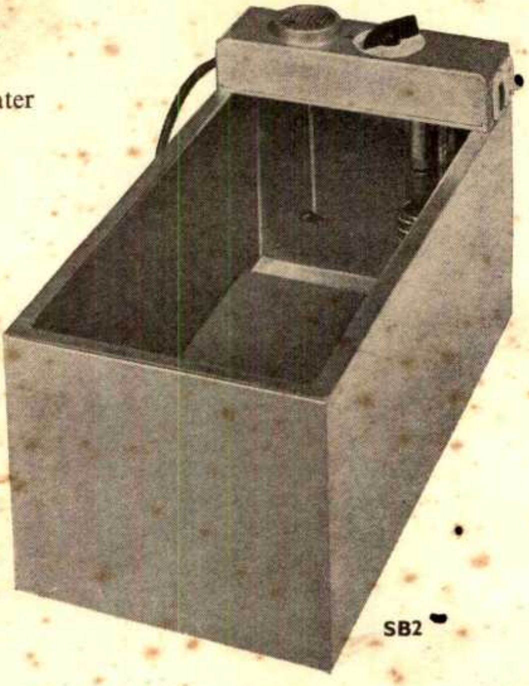
the standard laboratory bath

Stainless steel tank: Propeller stirring.
Dial marked in degrees Centigrade.
Available with pump for circulating water through other apparatus.
Wide range of test-tube racks, lids, cooling and constant level devices.
Unconditionally guaranteed for one year. Forty-eight hour repair service, and loan units available by return of post.

Standard Models
Range 10° to 100° C ±0·25° C

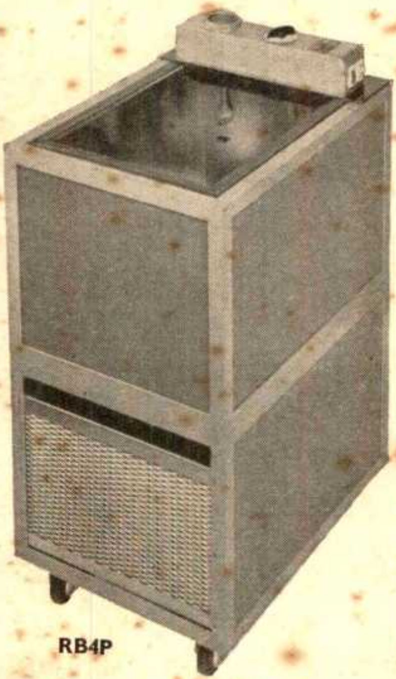
SB1 (9″×8″×6″) ...	**£27 5 0**
SB2 (15″×8″×6″) ...	**£28 10 0**
SB3 (21″×12″×11″)	**£32 0 0**
SB4 (15″×12″×9″)	**£31 0 0**

(working space in brackets)



SB2

low temperature bath



RB4P

Models RB4 and RB4P

Range −20° C. to +60° C. ±0.5° C.
This has all the features of our standard baths, but has a stainless steel heat extractor in the botton of the tank, driven by a refrigeration compressor in the lower section. If fitted with a pump (as illustrated) it can be used for circulating liquid at a controlled temperature through other apparatus.

Model RB4 (without pump)	**£97 10 0**
Model RB4P (with pump)	**£102 5 0**

(tank dimensions as SB4—see above)

Grant Instruments

(Cambridge) Ltd.

Barrington, Cambridge Telephone: Harston 528

Printed in Great Britain by FISHER, KNIGHT & CO., LTD., The Gainsborough Press, St. Albans, and published by MACMILLAN & CO., LIMITED, at St. Martin's Street, London, W.C.2, and ST. MARTIN'S PRESS, INC., 175 Fifth Avenue, New York 10, N.Y., U.S.A.—Saturday, June 18, 1960.